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

David Hung
Longkai Wu
Dennis Kwek *Editors*

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.

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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 ("embarkationl") 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 and assign them to students readily. Trainings were also more technically driven in nature, indicating rudimentary capacity building efforts that focused mainly on technology induction. These evidence suggested that technology-centric planning was the norm during this embarkation phase. As Gabriel mentioned in his interview, due to the very small number of participants, the mobile learning journeys conducted by FPS in the early years had limited impact although they involved participation across the five affiliated sister schools. Changes in assessment strategies were also not explored in tandem.

Notwithstanding that there were areas that need improvement during the early years, the motivation for using ICT was primarily student-centred, as gathered from the interviewees (Carl, Gabriel, Sheila) who reiterated the importance of using ICT to advance the affective development of the students. The main criterion to decide whether a project should be continued rested not on the quantitative evaluation of learning gains, but more on the affective monitoring of students, which could be distilled from their level of engagement. There was also evidence of self-organising efforts amongst interested teachers to explore how technologies could be best used to engage the students.

Towards the end of 2004, FPS called for a review of its ICT initiatives. The planning committee, in consultation with researchers from the National Institute of Education (NIE), decided to anchor its Primary Four curricula within the social-constructivist model of teaching and learning. In parallel to social constructivism, the school also promoted the idea of using action research. This new initiative paved way for using ICT in an even more meaningful way to meet the imperatives of student-centred learning.

To sum up, during this embarkation phase, the school focused on early reflections, saw the rise of emergent forerunners and employed affective monitoring of students as learning gains. Although instructional strategies were still predominantly confined to passive consumption, the school had started to make nascent efforts in pioneering small-scale cutting-edge innovations. Capacity building efforts were coalesced around technology induction, accompanied by efforts to build strong fundamentals for ICT-enabled environment.

Entanglement Phase (2005–2008) The entanglement phase spanned mainly from 2005 to 2008 and involved several key milestones. The year 2005 was perceived by Gabriel, the ex-ICT HOD of FPS, as a watershed year as MOE started to have more engagements with the school to understand how technology could be infused into teaching and learning. The school was acknowledged by MOE for its effort to move in tandem with the changes prompted by the government to "Teach Less, Learn More" (TLLM). The ideology highlighted quality, rather than quantity of programmes that nurture students holistically.

Carl defined the period of 2005–2006 as "crossing the tipping point" that saw both qualitative and quantitative growth in the number of ICT champions. In 2006, FPS achieved a school-based excellence award in ICT for encouraging greater diversity in its programme. In the same year, FPS became a LEAD school. Gaining momentum, the school received a nation-wide award for its excellent standards in innovation in 2007. Areas of evaluation include leadership, planning, implementation processes and results. The school perceived this as an attestation of its competencies for managing and sustaining innovation and commitment towards innovation excellence.

When Gabriel came on board as the IT HOD in 2006, he was cognizant about the wide range of technologies available and suggested to Carl that the school needed a focus. The discussion culminated in the decision to focus on 1:1 computing which Gabriel touted as a "field-levelling" tool where students could share ideas without inhibitions and explore at their own pace.

Carl also rationalised that "technology is not about waiting for somebody, or we wait for the technology, it must be relatively available for us". With immediate access, it would then be possible to integrate technology into the curriculum more seamlessly. There was no need to book the labs in advance and to use technology only during pre-determined time slots, which in Carl's eyes, was "artificial" and a "staged" way of learning.

However, as the school moved away from the ad hoc ICT project model to the whole-school programme, several flaws in execution became more apparent. Gabriel recalled:

> In that one year, 2005, many teachers came in and experimented. Many lessons failed. Infrastructure will fail us as well. You can go to the classroom, sit for 20 minutes, and still cannot log on. These are the things we learn.

Carl also remembered vividly the pressure placed on infrastructural demands:

> When we were doing some of the piloting, the devices at that time had a very low battery life. So an hour and a half, they went flat so we had to plug in power points. Those were the technical problems. But we didn't want the technical issues to stop us.

Besides challenges stemming from the instability of infrastructure, there were also other structural rigidities that affected the use of ICT for student-centred learning, especially after the initial expansion phase from 2007 to 2008. Han, an ex-ICT champion and middle manager, who was tasked to ensure teachers met the targeted level of Learning Management System (LMS) usage, described his frustrations. He said that timetable conflicts and other school priorities often got into the way and technology-enhanced lessons could not be carried out as planned. He also felt that many teachers were not fully harnessing the power of technology for collaboration, production or creative learning. LMS was still mainly utilised for disseminating electronic worksheets. Fundamental changes in classroom instructional practises were not prevalent yet.

The analysis of projects undertaken during this phase revealed common characteristics:

(1) The projects started to focus on personalised learning and cognitive development, allowing students to take more ownership of their learning, attesting to what Gabriel had elaborated about providing multimodalities, points of entry and catering to differentiated cognitive dispositions;

(2) Several projects highlighted the skill of multiple-perspectivities through networked platforms and communities;
(3) There was more focus on collaborative learning where students learned to discuss, negotiate and produce artefacts collectively.

Although promising, Han's view was that these positive developments were confined mainly to the experimental classes. As inferred from the separate interviews with the two generations of school leaders and ICT HODs, this was a deliberate policy by the upper management to contain more demanding research-based innovations within a few pilot classes to be led by experienced and willing champions, especially during earlier years of expansion where capacity was limited.

Whilst the use of technology for student-centred learning in classrooms was still not prevalent and frequently hampered by institutional constraints, the use of mobile devices for fieldtrips had undergone positive developments to incorporate the framework of experiential learning to encourage inquiry and data collection whilst on the move across all classes in primary four, indicating a stable state of expansion. There were also plans to scale up this generic framework of mobile learning for different subject areas and to students with different levels of learning abilities.

However, the fieldtrips also revealed other structural rigidities; one of which revolved the employment of assessment strategies. An examination of lesson plans and project briefs suggested that the assessment modes of these projects remained largely traditional. They were mainly worksheet-driven with close-ended questions. Students' collaborative or meaning-making processes were not woven into the assessment component. Electronic worksheets remained the primary, if not, sole yardstick for testing students' understanding.

The arrival of Terrence, the successor to Carl, in the last quarter of 2007, brought new perspectives which enhanced FPS' strong fundamentals in ICT development as well as challenged existing practices. This period of early expansion witnessed a flurry of emerging activities that exemplified polemic positions amongst leaders toward the use of technology, exposed some of the weaker links in the system, consolidated key developments, accentuated tensions and reinforced compatible practices. For example, Terrence who built on his predecessors' foresight in kick-starting the fieldtrips with good theoretical underpinnings, continued to fine-tune the programme by downplaying the use of electronic worksheets and enhancing the mobility of devices to augment constructivist practices. The learning journeys were also redesigned such that students' learning experiences were more aligned with the national syllabus.

Prior to 2008, assessment on the learning gains associated with ICT innovations was informal. Results of the experimental classes were tracked and compared with other classes of the cohort but there was no formal documentation or action research conducted. The new emphasis on the sustainability of projects saw Terrence expending energy on documentation to ensure the viability of projects in the face of staffing changes; and on accreditation in order to secure more funds. During

Terrence's stewardship, due to his focus on "teachers as researchers", all ICT innovations were considered action research projects to be grounded in pedagogical principles and results to be tracked consistently in a robust manner either by teachers or researchers to distil the learning gains. Such new emphasis on documentation, measurement and accreditation accentuated the tensions between new and old practices, which led to the next phase of exposition, where there was proactive effort from the management to re-articulate their vision and re-clarify the mission of using ICT for student-centred learning.

Exposition Phase (2009–2010) FPS had made great strides and won many accolades over the years. However, whilst riding along these waves of success, there were doubts of whether the school had placed too much emphasis on awards. Both Gabriel and Terrence were aware of such sentiments on the ground and offered their alternative perspectives. Terrence expounded:

> You can go and win the award. It's good! But your underlying objective, what is it? Is it just to go for award? Or is it a natural outcome? Because you have improved, you have spent time thinking through how you want to improve your teaching and learning process, you got it right, then you document it, and you present it at a conference, that's alright...It's always back to that same fundamental question. What is my motive?

Anchoring his philosophy of using ICT within the praxis of teaching and learning, Terrence's disposition was on reflexivity of teaching practices. Sharing this view was Jazz, a teacher who is proficient in using technology and has good pedagogical skills. She believed that children's learning should be foregrounded:

> We do not want to do things because we want to have a good name for the school but forgot about children's learning. If you bring in (technology), and the children did not learn in the end, it defeats the purpose.

Gabriel also explained that certain awards allowed them to reach out to wider networks and be connected to experts who would share invaluable experiences with regard to ICT leadership and to receive funding to continue research. Technology was only a means to an end and the school had set its longer-range goals on achieving excellence in teaching and learning.

In terms of the vision of learning, Terrence also focused on humanistic aspects, as with his predecessor, Carl. He believed firmly:

> As long as you make decisions not out of your own personal agenda but based on the welfare of the students, you can never be too far off.

In the interview with Terrence, he also talked about the purported benefits of technology in meeting different needs. He believed technology can allow students to "reach out to knowledge spaces" and acted as a "springboard to larger body of knowledge". This constituted a compelling need for educators to re-examine their epistemological beliefs. As part of Terrence's effort to re-establish the purpose and ways of using ICT for student-centred learning, he held meetings with Gabriel, the then IT HOD, who served as the conduit between Carl's and Terrence's reign soon after he came on board. Gabriel remarked that he could still recount the questions Terrence posed to him:

> What pedagogy, framework, and concept are the mobile learning trips built on? What are the research findings? How do we know this is much grounded? How do you know this is the right way to go? Do you have the research to back you up?

Gabriel reckoned these were pertinent questions and became acquainted with the idea of teachers as researchers, a concept which Terrence had enthusiastically promoted and incorporated into the school's cornerstone philosophy. Interviews with middle managers and teachers also echoed Gabriel's view that pedagogical frameworks were more foregrounded in FPS' ICT curriculum during Terrence's leadership, as compared to Carl's time.

There were attempts by Terrence to institutionalise the instructional framework. For example, for teaching and learning, FPS adopted the "The Skilful Teacher" model first articulated by Saphier and Gower (1997) and the Teaching for Understanding (TfU) framework which was mooted by the Harvard University as models of teaching as the cornerstone framework. Terrence thought it was essential for teachers to "understand the mechanics of lesson delivery and the ultimate purpose of education before any change in mindset can happen". However, he also felt that the mapping of these theories to the actual use of ICT can be further enhanced so that there would be more consistency across the frameworks.

During this phase, FPS' mobile learning trips continued to undergo evolutionary changes, especially after a review led by Terrence and ICT taskforce. In alignment of the principle to encourage active learning and shared accountability, the use of jig-saw cooperative strategies was added that required students to explore different parts of the learning journey. To give students more voice, student ambassadors were trained and acted as tour guides during the trips. The use of Google Maps and the option of inputting open-ended comments on the electronic discussion board were incorporated to encourage spontaneous sharing and knowledge creation. Most importantly, the teachers gave students more time to explore and interact with the physical historical artefacts, striking a balance between interactions between the virtual tools and physical world.

Although the mobilised curriculum structure was re-designed for student-centred learning, observations of the fieldtrip and post-fieldtrip activities signalled challenging problems that departed from the original intentionality of teachers who were involved in the re-design. Three notable ones include: (1) low levels of self-directed learning, as shown in students' desire for quick fixes by demanding answers from the student ambassadors when answering trip-related questions; (2) tokenistic level of knowledge exchange on discussion board; and (3) limited demonstration of reflection by student whom merely reproduced what the teachers had said at each station of the learning journey.

To sum up, whilst the instructional design of the mobile fieldtrip was embedded with strong elements of student-centred learning, the actual instructional strategies had yet to keep pace with the espoused principles. Students did not demonstrate reflective thinking and peer sharing based on the artefacts posted to discussion forum. Thus, even when technological platforms were proffered, the affordances were not fully exploited by both the students and teachers. Despite these shortcomings, the overall development of mobile learning initiatives was considered positive. Starting from a modest scale in 2001, the mobile learning programme had been scaled up to the whole school and incorporated into the scheme of work across all six levels by 2010. The current ICT HOD, Nigel, provided reasons for the resiliency of this programme, which included the school seeing “the value of merging technology”, the potential to “bring the learning of the students more alive” and gaining multiple sources of knowledge via “venues with rich resources”. Other projects implemented during this phase experienced a shift from classroom-based learning to the bridging of formal and informal learning, both in and out of the classroom context to create a dynamic and seamless learning environment for the students.

To gain insights about FPS’ classroom instructional practices during the consolidation phase, the fieldnotes of classroom observations were analysed. The lesson observations affirmed that the fundamental tenets of student-centred learning were present across the six technology-using teachers: both the students’ affective and cognitive development were emphasised, and students had opportunities to air their views, had space for exploration and were engaged in their learning. Teachers were also reflective about the students’ needs. As an example, Jazz displayed her student-centric considerations by critically examining which technological platform would meet her students’ needs and her pedagogical goal of fostering peer sharing on a Science topic. Post-lesson reflection also showed that she was aware of the competency gaps of students. She also reviewed the changes in how she integrated technology in classrooms over the years:

> Previously, it is more of the teacher telling the students, ok, I give you this thing, then you are supposed to do this. So they basically just follow. But now, it’s very different. It’s very student centred. I felt that way back in 2003, I have that ICT equipment so I plan according to that equipment. But now it’s the other way round.

Lesson planning had evolved from technology-centred to student-centred considerations. Gavin also expressed similar views of how emergent technologies had enabled him to include more interactivity in his lessons. He started using PowerPoint in a show-and-tell way in the early years and gradually advanced to using online collaborative tools after gaining inspirations from the professional development sessions conducted by colleagues.

The six lesson observations also showed some of the weaker links of enacting student-centred learning. Not all teachers were comfortable with giving students the freedom to explore as well as holding back the right answers. Sherry, for example, articulated the initial tension of enacting constructivist practices. As a beginning teacher, she had to grapple with content, pedagogical and technological issues. Both Sherry and her students faced transitional challenges with the change of instructional style. Some students were enthusiastic about researching and having a more prominent voice whilst others expected Sherry to spoonfeed them with “right” answers. The constructivist use of technology prompted a pedagogic transition which was eventually embraced by Sherry, students and parents after three months’ of adjustment.

During this phase, the school started to re-think about the assessment strategies related to the use technology for student-centred learning. In terms of assessment, although rigidity in grading practices was evident due to the macro-socio-political environment of preparing students for high-stake national examinations, the school was trying to diversify its assessment modes for other less examination-critical levels.

Professional development during this exposition phase also became more encompassing and diversified. The professional development practices were more elaborate and structured during this phase, covering areas such as curriculum innovation, project discussion, instructional practices and the exploration of emerging technologies. Terrence also highlighted how FPS had worked with external partners to conduct professional development courses. Examples of courses conducted by external partners include modules such as using ICT for inquiry learning conducted by NIE professors for the key office holders on-site; Microsoft online classes which connected key office holders to IT experts; discussion on lesson codesign between teachers and researchers and MOE-facilitated synchronous online classes conducted for the ICT mentors of every school. Teachers such as Janis and Jazz benefited from the professional development courses: Janis worked with the researchers to enhance her competency in student-centred facilitation and Jazz gathered useful lesson ideas from the nation-wide ICT mentorship programme.

In terms of infrastructure, the futuristic classrooms provided an environment conducive for collaborative and immersive learning. The micro-lab equipped with a one-way mirror in the lab catered for non-participant observation.

During this phase, the school continued to grow from strength to strength. It reached yet another pinnacle in their ICT milestone when MOE awarded the school with the status of Centre of Excellence for ICT. As a leader in this area, FPS was tasked to lead schools in achieving the goals of Masterplan 3. To achieve this mission, FPS had pledged to enable the following: setting up structures to harness technology to drive curriculum innovation in the schools, developing leaders and champions in technology planning and implementation and setting up a national platform for sharing of best practices. FPS was also recognised on the global front for its innovative use of technology when Microsoft accredited it as a "mentor school"—the highest accolade given to schools for developing ICT programmes that could serve as world-wide exemplars.

Overall, for this phase, curriculum innovation was anchored in pedagogical research. Due to the emphasis on pedagogical principles, Terrence had encouraged FPS teachers to work with NIE researchers for better grounding of research methodologies. An in-house centre for research and application was set up to make this long-term collaboration viable. There was broad consensus on using technology for student-centred learning. However, incongruence could still be observed during enactment. Didactic worksheets were still used in some instances and not all teachers were using technology to advance discussion. Teachers also struggled to internalise new frameworks so as to translate them into instructional practices that were aligned with the philosophical underpinnings of the frameworks suggested by leaders. There was also incremental diversification in terms of formative assessment. However, drill and practice was still the dominant strategy for preparing students for summative assessment. Professional development sessions covered wide-ranging areas to build up teachers' capacity to enact student-centred practices with technology. Teacher's involvement in ICT projects had also increased in this expositional phase. On average, with the exception of Primary Six level (school leaving examination year), about 50% of teachers per level from Primary One to Primary Five were involved in using technology to enhance teaching and learning. The high participation rate of teachers in projects, be it emanating from bottom-up or researcher-led initiatives across all levels, suggested a buoyant culture in using technology to drive curriculum innovation. Technology was positioned as a personalised, contextualised, collaborative and cognitive tool for learning.

Elevation Phase (2011–2013) In 2011, the school received the FutureSchool award, signalling its commitment to deepen the use of ICT for student-centred learning by scaling projects to the whole-school level, thus the labelling of this phase as "elevation". After becoming a FutureSchool, FPS was allowed to hire more teachers than other schools to develop pedagogically sound ICT programmes and to provide better technical support. This gave FPS more capacity to deal with the complexities of managing and coordinating the number of projects that have grown exponentially over the years.

During this phase, sustaining and scaling successful innovations were of paramount importance, not only because both aspects were requirements spelt out by MOE for FutureSchools, but because it was also the belief of FPS leaders that innovations should not be episodic endeavours. This could be seen from the school's effort to successfully scale up 3 ICT programmes across different levels and 5 ICT projects across the same level. Terrence had explicitly mentioned about the desire for and challenges of scaling up success:

> ……after you have started with one or two experimental classes, are there (further) opportunities? But it's a total different ball game to roll out to whole level and make it more pervasive because you will face another set of challenges……

Cognisant of the demands, Terrence sought the help of researchers to escalate capacity building efforts in curriculum design and research during the scaling process. The goal of FPS during this phase is to train teachers not only to implement, but also to design lessons for ICT integration and subsequently at a more advanced stage, re-design curriculum to enable learning anywhere, anytime. By 2012, more experimental teachers were able to hold their own fort and drive ICT programmes without intensive handholding from researchers. For example, Janis was able to conduct training sessions to colleagues and teachers from cluster schools on the enactment of technology-enhanced lessons, demonstrating the gradual shift of ownership from researchers to school. As Nigel remarked, one out of every three or four teachers in FPS was actively involved in ICT projects or programmes and would be ready to champion ICT initiatives.

Compared to the other three phases, the focus of development was more macro in nature. It had shifted from within-school milestones to inspiring other schools to use technology for student-centred learning. Nigel talked about how FPS could serve as a living example for other schools, especially in terms of transcending the technology-centric perspective when leveraging technology for learning:

> Yes, technology will be always there, because it (FPS) is tagged with ICT but it is not just technology, it is how we want to make the school into a successful model for others to follow. And that model would include the curriculum, the pedagogy behind that is driven with ICT. And we want the teachers to know that it is not all just a product of technology. It is about how we relook into the curriculum and the teaching pedagogy.

A meta-analysis of the projects undertaken during the four phases indicated a few trends about FPS' attempts to integrate technology into its curriculum:

(1) There was a shift in the emphasis of the ICT projects from enabling self-learning to nurturing self-directed and collaborative learners; and from classroom-based projects to projects that leveraged different learning spaces;
(2) There was "coming of age" of the ICT projects as the school entered the consolidation phase to scale up and sustain successful projects. The ICT projects had undergone constant reviews, and a new lease of life was injected into promising projects so that they can be fine-tuned to benefit more students;
(3) The learning objectives of the projects had become less technology-centric and more contextualised and anchored in pedagogical framework;
(4) The school's emphasis had moved beyond motivation and student engagement to knowledge creation.

Nigel also reflected on the changes to the championing of ICT initiatives in FPS:

> In time to come, we got the IP (core instructional programmes) departments involved……but the IT department was still championing few of these projects. So now, we are getting them more involved by letting them take over the autonomy or the ownership of the project, to put it into their curriculum and scheme of work. So with that, we can see more synergy and integration.

Here, the emphasis of ICT integration had shifted from information structure to social structure, from piecemeal to integrated approach by having more cross-departmental fertilisation of ideas accompanied by joint effort in implementation. However, infrastructural issues seemed to resurface during this elevation phase, especially in 2011, due to unstable wireless connection when many users were logging in at the same time. This problem was mitigated after collaboration with multiparties.

In terms of instructional practices, interviews with Sheila and Amelia, both of whom had observed many lessons for the purpose of appraisal as middle managers, commented that very few teachers were using ICT in a didactic manner. They emphasised that there was an elevated awareness of using ICT for constructivist practices due to the numerous professional training sessions the teachers had attended. However, Amelia interestingly noted that when teachers did not have the ICT tools with them, they tend to revert to traditional teaching, thus supporting the view that technology can promote changes in pedagogic practices and expand teachers' repertoire of teaching strategies.

Insights from classroom observations seemed to be in congruence with the proposition that technology could potentially change teaching practices, especially for conducting formative assessment. Gavin, one of the participating teachers, explored the use of a new language learning portal for peer learning where students were encouraged to learn from, critique and correct one another's mistakes. He consolidated the learning points and shared sentence-making strategies in class based on students' online posts, which was aligned with the notion of just-in-time feedback. This suggested that experimental teachers like Gavin had become increasingly aware about the importance of student agency and refrained himself from becoming "Sage on the stage".

Another breakthrough in formative assessment was the increased use of TfU framework in formative assessment for Primary Five Science experimental classes. This nascent effort was considered very forward looking as the deliberate effort to allow demonstration of students' understanding was not widely practised in primary schools. This stance represented a departure from the rigidity and stability of traditional assessment.

Assessment of teachers had also gone through changes during the elevation phase. First, teachers were profiled based on the results of their self-reported surveys. It had also become mandatory for teachers to use technology at least once out of the two lesson observations that would be conducted by their reporting officers each year. The rubrics of appraisal revolved around tenets of self-directed and collaborative learning, both of which were competencies emphasised in ICT MP3. According to Nigel, there would be a pre- and post-lesson conference between the teacher and reporting officer. He commented on this appraisal system:

> It gives the teacher a chance to clarify certain things, it allows the reporting officer to value add, to help improve the lesson so that on the day of the lesson observation, it is something that I would say, one of the better lessons that the teacher can offer.

The new appraisal system enabled the leaders to monitor the usage of technology for student-centred learning and to also build teacher competency. This was important as the elevation phase placed greater demand for curriculum experts and the need for more sophisticated professional development system.

From the interviews with Hannah and Jazz, the benefits of nation-wide ICT mentoring scheme, which was part of MOE' s effort to enhance capacity building, had begun to cascade down to school. In FPS, the four designated ICT mentors would share ICT lesson ideas or organisational tools with staff every quarterly, each time lasting for 3–4 h. Hannah commented:

> Teachers are generally busy and have no time to explore technologies. ICT mentors can explore and test out tools which can be used in the classroom. We can get ideas from friends, course mates or educational technology officers from MOE. We will usually do internal testing first before sharing with our staff.

According to Hannah, although there was feedback that the ideas shared were feasible and useful, jam-packing the introduction of various tools in a compressed timeframe of three-hour programme would be an overkill. Teachers expressed their preference for smaller 1:1 coaching at a slower pace. The ICT department acted on the teachers' feedback and encouraged teachers who shared similar interest to form groups of 2–5 persons. The ICT mentor can then spend one hour walking through the steps with teachers. The direction of breaking out into "mini ICT PD sessions" showed that the professional development sessions had become more personalised than before.

Lastly, due to the emphasis on the scaling of the ICT projects, the administrative load had increased manifold. Anecdotal evidences from resident researchers indicated that the demand for ICT support staff to maintain the equipment and to troubleshoot technical problems in the classrooms had been overwhelming. The interview with Gavin also offered insights that middle managers now had to negotiate with multiple stakeholders such as parents, researchers and commercial vendors to get the projects going at a wider scale, which required nuanced skills beyond his core scope of teaching and learning.

1.5 Implications

The mapping of the ICT development trajectory of FPS over the four phases was an attempt to provide a rich historical account of what happened to the school from 2002 to 2013 as it harnessed technology to meet the pedagogical reform for student-centred learning (See Appendix 1). There are important lessons to be learned with regard to innovation development within a school context. Several assertions can be made based on the school's longitudinal use of technology:

Assertion 1: Whilst there could be deeper alignment between the use of technology and the principles of student-centred learning over the years as a result of long-term enculturation, tensions that threatened the fidelity and adaptations of innovations may not abate correspondingly.

Over the four phases of development, there was anchoring of student-centred learning principles. This could be seen from the humanistic belief of both principals, pedagogical grounding, systemic integration for promising programmes, heightened awareness for using technology to realise constructivist practices, incremental diversification for formative assessment and grading practices and the encompassing enculturation for professional development practices. However, there were other tensions that proved to be more tenacious, such as the tensions between new instructional emphasis (e.g. TfU) and the rigidity of national examination format which called for the need to design a generic but validated instrument for evaluating students' competency across levels and subjects.

Although broad pedagogical consensus to infuse socio-constructivism as one of the important teaching strategies had been achieved, the abovementioned tensions gave rise to incongruent internalisation of pedagogical principles and the gulf between espoused and actual enactment of student-centred practices. Interactions with stakeholders were also fraught with tensions throughout the four phases. The empirical evidence that arose from FPS' case study suggested a departure from Tong and Trinidad's (2005) view that many favourable conditions can be fulfilled and constraints be eliminated as the school advances in its ICT journey. In fact, for FPS, living with and reconciling perpetual and multifaceted tensions were part and parcel of enabling processes that fostered an innovative culture.

Assertion 2: The continuous perturbations could be discernible from the entanglements between technologies, pedagogies, learning theories and bureaucracies. These entanglements, however, could lead to the crystallisation of strategic direction.

Entanglements, which could be interpreted as a state of "becoming", were intertwined with the specificities of technologies, rise of pedagogies and learning theories as well as bureaucracies, most often experienced as logistical challenges such as top-down directives or structural rigidities of schooling. As seen in FPS' case, these entanglements could be productive as they led to the crystallisation of values and future directions. The expositions of learning and teaching framework and the strategic positioning of focusing on 1:1 mobile learning were responses to such entanglements. The introduction of these frameworks may create perturbations at first but can subsequently serve as a unifying principle for lesson planning. The teacher's ability to enumerate the imperative of aligning their teaching practices to sound pedagogical principles during interviews was an example of common understanding shared amongst the diverse group.

Assertion 3: Sustainability of wide scale and meaningful ICT integration requires political will and skilful orchestration of resources across generations of leaders.

FPS started out as a mainstream school conducting sporadic ICT experimentations in 2001 and became recognised both locally and internationally as a school that epitomised meaningful ICT integration by 2013. Undeniably, some early success as first mover in the field had fuelled momentum. However, to sustain this work requires political will to overcome different entanglements (as mentioned above) and skilful orchestration of resources from within and beyond school. More importantly, there must be continuity of philosophy and drive to take this complex endeavour further. FPS was able to create greater depth and breadth not due to the vision of one leader, but collective envisioning of different generations of leaders, including middle managers and champion teachers. The first principal focused on teacher agency whilst the second principal provided overarching structure for sense-making of on-going efforts. The congruence in the philosophy of the two principals, the nurturing of internal professional capacity and the sustainability of innovation culture enabled reforms to survive leadership change over the 13 years. The school had consistently connected the dots (be it temporal, epistemic, policy, social or structural) within and across the various subsystems in its learning ecology to make pedagogical innovations and change sustainable (Toh, 2016; Toh et al., 2014).

Assertion 4: Leveraging partnerships is vital, especially during the infancy stage of innovation implementation but the synergistic collaboration must eventually result in capacity transfer from partners to school-level agents.

The capacity building process of FPS was evolutionary. The school started out by working with strong partners such as university researchers to build up internal design capacity—an important implication for other schools as it is the internalisation of expertise that would engender long-term spawning effects of capacity building within the school. Caution must be exercised to ensure there is no accentuation of dependency culture between innovation schools and their partners. With the shift of innovation ownership from researchers to teachers, FPS teacher champions became the change agents in their own right. They were capable of helping other schools to create an ecosystem that was conducive for the innovations to take root (see Toh et al., 2016).

To recapitulate, the mission of FutureSchools was to propagate innovations that had achieved proof of concept within their incubator environment to less ICT-ready schools in the local system—part of MOE's multipronged strategies to level up schools' capacity for ICT integration. An introspective examination indicated variegated results with respect to the fulfilment of this mandate. On a positive note, FPS was one of the FutureSchools that had taken a more proactive stance in diffusing their innovations beyond their own school context whilst most of the experimental schools did not undertake such a systemic perspective then. By the year 2013, FPS had spearheaded a few learning communities, investing tremendous amount of time and resources to enculturate affiliated schools to adopt some of their successful ICT-mediated innovations. The process of peer apprenticeship was a long-term effort which saw teachers, NIE researchers and MOE educational technology officers meeting fortnightly over a period of two to four years to engage in professional dialogues. Since the inception phase of diffusion, FPS had a clear vision to transfer design capacity instead of merely disseminating lesson plans to participating schools. As this transfer entailed the iterative processes of codesigning, enacting and reflecting throughout the innovation cycle, there was propensity to effect deep changes in the teaching practices of participating teachers. Understandably, it would take a much longer time for such innovations to reach systemic impact as the nature of innovation lends itself to achieving depth, rather than breadth (Hung et al., 2016). FPS' commitment to take on such a mission was laudable, as the school would need to bear some implicit cost of coordination and mentoring. Without the unwavering support of school leaders and buy-in of teacher champions, it would be difficult to sustain this exercise over the long run. The future challenge would be whether these learning communities would be self-sustaining and whether the newly seeded teacher champions from other participating schools would be able to take these innovations further by actively promoting them to other communities.

1.6 Conclusion

This chapter traced the trajectory of FPS' ICT development over a decade by looking at a variety of aspects: levels of usage, number of champions, motivation to use technology, instructional practices, curriculum structure, project nature and professional development design. The preponderance of evidence suggests that FPS had been using technology to promote student-centred learning, specifically in promulgating social-constructivist learning, tapping on student agency and giving students more voice. Their ICT curriculum had advanced from piecemeal projects to systemic whole-school programme; the evaluation of projects from a more laissez-faire approach to a more critical examination of learning gains; scaling of projects from sporadic championing by small groups of teachers to whole-school participation in curriculum-related decision making. Infrastructure provision was also increasingly sophisticated. The four phases provided insights about the developmental trajectory of FPS' journey into using ICT to transform teaching practices (See Appendix 1). The four phases are not linear in terms of ICT implementation. What I had attempted to do is to foreground FPS' different locus of concern over time as it powered up the use of technology at a whole-school level. As this chapter delved only into one case study, generalisation is clearly not the aim. Context matters especially in this complex endeavour of "unfreezing" (UNESCO, 2011) the various components of school for ICT integration. However, what we can distil is that such "unfreezing" process is evolutionary and knowing what levers to unfreeze and how to unfreeze takes prolonged and collective efforts. In addition, knowing how to prevent the regression of "freezing" is also vital. Without the philosophical congruence and political commitment between generations of school leaders, the initial presence of innovation culture and internal capacity in any school may merely slow down the inevitable and vexatious process of re-freezing—before eventually subjugating to the prevailing forces of what Hogan et al. (2013) term as "credentialing anxieties".

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Appendix 1

Development trajectory of using ICT for pedagogical reform.

Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
Priorities	Whether technology can engage and add value to learning	Early reflection	Getting the fundamentals right	Building foundation	Re-clarification Accreditation Expansion	Consolidating gains	Scaling within and beyond FPS	Extensive scaling
Champions	3 teachers in 2003 15 participating teachers in 2004	Emergent forerunners	Growth in number of participants crossing the tipping point	Expansive advocates	More than 50% of teachers were involved in projects	Pervasive supporters	25–50% teachers were ready to champion	Buoyant activists
Philosophy	Students should continue to use technology as long as they are enjoying the process. Engaged learning is the key	Affective monitoring	Strategic re-positioning to focus on 1:1 computing	Strategic re-positioning	Everyone can learn and technology would be able to cater to the differentiated needs of learners	Humanistic anchoring	Serving as an exemplar for other schools	Prototype exemplifying

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Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
ICT Programmes and Curriculum structures	Early pockets of success in experimenting cutting-edge technology to promote active learning. In general, programmes had limited impact	Nascent pioneering	Emphasis was on socio-constructivist practices. However, the ICT projects were mainly ad hoc and piecemeal involving very few classes. No incorporation of projects into the scheme of work	Pedagogical Seeding Piecemeal trialling	Curriculum innovation anchored in pedagogical research. Projects emphasised bridging of formal and informal learning, re-designed learning journeys based on systemic considerations	Pedagogical framing Holistic integration	More projects with proof of concepts were integrated into SOW. More cross-departmental collaborations can also be observed	Pedagogical translation Inclusive collaboration

(continued)

(continued)

Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
Instructional practices	Predominant use of electronic worksheets disseminated through LMS. No fundamental change in instructional practices	Passive consumption	Tensions due to technical glitches, implementation incompatibilities and limited understanding of pedagogical implications	Systemic tensions	Broad consensus on expanding use of ICT for student-centred learning. However, incongruence between espoused and actual enactment could be observed as teachers struggled to internalise new frameworks	Pedagogical consensus Incongruent internalisation	Majority of the teachers were able to enact constructivist practices when using ICT. Technology was perceived as a catalyst for changing teaching practices at a larger scale than embarkation phase	Catalytic transformation

(continued)

(continued)

Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
Assessment strategies	Traditional assessment and grading practices were especially rigid to changes	Status-quo maintenance	Not many changes were introduced during this period. High incongruence between grading practices and principles of student-centred learning	Widening divergence	Isolated evidence of students learning how to assess their own or peer's work. Some attempts at making formative assessment more varied and just-in-time. Drill and practice was still the dominant strategy for summative assessment	Incremental diversification	New appraisal system for teachers that emphasised collective voice. For assessing projects, a more formal and collective evaluation was introduced	Collective evaluation

(continued)

(continued)

Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
Professional development system	Training was more technically driven in nature, for example, the teachers were trained in the use of the school's LMS or certain softwares	Technology induction	A few interested teachers explored technologies together but these efforts were not integrated into the professional development system	Isolated exploration	Covers wide-ranging formal and informal aspects such as encouraging curriculum innovation, ironing out implementation issues, improving instructional practices for student-centred learning, providing upgrading opportunities, connecting to experts and mentoring colleagues	Encompassing enculturation	PD sessions were also more customised. Time-tabled time, small-group handholding were implemented	Customised iteration

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Phases/Attributes	Embarkation (2001–2004)		Entanglement (2005–2008)		Exposition (2009–2010)		Elevation (2011–2012)	
	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features	Rationale and actual use of technology for student-centred learning	Salient features
Infrastructure	LMS and school portal ready. IT department designed lesson packages	Building fundamentals	Unstable connection and long log in time. Low battery life of devices and option for charging is not readily available	Variable operating conditions	Futuristic Computer Lab for collaborative learning and classroom observation. P3 classrooms rewired for device charging	Pedagogic focus	Wireless coverage higher but highly unstable. More demand on ICT support	Suboptimal connectivity

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Chapter 2
Nurturing Maker Dispositions Among Children with Open-Source Tools: A Case Study of a Junior High School in Singapore

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Abstract The recent phenomenon of maker culture has garnered the interest of educators as arguments have been advanced for the foregrounding of making in learning. Making in learning is an example of how participatory cultures of learning focus on authentic contexts outside of the formal spatial and temporal bounds of schooling. This chapter describes how a specialized school in Singapore made use of a curriculum design framework known as the Six Learnings (Lim,.Journal of Virtual Worlds Research 2:4–11, 2009) because of its origins in contexts of learning such as games and immersive environments. The authors facilitated the process and based the design and principles of the learning space to articulate key dispositions in learners through the nurturing of a culture of making. Foundational to the activity was a commitment to reconceptualizing the emphasis on routine tasks and instructions that are typically present in a formal classroom setting.

2.1 Introduction

Since the industrial revolution, the development of civil societies in the West has been characterized by periods of steady growth and relative stability. Progress was understood from a Kuhnian (1962) perspective of paradigms, perturbations and consensus building; this resulted in long periods of steady state, each of which lasting for several decades. In turn, these steady states meant that skills could be developed over time, knowledge bases could be incrementally grown, and both knowledge and skill sets remained relevant throughout a person's lifetime; career paths were clear,

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and systems of education designed along functional philosophies were able to service the needs of countries well.

From the latter half of the twentieth century—precipitated by the forces of globalization and the imperatives of networked social and economic architectures—the assumptions of steady state that had so successfully undergirded statecraft in Singapore and the West rapidly lost their validity. Instead, we characterize societies in the twenty-first century as being in a continual and dynamic state of change, driven—for example—by exponential advances in computation. These advances hold far-reaching implications for social practices and genres of socio-economic participation that we are continually articulating. The implications include those pertaining to how children learn, the nature of disciplinary understanding and the social co-negotiation of structures of authority and trust.

As such societies are much less hierarchical compared to the past, and consistent with Anderson's (2006) notions of the long tail, children from all social and economic strata can have opportunities to move up the social ladder. Schooling systems have historically been designed largely based on an industrial model and mass production of skills; in such systems, the impartation of knowledge through rote and memorization were dominant. However, the highly structured nature of schooling today can be complemented by more emergent and unstructured forms of informal learning, including networks of practice existing in social media and online worlds.

Singapore's education system has largely been very successful with a very strong academic emphasis. Science, math and engineering have been the dominant staples of economic success. The system began with the streaming of students, but has now evolved such that students on different tracks can move from one track to another.

However, members of Singapore's senior political leadership have recently alluded that the education system may have also stratified the student population, and while we acknowledge that not all students can attain the same degree of academic performance, care should be taken to cultivate students' abilities to the fullest.

Instead of obliging everyone to conform to the same mould of academic performance, this chapter attempts to frame a context—or a remaking of a context—in Singapore in which multiple talents and disciplines are widely recognized as advantageous; this is especially critical to sustain economic development in Singapore in a world increasingly characterized by instability and unpredictability.

In the twenty-first century when imagination and play are critical, the talents of all our students, especially the academically lower achieving students, should be harnessed. These latter cohorts of children have always been stronger at expressing themselves through non-traditionally academic means, such as through the visual and performing arts, and through craft and design thinking. With regard to the latter especially, there is an increasing recognition—since Brown's (2008) seminal paper in the Harvard Business Review—that these are dispositions and expertise sets are of critical value to ensuring the nimbleness and adaptivity of societies in the twenty-first century. This is in large part because disciplinary domains are less accurately described as 'stocks' of knowledge, but as 'flows' in an age of the networked learner. In such a characterization, learners are adopting much more co-equal stances with more traditional domain arbiters as they participate and negotiate in the de- and reconstruction of knowledge and the ontologies thereof. To quote Weinberger (2012):

> we used to know how to know. We got our answers from books or experts. We'd nail down the facts and move on. We even had canons. But in the internet age, knowledge has moved onto networks. There's more knowledge than ever, but it's different. Topics have no boundaries, and nobody agrees on anything.

It is worthwhile to note that the point that Weinberger is making is not one of information overload—that would be too superficial a reading of his critique. Instead, Weinberger is highlighting the malleability of modern manifestations of knowledge, and how this malleability has resulted in the arbitrations of knowledge as being more contested than it has ever been in human history.

It is our view that—from such a framing, at least—good questions are more important than good answers. We can learn from the maker movement as to how a respect for a diversity talents can be nurtured.

2.2 Maker Culture

The recent phenomena of maker movements in Germany and the USA are very good examples of the increasingly participatory culture of learning that characterizes so much learning in authentic contexts outside of the formal spatial and temporal bounds of schooling. Turning Descartes's *cogito ergo sum* on to its postmodern head, maker movements recognize that understanding is socially constructed and frame it in terms of *participate ergo es*—we participate therefore we are; the very act of legitimate peripheral participation in socially authentic contexts engages selves in dialectic coupling with the social corpus in ongoing shapings and negotiations on identity.

2.2.1 Homo Faber

The learnings that accrue from defining ourselves as social beings—in relation to social others—are very different from those which arise from an understanding of self as a stand-alone construct; the latter reinforces a notion of the acquisition of knowledge as stock, the former foregrounds an understanding of the negotiation of knowledge as flow.

To elaborate, learners are engaging in participatory performances in which they derive authenticity thrive on—and look forward to—having their respective creative processes critiqued by social others; one only needs to look at trust-based online communities—such as Flickr, YouTube, eBay, Amazon and fan-authored wikis—for evidence of this. This can be thought of as akin to a shift from a quasi-Cartesian 'I am what I own/I am what I control' to 'I am what I share with others to build upon'.

In such settings, learners derive meaning and authenticity from their membership and participation in interest-driven communities—no one needs to tell them to persevere and improve, instead they engage in a complex series of performances encompassing goal setting, resource evaluation and self- and peer-assessment according to both personal and socially moderated standards. In such performative environments, the traditionally binary distinctions between success and failure are rendered meaningless, because the learners realize for themselves they are not only seeking a continuously shifting bar, but—critically—that they have some influence over the nature of the bar itself. That is to say, the learners realize for themselves they have the ability to create their own contexts for personally meaningful experiences of learning.

2.2.2 Homo Ludens

Learners engage in the creation and curation of contexts, through deliberate participation in play. By 'play', we refer not only to situations in which the learners are actively participating in the structured activities of games, but also to the dispositional approach of the learner to attempting to understand whatever is presently holding his/her attention as a system to be analysed, de- and reconstructed (either/or both metaphorically and/or literally). Play is therefore an extremely intentional activity, and it is also a disposition which is increasingly defined in negotiation with one's social others.

Framing learning through the disposition of play is important, because it has the corollary that 'failure' (as traditionally defined) is an option—to the extent that it is understood as a learning opportunity—the whole concept of 'cheating' (taking a shortcut to success) is also rendered invalid because the learners would not stand to gain personally from having 'cheated'. Cheating is only a worthwhile strategy if assessment is understood as a stand-alone output ('stock'), as in 'I won'/'I achieved the highest score'; it loses its validity once personal worth is understood as a developmental process ('flow'), as in 'I am getting better at this'/'I am understanding better how this works'. Further, few think of leveraging the technologies to 'cheat', because they realize for themselves the hit that would mean to their reputations in these communities—the premium that Shakespeare's Othello placed on reputation still rings true today. In this way, these interest-driven communities have helped redefine understandings of apprenticeship, in ways which extend its roots from social enculturation into a more contemporary understanding of the nature of the learner and the learned.

2.3 The Maker Movement in Education

The maker movement has been making waves in education lately as progressive educators have argued for a more active role of making in learning. Perhaps one of the earliest known ideas of learning from making was from a Swiss education reformer. Pestalozzi (1746–1827) believed that learning should be a cross-curricular balance between the 'head, hand and heart'. He gave great consideration to what children could learn from nature, play and from observations of the world. Pestalozzi believed that learning resulted from the learner's own self-activity and first-hand experiences. He recognized that the interests and needs of the child should be nurtured, in a child-centred rather than teacher-centred approach to teaching.

Like Pestalozzi (1912), psychologist Jean Piaget, more than a century later, formalized these ideas with his theories of constructivism. In his *To understand is to invent*, he advocated that 'every new truth to be learned, be rediscovered, or at least reconstructed by the student and not simply imported to him' (Piaget, 1976, p. 15). He also called for teachers to teach from an 'interdisciplinary point of view' and to give 'general significance to the structures they use and to reintegrate them into overall systems embracing the other disciplines' (Piaget, 1976, p. 29).

Similarly, Seymour Papert, who is known for his theory of constructionism, positions the embodied, production-based experiences as the basis of how people learn (Harel & Papert, 1991). Papert, whose theory of learning undergirds the maker movement's emphasis on problem-solving and digital and physical fabrication, has been ascribed as the 'the father of the maker movement' (Martinez & Stager, 2013, p. 17). Papert (1993) postulated that it was the physical process of constructing an object that would help students develop and demonstrate an understanding of the subject they were learning. That meant that students would be able to learn effectively by actively constructing knowledge through the act of making (Martinez & Stager, 2013).

Today, the presence of technology offers learners tremendous resources and plays a significant role in the maker movement. Technological experimentation and the availability of digital devices and technologies like open-source 3D design programmes are just some of the tools that support a learner's design and construction goals.

State Craft and Street Craft

To date, the Singapore government has been effective in creating new contexts for learning through careful planning. An example is the so-called specialized schools, which were set up in order to cultivate talent in the arts, sports and math/science, the Ministry of Education in collaboration with other ministries created specialized schools to cultivate and nurture such talent. The 'context' created enables new forms of interactions to occur. These new forms include exploiting on professional practices and practitioners to advance skills and dispositional cultivations. Academic teachers have closer relationships with practitioners within the same community networks.

While we acknowledge that the state engineered and planned for these schools, enabling new contexts to be engendered, students in these schools were also able to delve into creating new possibilities in learning. In other words, the government enabled an environment (what might be termed big ‘C’—context) where small ‘c’s were able to be created by the students, teachers and practitioners from these respective specialized schools.

We acknowledge that these specialized schools are expensive relative to typical schools, but they clearly serve a different purpose. In the overall ecology of schools, we need to have a diversity where talents can be harnessed, but importantly, cross-fertilizations need to be encouraged.

The maker movements in the USA exhibit a deep web of social relationships and networks where individuals come together to make things. In a sense, these maker movements are very similar to open-source communities which acted as a counter-force to the institutional giants. One wonders if there were no big giants whether these counter-forces would have flourished. In the overall ecology, we believe we need both kinds of forces.

In a way, the manifestation of government is akin to the ‘institutional giants’. In Singapore, we should encourage these counter-movements rather than seeking to quench them. The issue should be defined in terms of how to manage these tensions productively.

2.3.1 ‘Minds on’ and ‘Hands on’

The maker movements show the intertwining nature of ‘hands on’ and ‘minds on’. In the quest for achieving their goals, these individuals exhibit passion and tap upon these networks to solve authentic problems. They both make and think in a close knit manner, tacitly knowing (Thomas & Brown, 2011) how to source the requisite resources in a just-in-time manner. In this sense, mind and body are not divorced, just as plans are not divorced from actions.

The industrial revolution privileged the Cartesian model where abstracted knowledge is legitimized, and students learned and are assessed predominately through a minds-on pedagogy. Minds on, the derivation of good plans through critical thinking, epitomizes the Cartesian worldview. This assumes the stability of the world around. However, going ahead, it behoves us to seriously reconsider this worldview and to return to the inextricable relationship between cognition and context. Hence, the dialectical nature of a minds-on–hands-on philosophy. Situated in the appropriate nurturing contexts, a ‘hearts-on’ disposition would also be fostered since the leverages of embodiment in social practices are designed for.

2.3.2 Planning and Playing

Not only have we to acknowledge the inextricable nature of cognition and context, Thomas and Brown (2011) also posit that today’s tools and environments afford learners to create new contexts. The creation of contexts is not only the privilege of the established institutions, but big ‘C’ can be possible even for those traditionally seen as outliers and at the periphery of society (e.g. children). Such a disposition should be encouraged as it requires both play and imagination to create new possibilities and worlds. Children all over the world are creating small ‘c’ through the creation of powerful, compelling and complex narratives (fan-fiction) upon these imagined worlds.

If we look beyond the academic performance of specialized schools in Singapore, there are common interests and dispositions which can be leveraged upon. The collective coming together of these students can enable and catalyse an ‘edge’ phenomena, and because these students come from academic scores that can be wide, a cross-fertilization of students’ play and imagination can be recognized to permeate across social strata.

2.4 Background to the Case Study

Quest High (QH) is one such specialized school in Singapore. It provides a customized, technical-based curriculum that is designed for hands-on and practical learning. There is less emphasis on academic-focused methods, and the learning environment goes beyond the traditional academic demands of a regular classroom. The school’s broader objective is also to provide multiple pathways that cater for the different learning needs of students.

In 2013, researchers from the National Institute of Education in Singapore worked with three teachers and fourteen students of Quest’s New Media Club, to design and build a full-scale model and simulation of the school campus using an open-source platform, OpenSim. It was a two-year project with the students (13–15 years old), who built a 3D virtual model of the campus as their vision of how the actual school campus might evolve in five years’ time. The final artefact, a video of the virtual campus, was showcased during the school’s opening ceremony.

The researchers facilitated the process and based the design and principles of the learning space to articulate the key features of the maker culture. Underlying all of this was a commitment to reconceptualizing the emphasis on routine tasks and instructions that was typically present in a formal classroom setting. However, as the students and teachers were new to a non-traditional learning environment, the facilitators played a crucial role in trying to balance the ethos behind the maker culture and the expectations of the school.

The school was designed to unlock the hidden talents of low process learners, to help develop their potential in a persistent and sustained way, by consistently building on their successes over time. There is also a long-term objective of developing the holistic growth of the students. To address their social–emotional needs, there are personal and social learning, physical and aesthetics programmes that cater to helping students acquire the values and competencies needed to succeed in post-secondary education and eventually in employment and in life.

For more realistic learning situations, the school collaborates closely with industry partners to develop programmes and attachment opportunities, which are in industries that students can work in after graduation. The pedagogy adopted in the school emphasizes skills-based activities and practical learning in a real-world context or workplace setting. In order to facilitate its skills-based pedagogy and programmes, QH adopts a higher teacher-to-student ratio, with a class size of twenty students. This is in contrast to classroom sizes in Singapore, with typically forty students in each class.

Apart from their core subjects, students are exposed to vocational skills in four areas—facility services, mechanical servicing, retail services or hospitality services. The purpose of having these vocational modules serves to illustrate the relevance of academics to students and to help them pick up skills-based, practice-oriented training and as a basic foundation of technical skills applicable to their daily lives.

The school has garnered the support of partners and the community to design the classrooms after an actual supermarket and a local Do-It-Yourself 'DIY' retail chain, thus providing students with a more realistic learning environment. For instance, students will see how learning about percentages during math class is relevant to calculating discounts when attending to customers in a retail job.

2.5 Design of the Study

School leaders have witnessed the progress that students have made after being exposed to authentic learning environments and have highlighted how it is beneficial for students to see the relevance of what they are learning. They have noted that when there is a link to a situation that students are familiar with, learning becomes authentic and engagement levels will increase.

Making develops an alternative way of learning, one that contrasts with mere abstract analysis. It provides learners the opportunity with work with both the 'hand' and the 'head'. By engaging both the head and the mind is a way to engage students who have difficulty applying what they know to the world around them. These are the principles that undergird the intervention in Quest High, which will be described further in the subsequent sections.

The first stage of the project consisted of mapping and identifying the additions and development potentials the students could imagine in their school in five years. Following that the students devised a survey instrument and administered it using an online tool, to their peers from the rest of the school. They then used the results from the survey to shortlist a number of new improvements which they would like to see in the school. Thereafter, the students brainstormed and developed a range of ideas and suggestions for solutions to the identified problems that were raised and executed them in OpenSim. The whole context of the learning experience was centred on an ethos of 'making and doing', instead of a 'sit back and be told' school culture, in which students exercised self-efficacy by solving set challenges in a student-led environment (Claxton, 2008; Gaunlett, 2013).

In the study, it was designed for the students to exercise their own autonomy and not be dependent on the facilitators for help. However, the researchers understood that as the students and teachers were new to this pedagogical approach and that the students might not be able to adapt to it at the start, the initial two sessions would be slightly structured. The students were taught basic building concepts and specific operations, like how to create a design primitive ('prim'), how to clone it and how to apply mathematical translations to it. Then as the students got used to this approach, the facilitators would get them to start exploring on their own. The students were encouraged to start building what they wanted and the facilitator would be available to help and support them as needed. Some students needed more encouragement than others, but most students were eager to try out and start exploring on their own.

2.5.1 The Six Learnings Curriculum Design Framework

In most school activities, structure is valued over unplanned, free-structured learning. Creating a spontaneous learning environment that breaks a carefully planned structure is difficult as it requires a new teacher mindset that entails giving the students the autonomy to do things differently. When learners are allowed to experiment, to take risks and play with their own ideas, we give them the freedom to explore their own interests. They start to see themselves as capable of having good ideas and the ability to turn their ideas to reality.

The Singapore education system has evolved from a highly prescriptive to one that allows for an increasing degree of school autonomy in terms of resource management and pedagogical experimentations (Ng, 2010, 2013). Although these mitigating approaches have been introduced to promote a more holistic and student-centred curriculum, these reforms are still in their nascent stages, and generally, schools are still very much accountable to the pragmatics and economic considerations of the Ministry of Education (Lee et al., 2016).

At Quest, we had to think about how to support a student-centred learning environment while balancing it with meeting the deadline of completing the virtual campus. The curriculum design framework we adopted was the Six Learnings framework for the design of learning environments, which is particularly well suited to contexts of learning within games and immersive environments (Lim, 2009). Briefly, the Six Learnings are: Learning by Exploring, Learning by Collaborating, Learning by Being, Learning by Building, Learning by Championing, and Learning by Expressing. Together, they describe the six primary affordances for learning, of game-based worlds and immersive environments. For the purposes of the study reported in this chapter, the Learnings of particular relevance are Learning by Collaborating and Learning by Building. To quote Lim (2009):

> By 'Learning by collaborating' is meant the learning that results when students work in teams, either on problem-solving tasks or in other forms of structured inquiry. The focus here would be on helping the learners increase their metacognitive habits as well as their understanding of distributed cognition and the social dynamics of group work in general.

This learning draws on the rich body of established literature on the benefits of learning collaboratively, as opposed to learning competitively (e.g., Johnson & Johnson, 1994).

By 'Learning by building' is meant the learning that results from tasks that require the learners to build objects and / or script them. Such activities could potentially involve the demonstration of mathematical understandings of trigonometry and physics, the learners' sense of aesthetics, as well as their grasp of the logical algorithmic flows inherent in a scripting language. Departments in a school that might wish to focus on 'Learning by building' include the design and technology department and the mathematics department, as well as the computer Club.

2.5.2 Dan—Working in an Interest-Driven Space

A critical role of the facilitator would be to create a starting point for students who may be cautious in trying out something new for the first time. Some of the students had volunteered to join the programme, and some had been selected by the teachers, but all were new to 3D modelling and it was apparent at the start that most of the students were hesitant in trying out the various tools on their own as they were afraid, to a certain extent, of making mistakes. The main hurdle for them was not picking up the basic tools, and it was figuring out how to use these tools in the world to actually knowing what to build with them.

By observing how students worked, their personalities and characters, and by talking to them about their ideas, facilitators can identify what their ideas might be and then make suggestions based on these ideas. The facilitators tried not to intervene excessively, even when the students seem to be stuck at a problem, as jumping in too early might take authorship away from the student, which may result in the learner giving up prematurely.

The facilitation is intended to spark interest in the students. For instance, there was a student, Dan, who wanted to build a water fountain based on the logo of the school. At first, he created it using a simple plane and coloured it blue, but after some deliberation, he felt that a static body of water did not look authentic. The facilitators told Dan that he could look for scripts to create movement in the water. Dan was very excited at the prospect at creating a virtual representation of the fountain and readily did research on how he could achieve that effect. His enthusiasm and excitement in trying to create the fountain led him to create many iterations of the water fountain design, and eventually he managed to manipulate his original object further by adding sounds to it using scripts, making it more realistic.

Rather than providing step-by-step instructions on how to use the tools to build objects in the environment, facilitators can give feedback and make suggestions. If the student is still unable to build the object, facilitators will step in to draw the student's attention to a particular action. These are the facilitation moves that the facilitators would take to help them become unstuck and follow through with their creative process.

The facilitators observed that when the students reached an impasse, the situation served as a good learning opportunity for them as they learnt how to work through problems on their own. With persistence, some of them even saw how they could complexify their ideas. Take the example of Dan who first designed the water fountain as a static object. It took Dan several persistent cycles of de-bugging and iterations before he got to his final artefact, which was much more complex than his original design.

As students like Dan became more comfortable with new challenges by eagerly pursuing more complex designs, they become more engaged and spend more time on their own experimenting and investigating with confidence. With this added confidence in their own abilities, the students take ownership for their own learning and understanding. It is the personal accomplishment of breaking the impasse, plus having the final artefact that validates the students' confidence and self-esteem. Research has shown that a sense of validation is important for students and can serve as a means to help students gain a sense of belonging in the academic environment, especially those who do not perform well academically (Linares & Muñoz, 2011).

2.5.3 Adam—Being Driven by Interest and Becoming Motivated

Lepper and Cordova (1992) reported a series of studies that demonstrated how injecting fun in learning resulted in an increase in interest and learning. A vital dimension in nurturing the joy of learning is that students derive high levels of intrinsic motivation and learning efficacy when they are working in areas that they are most interested in.

To create as much possible ownership and at the same time the highest learning outcomes, it was critical for students to be included in all the stages of the design process, from conceptual to construction. The students were asked to decide, independently, which areas they would want to improve in their school. Initially, as the teachers were new to the project, they adopted a more task-oriented approach and were conservative in giving the students autonomy in building what they wanted. The students felt lost and pressured in meeting the tasks dictated by the teachers. It was only when they were able to freely express themselves that the students discovered their own capacities for creative and collective problem-solving. When given full autonomy to build objects in the virtual campus, the students started doing their own research, questioning and exploring and even learning coding on their own, without being prompted by the teachers.

For instance, a student, Adam was adamant on building a rock climbing wall in the sports complex, but found it challenging at first as he could not find an appropriate location for it. He had to figure out how the wall would look like and, more importantly, how he would integrate it into the existing infrastructure of the school, and then figure out how to build it using the OpenSim 3D modelling tools and scripting language. Because Adam had a personal interest in rock climbing, he was intrinsically motivated to build the wall and showed persistence in solving problems that he had encountered along the way. The teachers and researchers, without overly controlling the process, encouraged Adam to solve the problems he faced in the process, supporting his self-initiation and experimentation.

Here we see that these student's accounts support the research done by Vansteenkiste (2006) and colleagues that fostering intrinsic learning goals will lead to positive effects on student motivation learning, and achievement, as opposed to promoting the goals in a controlling manner. If students feel pressured or controlled in the learning process, or if the goal conditions are inflexible and narrow, learning is less likely to be enjoyable and purposeful and their persistence at the learning activities are likely to be forestalled.

In doing so, students cultivate competencies and skills that go beyond just routine cognitive tasks, such as the ability to critically seek and synthesize information, the ability to create and innovate and the ability to self-direct one's learning (Dede, 2010).

2.5.4 Tim—Sharing and Interacting as Part of the Making Process

A part of making also embraces the ability to share not only the object that has been created, but also the process of making. The editor-in-chief of *Make* magazine, the magazine which reportedly provided the catalyst to the maker movement, writes of how sharing leads to inspiring others in a 'virtuous circle' that happens when people document and share their projects with others (Frauenfelder, 2011). The projects that he has shared online has spurred others to work on their own projects, who, in turn, share their projects, which further inspires others.

From discussions with the facilitators, it was clear that the students were motivated by a large part, through sharing. When a student had discovered a new action, or a new way of creating an object, they would excitedly tell their classmates about it, inspiring the rest of them to start tinkering with their new-found discovery. Also, because the students were all designing simultaneously in the same OpenSim environment, they were able to see other's design in real time.

For instance, when one student, Tim, created a motorcycle in the environment, he felt that it was no fun if he was the only one with it. He urged the rest of his peers to create motorcycles too so that they could all join in the fun and share his excitement. Tim got his friends interested and shared with them how he created it, and as a result, he got his peers to learn a new action.

We made two observations from this incident: the value of having fun in learning and the importance of interaction between students. The amount of enjoyment a student derives from a self-discovery can be contagious, and this enjoyment is an intense experience in which students will devote enormous amounts of time, energy and commitment to.

The peer interactivity that was observed was a natural process that the students gravitated to gradually. The students would typically work in pairs, but started collaborating with one another through an exchange of ideas. Some students would also prefer to seek help from their peers, instead of approaching the facilitators. As the study was set in an informal learning environment, the students would walk over to each other's desks and engage one another actively and freely with feedback and ideas. There was a vibrant exchange as students started to articulate their ideas verbally by critiquing each other's work.

Critical in those interactions is in establishing a sense of shared goals, meanings and ideals. In fact, the facilitators revealed that peer critique was probably of more value than the teacher's critique because students could empathize more with each other's views and perspectives.

These observations are consistent with Vygotsky (1978), who argued that social interactions are essential for cognitive development and that the communication among peers is an effective way for individuals to attain skills and knowledge valued by a by a particular society, which in this case, the OpenSim environment.

2.5.5 Designing a Student-Centred Learning Environment

After a series of scaffolded learning activities to familiarize students with the building tools in the open-source environment, students were given opportunities to start exploring and figuring things out on their own. Some students relished working on their own more than others, and some students who were more passive would not ask for help even when they were faced with difficulties. Translating this idea required educators to know how much and when to dispense the smallest dose of instructions possible to ensure forward progress that which is purposeful without instruction.

In the words of Papert, the role of the teacher is to 'create the conditions for invention rather than provide ready-made knowledge' (Papert, 1993). Creating a learning environment that consciously breaks such a mindset is challenging, as the facilitators talk about the struggles of realizing this:

> Initially the teachers found it a struggle trying to grasp the concept of allowing the students decide what they want in the environment........they wanted everything to be prim and proper, so it's quite weird. If they want everything prim and proper, the classroom desk to look as realistic as the real life desk, these kind of standards were imposed on the students. So the students felt like there's no motivation to do what they wanted so they struggled a lot. They felt very suffocated so to an extent that hampered their progress initially. It was only when we were able to convince the teacher to let what the students wanted that they changed. Some of the students when they were able to design what they want, after a while when they get to improve on the designs.........Also they are more confident that they are able to come up with such detailed product so they don't mind doing [what the teachers wanted]. So it's a different approach. Initially they were pressured ....They feel compelled to do it so it's different, different form of motivation.

The teachers appreciated the opportunities afforded by the approach to gain insights into the design intuitions (Lim, 2015) which their students brought to the classroom. In order to do so, they had to take a step back and allow the students to involve themselves in the conception and elaboration of their own ideas. If the teachers were apprehensive about a design that the students had created, they would ask the students to articulate their thought processes and allowed time for more iterations and meaningful discussions. This helped the students in gaining confidence in their own abilities, especially in deciding what was worth keeping or what needed to be tweaked further. The teachers' approach became less task oriented; they kept an eye out for students who were off task, but allowed for those who were on task to work independently.

It was observed that because the students were involved in all the stages of the design process from idea to construction, there was a high level of student ownership generated. When a new teacher had been assigned to head the club, she engaged the students in questions about the tools and the software, getting the students to explain the tools functioned in the virtual campus, thus subverting the normal relationship that a student and teacher would normally have. As a result, the confidence levels of the students rose and showed more initiative and self-assurance in executing their ideas and designs.

2.6 Conclusion

The Singapore education system is highly regarded internationally and has been consistently among the top-ranking countries of international evaluation studies. However, while Singapore students produce consistently high results in such tests, government leaders recognize and acknowledge the apparent lack of thinking skills and creativity among students (Tan & Gopinathan, 2000). Efforts have been made to go beyond the focus on content knowledge to one that promotes active learners with a creative and critical thinking culture within schools.

There are basically three issues that can be considered in this remaking of the context of education in Singapore, namely

(1) State craft and street craft
(2) Minds on and hands on
(3) Planning and playing.

Singapore's main narrative since the days of independence has been that she is a city–state with few to no natural resources. Hence, the latitude for failure has been kept to a minimum for fear of detrimental consequences to the state and economy. The developmental rhetoric of the past four decades has been predicated upon good planning for the foreseeable future. To date, Singapore has been quite successful by these economic criteria.

Going forward, this same philosophy of governance may not be as relevant because the rate of change is exponential. While planning is useful and needful, over-planning without a deep embodied interaction with the ground or phenomena may well lead to plans that become obsolete before they are even executed.

Today's world and success in this ever-changing *milieu* require a disposition less for planning but more towards adapting to change and tapping on networks to both bring about change and influence change. Each national economy and education system is struggling to stay ahead of the change game. To reiterate, dispositions are not taught, rather they are cultivated in and through rich embodied experiences within social practices.

Hence, the implications for state craft and street craft need to be understood and managed carefully through ongoing conversations. By dint of her geopolitical context and her globalized economy, Singapore is particularly exposed to the vagaries of sociopolitical and economic forces external to the country; however, this does not mean that we are unable to create new contexts which can impact upon others as well.

Students and learners are the best people to ask as to what interests them and what they are passionate about; the thing is that they learn to suppress the time and effort invested in exploring these interests because the rhetoric from the state and societal groups is that these exploratory diversions are potentially a waste of time (they know it is not, but this is the rhetoric that they receive) because they represent inefficient expenses of time and resources, which could be better invested in more direct, outcome-driven behaviours. Tinkering and the playful experimentative disposition are not generally accorded with their due value in Singapore.

Thus, there is only so much that these creative spaces can be structured for (e.g. *Scape along Singapore's Orchard Road), because being given the room, the resources and the autonomy to spend significant time exploring one's (ostensibly non-curricular-relevant) interests requires a renegotiation of the implicit social contract between citizen and state.

Policy-makers need to understand that the value of these creative diversions lies not directly within the learning within the interest domain (e.g., skateboarding, knitting) but in the literacies and dispositions engendered by the socially networked embodied practice that participation in such interest domains involves. These literacies and dispositions can (and should) be mediated (through brokering) to be directed towards improved performance in more traditionally understood outcomes (e.g. academic grades).

The state-sponsored structuring should therefore manifest itself through the brokering and not in the setting aside of creative spaces per se. More can be done to harness the contributions of the specialized schools, to the wider system of education. These schools can come together in ways which enable them to be a significant influence towards play and imagination.

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Chapter 3
Scaling Community, Conditions, Culture and Carryovers Through Apprenticing and Ecological Leadership: The SCAEL Model

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Abstract The Singapore education system provides all schools with opportunities to innovate through educational interventions. Based on a review of research work in innovation diffusion in Singapore schools from 2013 to 2017, we have developed the SCAEL model- a context-sensitive translational and scaling framework that can translate theories to practices for sustained educational changes. SCAEL stands for 'scaling community, conditions, culture and carryovers through apprenticing and ecological leadership'. Apprenticing leadership and ecological leadership refer to leadership that facilitates professional learning and support at the peer-to-peer (apprenticing leadership) and vertical levels (ecological leadership). We use the SCAEL model to analyse recent Singapore-based education innovations that

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have attained substantive traction as well as recent reforms in the German education system. We also propose an iterative practical framework for school leaders for operationalising SCAEL.

3.1 Introduction

Change is a complex phenomenon, as any effort to scale change in an education system will demonstrate. The Singapore education system provides all schools with opportunities to innovate through educational interventions. Based on our review of research work conducted by the National Institute of Education (NIE), Singapore, in innovation diffusion in Singapore schools from 2013 to 2017, we have developed the SCAEL model. This SCAEL model is a context-sensitive translational and scaling framework that can translate theories to practices for sustained educational changes. SCAEL stands for scaling ‘community, conditions, culture and carryovers’ (four items collectively represented by “C”) through ‘apprenticing and ecological leadership’. Apprenticing leadership refers to leadership that facilitates peer-to-peer professional learning and support within each horizontal level of a hierarchical system. Ecological leadership refers to leadership that facilitates professional learning and supports across vertical hierarchical levels within a typical school or within a school system. Apprenticing and ecological leadership provides the necessary horizontal and vertical alignments, respectively, for professional learning and support in educational change (Toh et al., 2014).

SCAEL is essentially a translational and scaling pathway for sustained educational change. While the model’s four dimensions may appear to be intuitive for experienced school leaders and organisational change researchers, we believe that the model will provide an optimal translational and scaling pathway to sustained educational change through the dynamic adjustments of the four dimensions in line with apprenticing and ecological leadership.

The SCAEL model is salient for educational policy formulation and for school leaders to understand that the spreading or scaling of learning and pedagogical innovations is unlike other prescriptive efforts such as the proliferation of pharmaceutical drugs in medical studies (although we recognise that getting pharmaceutical drugs to market in today’s context is not easy). School leaders need to recognise the complexities of scaling and that artefacts do not travel by themselves. In fact, it is the capacity of teachers and other people involved that bring artefacts along to other contexts.

Medical science is well known to have developed effective translational pathways from basic science to the introduction of drug treatments in the market (University of Miami, n.d.). A typical translational pathway in medical science is shown in Fig. 3.1. In developing our SCAEL model, we hypothesised that the translational pathways used in the medical sciences would not apply wholesale to the education sphere. Medical science’s translational pathways adopt replication metaphors where the product at hand is the focus. However, we posited that the translation and scaling of social phenomena such as education are people-focused and dependent on

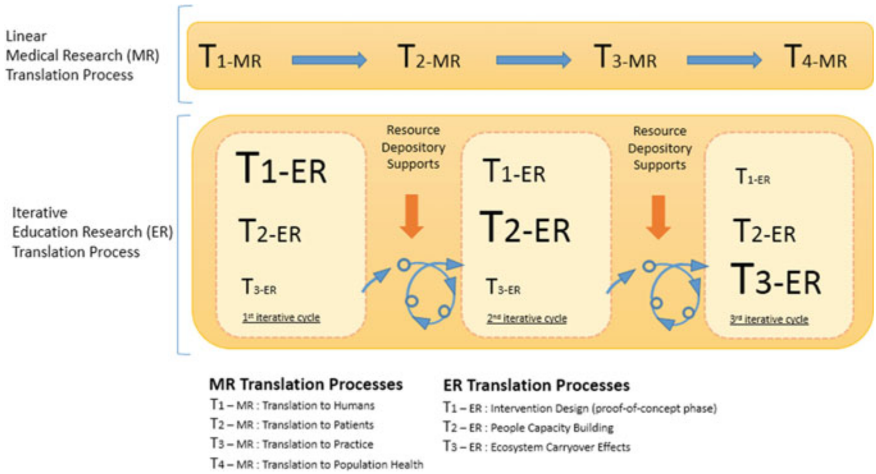

Fig. 3.1 Medical research translation process vs. education research translation process, University of Miami

the supporting structures, environment and carryover mechanisms needed to sustain them. Thus, the T1 to T3 phase of the educational translational pathway is not a linear exercise. It is a social phenomenon representing actual stakeholders who grow alongside the growth trajectory of the model. Medical science's linear translation frames create outcomes that are judged in relation to a "gold standard" previously benchmarked to an initial intervention (with fidelity in implementation). In educational change, we recognise that context does not stay constant when scaling occurs, and hence, the appropriate metaphor for the goal of educational change is a "sufficing" one (Hung et al., 2015b). Scaling diffusions of change in education are thus not straightforwardly about multiplying an innovation (hardware) per se; rather, it is more about building people capacity (software) for that innovation and adapting the cultural context (heartware) that surrounds it while leveraging the carryover effects (shareware).

3.2 SCAEL: An Ecological Approach

The SCAEL model is thus an iterative process of growth in people capacity alongside the multiple artefacts and products/resources that accompany an innovation and change process. The four items represented by "C" mentioned above and hereby referred to as the "4Cs" denote the following:

- C1 – community, or *software*
  Community reflects *collective* capability rather than *individual* capability required to sustain change.

- C2 – conditions, or *hardware*
  Conditions refer to structures provided to enable change.
- C3 – culture, or *heartware*
- C4 – carryovers, or *shareware*

It is important to note that the 4Cs are developmental and benchmarked relative to themselves in self/system improvement cycles. The iterative developmental process is denoted in the C4 process as carryovers in which sharing is key to improvement. This evolutionary and developmental process is the very essence of the SCAEL framework – a model of forward-moving improvement cycles. Still, it is worth noting that the 4Cs are not strictly distinct phenomena and there will usually be some ambiguous or overlapping boundaries. Therefore, it is not necessarily the case that change in one fundamental factor will simplify the change in other less fundamental factors. With ambiguous and overlapping boundaries, making fundamental and lasting change may require complex nonlinear pathways with multiple aims in relative tension. Figure 3.2 illustrates our thesis.

Educational change is complex, especially when situated in an education system that has to manage consistent academic excellence in schools while at the same time introducing new innovations for reform change. Our SCAEL model of scaling and diffusion looks at educational change from a systemic perspective. The SCAEL model is also consistent with social phenomena from an ecological perspective. In addition, the apprenticing and ecological leadership within the SCAEL model is also described.

From the research conducted by the Office of Education Research (OER) at NIE, we have observed that systemic change in our centralised–decentralised system involves three layers. We have named these layers the macro-, meso- and micro-layers of change as shown in Fig. 3.3. Each stakeholder has an important part to play, with the middle or meso-layer playing the most important role as they act as

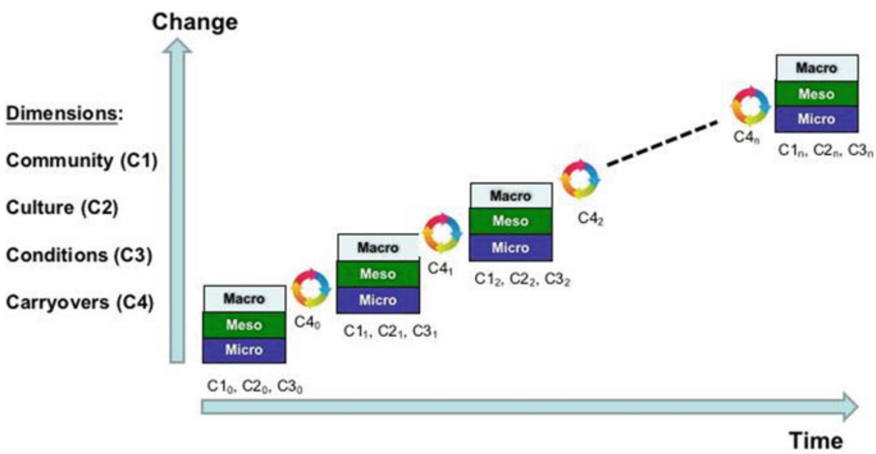

Fig. 3.2 SCAEL model

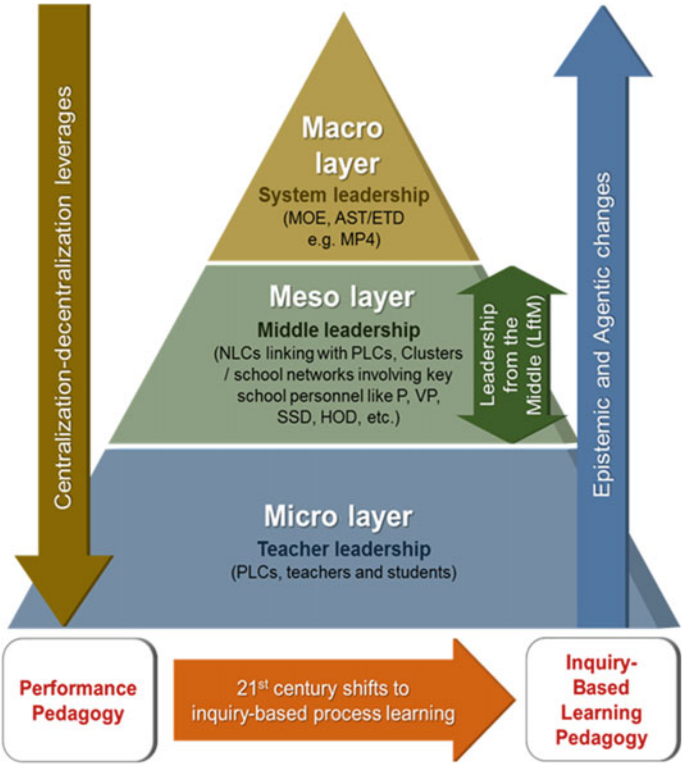

Fig. 3.3 Ecological system of coherence and alignment at the macro-, meso- and micro-layers as an integrated whole for the change process. *Source* Koh and Hung (2018a)

the interface between the two other levels, and also because they have opportunities to percolate innovations upwards and downwards in the system to help align policy, implementation and practice.

We will now address each level from the systemic perspective using the SCAEL model. Firstly, the macro-layer comprising the school leaders and education ministry (or the equivalent at the state or provincial level) is important because they are the stakeholders who have to buy into and lead the system with a vision and strategic goals. On the other hand, at the micro-layer, we have the school teachers who are at the heart of system change because not only are they directly involved with pedagogical practice and implementation, their pedagogical content knowledge, practice, capacity for lesson design and mindsets directly impact students on a day-to-day basis. They fulfil the system's everyday needs. The middle layer, also known as the meso-layer, comprises of social networks of teachers and groups of core school personnel who are able to lead from the middle due to their inbuilt capacity for their functions and their ability to leverage their network effects. This meso-layer mediates the attainment of strategic goals and the fulfilment of system needs and is thus the better lever for school and educational change. Not only does the middle layer lead from the middle, but it also cultivates a change in mindset from leading in the middle to leading from the middle.

Figure 3.4 describes the impact of ecological leadership and the upward and downward percolation of change in a centralised–decentralised system like Singapore's. Again, it is at the meso-cluster where ecological leadership is built through a process of apprenticeship. Through the various networked or professional learning communities, the collective and individual apprenticing of teachers are open to mediation by such structures. A teacher from the micro-layer, who has undergone a change in mindset and who is a champion for innovation, is called an "influencer" of social change in our model, and in Singapore's system (or any other system) he or she is sustained by support from the ecological carryover effects. In turn, he or she will

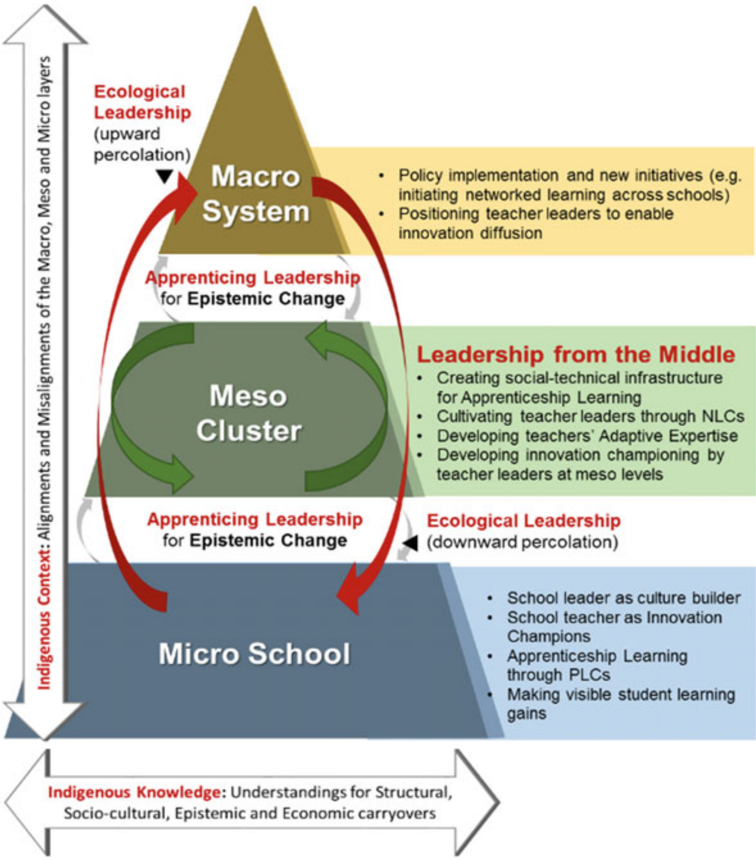

Fig. 3.4 Alignments needed as a system with ecological and apprenticing leadership. *Source* Koh and Hung (2018a)

facilitate the innovation culture in his or her school being **cross-enculturated** with other schools or educational systems.

3.2.1 Sustaining Change

The SCAEL model is a sustainable model as it involves adapting the model for the indigenous sociocultural context. In terms of "native" characterizations, this means that there must be recognition of variations in the functioning of education systems and that their historical, national and regional policy contexts will exert different degrees of influence on the institutions' work and therefore on the role of leaders in schools (Day & Sammons, 2013). We must also take heed of indigenous knowledge as local knowledge unique to a culture or society. This unique local knowledge also comes by other names such as "'people's knowledge', 'traditional wisdom' or 'traditional science'…." (Nakashima et al., 2000). Such socio-technological infrastructure in terms of carryovers enables sustainability. Figure 3.5 illustrates the tenets for sustainable change, which involve the three micro-, meso- and macro-layers (3 M) in an alignment consistent with ecological framing. At the meso-layer, we know that the teacher's epistemic change and hence change of mindset is key to the ecological leadership and apprenticing leadership that enables change to occur (Lee et al., 2016).

In an educational system like Singapore's, we are fortunate to be able to leverage ecosystem carryover effects in sustaining educational innovations that move towards achieving lifelong, life-wide, life-deep and life-wise learning in schools (Koh & Hung, 2018b). Ecosystem carryover effects are defined by Ron Adner (2012) as the process of leveraging successful elements from constructing one ecosystem in order to create advantages in constructing a new ecosystem. Such ecosystem carryover effects occur in self-renewing learning networks and include structural, economical, sociocultural and epistemic ecosystem effects (Toh et al., 2016).

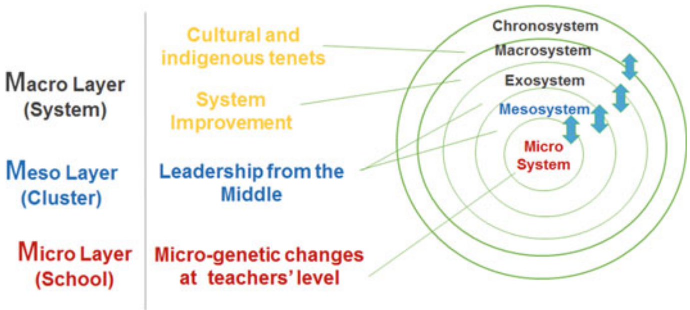

Fig. 3.5 3 M Layers: Tenets for sustainable change. *Source* Hung et al. (2016a)

The SCAEL model proposes a framework and methodology for implementation that is context-sensitive. Its key strategy is rapid prototyping and iterative design frameworks. Carryover effects are after all, designed through social processes. Learning in context leads to cultural change, and deriving positive observable outcomes such as students showing their level of engagement in exploring, explaining, elaborating and evaluating their own work in actual classroom enactments, enables cultural change within and across schools. Day and Simmons (2016) also states that school leaders play an important role in establishing the conditions, cultures and climate for professional learning and development in their schools.

3.2.2 Mitigating Tensions and Obstacles

The above observations about carryover effects also cohere with our work on apprenticing leadership or horizontal percolation within the meso-layer. Apprenticing leadership occurs through an apprenticing journey and phase shifts, namely from tolerance, to gradual acceptance, and culminating in willing acceptance. This change in phases requires the teacher to be very open to listening to their colleagues (Hung et al., 2015a). Teachers who are assigned to curricular innovations and merely tolerate going to NLCs to plan, dialogue, design and enact lessons must first be cognisant and come to accept the need for change in order to effect a change in mindset. From a starting point of deference to authority, apprenticing leaders must end up "taking joy in acceptance" (Koh & Hung, 2018a, 2018b, pp 158). Hung (1999) described apprenticeship as a journey of change in beliefs in contradiction to traditional references to skills and competencies.

Nevertheless, any plans to effect a change in mindset must be contextualised in the local conditions of a particular educational system. For example, while our research indicates that teachers' epistemic shifts are the highest point of leverage for sustainable epistemic change in the whole system, what stands in the way of such shifts are to be found in the local context. In Singapore, evidence shows that the biggest obstacles are fear of failure and inertia. Local teachers are afraid that their students might not be up to the challenge of learning under new pedagogies that are less dependent on the transmission of knowledge, and this makes it very difficult for them to let go of traditional teacher-centred pedagogies. However, if we demonstrate to them that the sky will not fall if they let go, they are more likely to show some willingness to try and get past their inertia. It is also important in changing teachers' "indigenous" beliefs and mindsets that we allow them the time and space to experiment with new pedagogies and to discover the links between the formal and informal curricula for themselves. Genuine epistemic change can only happen to open and willing minds, especially when they are discovering for themselves how to implement changes in their own context (Office of Education Research, n.d.).

Looking at the whole system as a holistic ecology of epistemic change, however, we observe that downward percolation, when leadership is not distributed throughout the system, is significantly higher compared to upward percolation. This points to the current importance of leadership in making epistemic change coherent throughout the system. Toh et al. (2014) state that "ecological leadership exhibits the characteristics of forging alignments and convergences in the different ecological layers, mitigating systemic paradoxes as well as local and cross-school tensions". Ecological leadership is needed to make meanings and understandings consistent across ecological layers and is looked to first to solve differing and competing understandings and interpretations that may arise among different schools or clusters and lead to contradictory practices.

This is especially pertinent in Singapore where power distance is traditionally a significant problem. Power distance, which describes both the way power is distributed unequally, as well as the way less powerful people accept this unequal distribution, is a particular problem in Singapore as it is in many Asian societies. Power generally decreases the further away one is from the source of power and in Singapore, we more readily accept hierarchical distributions of power than Western societies. This deference to power stands in the way of upward percolation of epistemic change. We conclude then, that leadership must also be distributed upwards for alignments for epistemic change to take place.

Michael Fullan's conception of "leadership from the middle", or LftM, fortunately helps provide a model of ecological leadership that is designed to overcome power distance and help align the macro- and micro-layers of the ecology through alignment in the middle or meso-layer. "… it implicates the whole system starting from the middle out, up and down. In addition to our system-use of the concept, LftM can and should be used within other levels. Schools, for example, are the middle if you use a within-district focus. Teachers, students and families are the middle when you think of intra-school and community work" (Fullan, 2015, p. 26).

If we look at Fig. 3.6, the LftM model therefore breaks the 3 M layers into a further three layers (3 m) each in order to find a middle to each 3 M layer that can anchor leadership within each 3 M layer. Taking the teachers from the school level, the school leaders from the cluster level and zone directors from the system level, this distributed form of leadership will anchor the tight interplay of the percolation of changes upwards and downwards within each 3 M layer, helping overcome power distance within each 3 M layer. This disruption of the hierarchy within each 3 M layer creates a fractal alignment of percolation that is reflected in the next scale up in the system, where school clusters in the meso-3 M layer can lead to epistemic change for the micro- and macro-3 M layers.

3.2.3 Patterns of Innovation Diffusion

Our thoughts about how change can occur naturally lead us to think about how exactly change is diffused through the system. That is, we looked at how efficiently change can be diffused from a single or limited starting point. In model A, shown in Fig. 3.7 below, a single innovative school can influence many other schools. So for example, if School A invents a new way to exploit experiential learning through ICT, this

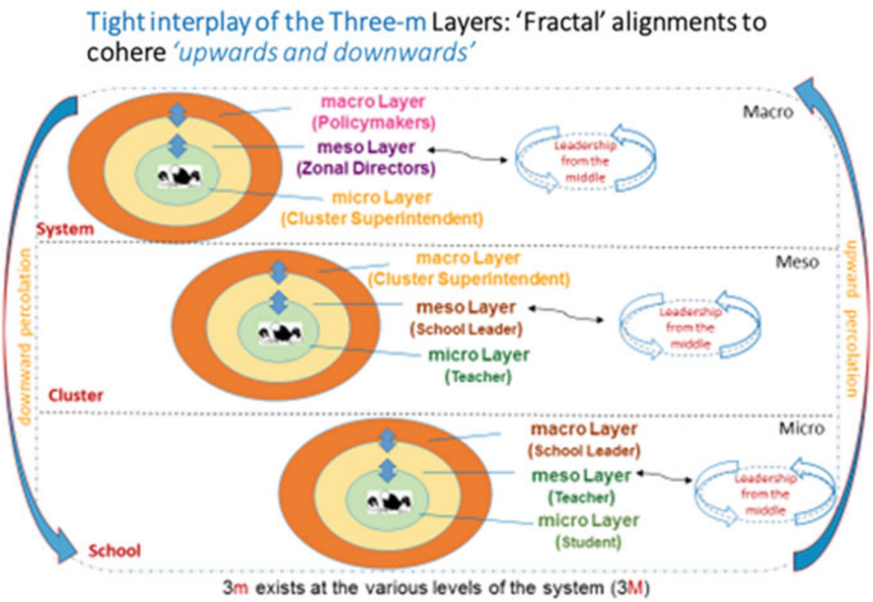

Fig. 3.6 Leadership from the middle. *Source* Hung et al. (2016b)

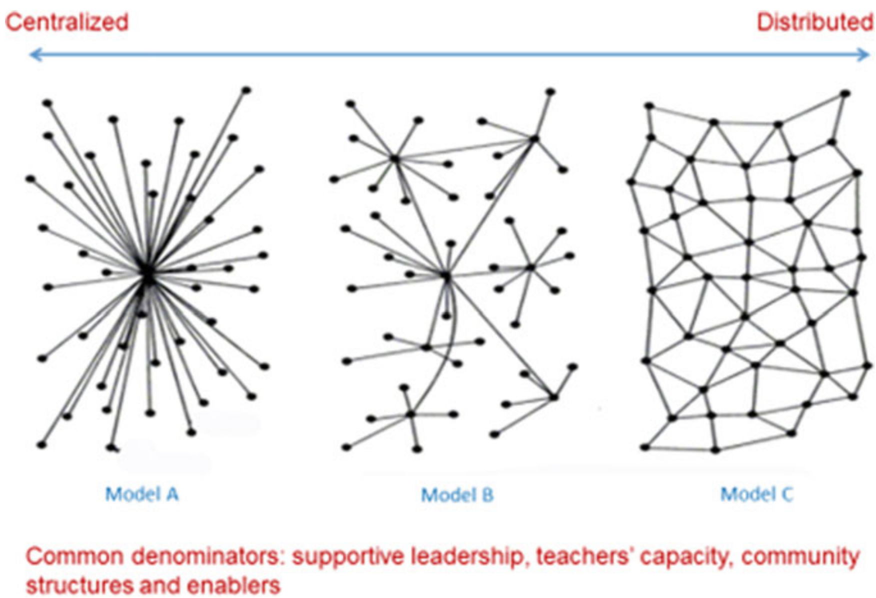

Fig. 3.7 Patterns of innovation diffusion. *Source* Hung et al. (2016a)

innovation may spread through direct formal and informal relationships with other schools. However, since model A depends on schools having direct relationships with the original innovating school, the larger the system, the less likely that all schools will have a direct relationship with any particular originator school.

In model B, innovations spread through satellite schools. In this model, innovations originate from a single school and spread to several others through direct relationships. Thereafter, this first tier of schools branches out and influences a second tier of schools that do not have a direct relationship with the original innovating school. This model is more efficient than model A because it does not have to depend on direct relationships with the original innovating school. The efficiency of this model is even clearer in large countries with multiple tiers of branching, where one can more clearly observe its viral pattern of diffusion.

Model C, however, represents the most efficient model of innovation diffusion. In this model, every school influences the closest schools with which it has direct relationships and in that way, as the system matures, every school becomes in a sense, a node or a satellite school. In addition, because every school is a nodal school, the network is represented by a net structure rather than the more familiar spoke wheel pattern. Model C is very difficult to achieve, no doubt, but in Singapore, we have seen some evidence that within one particular cluster of affiliated schools, the schools have developed multi-nodal network relationships with one another (Hung et al., 2016a).

In summary, the SCAEL model provides an iterative design framework and methodology to accompany stakeholder involvement with built-in scalability and sustainability. We have shown the framework and methodology to be grounded upon sensible and stable principles of educational change. The SCAEL model takes the diffusion of innovations' theory which was developed by earlier studies (by the SCAEL team) and conceptualises a translational pathway for implementation.

3.3 Study and Methodology

In this section, we use the SCAEL model to analyse established OER innovations and evaluate factors behind their performance in translating theory to educational change. These innovations are shortlisted from promising OER innovations over the last decade that have attained substantive traction in schools. From a pool of 14 innovations, three innovations were shortlisted as they possessed the following criteria:

(a) Sustained participation by schools
At least some schools which took part in the innovation continued, to some extent, to apply its pedagogy and concepts beyond the formal end of the research project.

(b) Proof of concept
Research has produced preliminary evidence for the efficacy of the innovation.

(c) Teacher base support

> A network of teachers, whether or not they participated in the research, has awareness of and actively supports the implementation of the innovation.

We employed a mixed methods approach in examining how the three innovations gained traction among practice and policy stakeholders. Interviews were conducted with principal investigators and research team members as well as participating teachers and school leaders. Transcripts of the interviews were analysed to identify salient themes.

3.4 Findings

3.4.1 Case Study 1—Productive Failure

Productive failure (PF) is a pedagogical learning design embodying constructivist principles that have been shown to be effective in Singapore mathematics classrooms (Kapur, 2008; Kapur & Bielaczyc, 2012). A strong proof of concept and practice findings have been established by the researchers' work with over 13 schools, 100 teachers and 6000 students from the primary to junior college levels.

Scaling efforts for PF were bolstered by ministry support. Several years into the research programme, the Ministry of Education (MOE) awarded a significant grant for the translation of PF design principles to the A-level Statistics curriculum. This enabled PF researchers to work closely with the MOE Curriculum Planning & Development division (CPDD) Mathematics Unit to develop the curriculum and build teacher capacity in the implementation of PF principles.

However, as of this writing, about a decade since the start of the PF research programme, relatively few junior colleges have implemented PF into their curriculum given the extent of ministry support. Viewed through the lens of the SCAEL model, PF benefitted from system leadership but was limited in its scaling by a weaker focus on networked learning communities (NLCs), which in turn hampered its impact on the ground. Without any NLCs playing a role in facilitating the collective and individual apprenticeship of teachers, the innovation did not gain enough teacher leaders to nurture a culture of PF implementation in schools.

3.4.2 Case Study 2—Knowledge Building

Knowledge building (KB) engages students in collaborative solution finding efforts for knowledge problems and in sharing in the responsibility for the success of the efforts (Scardamalia, 2002). Since 2001, researchers have integrated KB pedagogies across multiple schools in Singapore with tools such as the computer-supported Knowledge Forum collaborative platform.

This KB research has generated a proof of concept through iterative and collective efforts by members in the KB network (see scaling effort below), consolidating practice evidence across various subjects from the primary through high school levels.

KB scaling efforts are characterised by a decentralisation strategy anchored by active professional learning communities (PLCs) and NLCs that sustain design effort to bring about mindset change. These efforts are exemplified by one KB project that focused on sustaining KB environments through teachers' discourse and community building. Within each participating school's community, a senior teacher facilitates the continual deepening and sharing of knowledge-building practices as well as the sharing of students' artefacts. Members of a community are encouraged to try out the ideas discussed in their schools and classrooms as well as bring their own enactments and students' artefacts back to the community. These communities ensure that "[w]eek after week, the teachers continued to be inspired by their own students' ideas and work" (Tan et. al., 2014). Starting with one secondary school and two primary schools, the project has spread to other schools. An inter-school professional learning community has enabled teachers to exchange ideas within a larger community.

Viewed through the lens of the SCAEL model, KB scaling efforts have been successful at nurturing innovation champions who exhibit strong epistemic agency in leading the spread of the innovation and creating new knowledge about their practices. However, likely due to the lack of movement at the macro-layer (system leadership), KB scaling is relatively slow, with 15 schools implementing KB over a 10-year period.

3.4.3 Case Study 3—Seamless Learning

Seamless learning (SL) emphasises the bridging of learning efforts across diverse learning settings (i.e. formal and informal learning, individual and social learning, learning in physical and digital realms). As a learning notion, Seamless Learning leverages on 1:1 mobile technology (one-device-or-more-per-student) to enable cross-space learning 24 hours a day, 7 days per week.

NIE researchers Prof. Looi Chee Kit, Dr. Peter Seow and Dr. Wu Longkai first seeded Seamless Learning in a local primary school through the Inquiry-based Seamless Learning in Primary Science project (Looi et al., 2010, 2011). Under the leadership of the school principal and tapping on the school's capacity and appetite for innovation, the project diffused from the first classroom to other classrooms within the school. When another NIE Seamless Learning researcher Dr. Wong Lung Hsiang introduced two other intervention research projects: Move Idioms and MyCLOUD (Wong, 2012; Wong & Looi, 2010; Wong et al., 2012, 2015), Seamless Learning continued to diffuse from the Science curriculum to the Chinese Language curriculum. As of today, the NIE Seamless Learning suite of research projects continues to be adapted and integrated in schools from informal and formal networks.

3.5 Analysing the Case Studies

In Fig. 3.8, we map the three case studies according to their change model or trajectory of scaling through school-to-school networks.

PF is characterised by a strong proof of concept, whereas KB is grounded on teacher communities and SL on strong leadership support. School leadership enables sustainability by providing the socio-technical infrastructure, that is, the conditions that enable innovations to be diffused and sustained. From Fig. 3.8, SL and KB have carryover effects from the micro-teacher and meso-school levels, whereas PF has macro-system effects. SL and KB are amenable to pathways of translation to schools in deep ways, whereas PF, while enjoying macro-level support, requires sustained buy-in from the schools in which it is deployed. All three layers of the system are crucial. Innovations can spread from the macro-level (centralisation efforts), or from the micro-level (decentralisation efforts), but ultimately, all layers need to be in alignment for deep change to happen. However, not all innovations are meant for widespread implementation throughout the system.

In retrospect, the diffusion of innovations, supported by the triangulation of the three case studies and aggregated by all 14 OER interventions is best attributed to three key factors:

(a) Strong research/practice-based proof of concept
Research teams were based in schools and deeply involved in the implementation process, receiving just-in-time feedback to their research design, and tailoring and conducting professional development for teachers.

(b) Strong PLC and NLC cultures

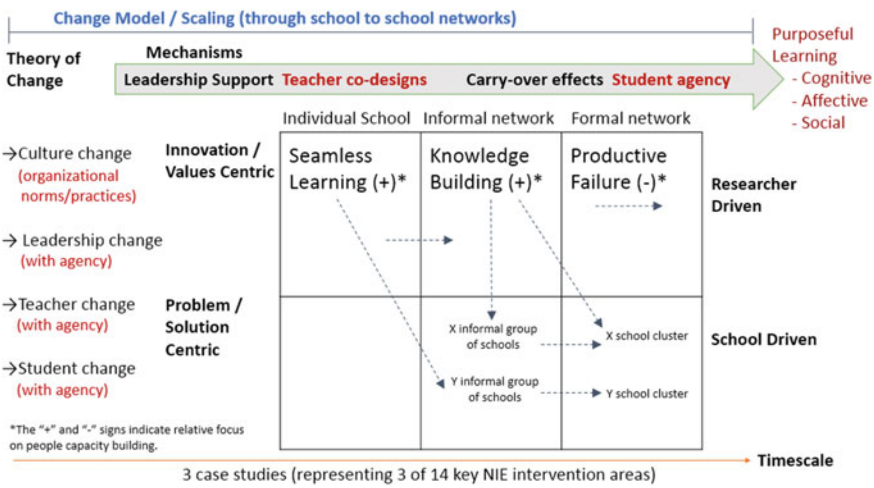

Fig. 3.8 Change model/scaling (through school-to-school networks)

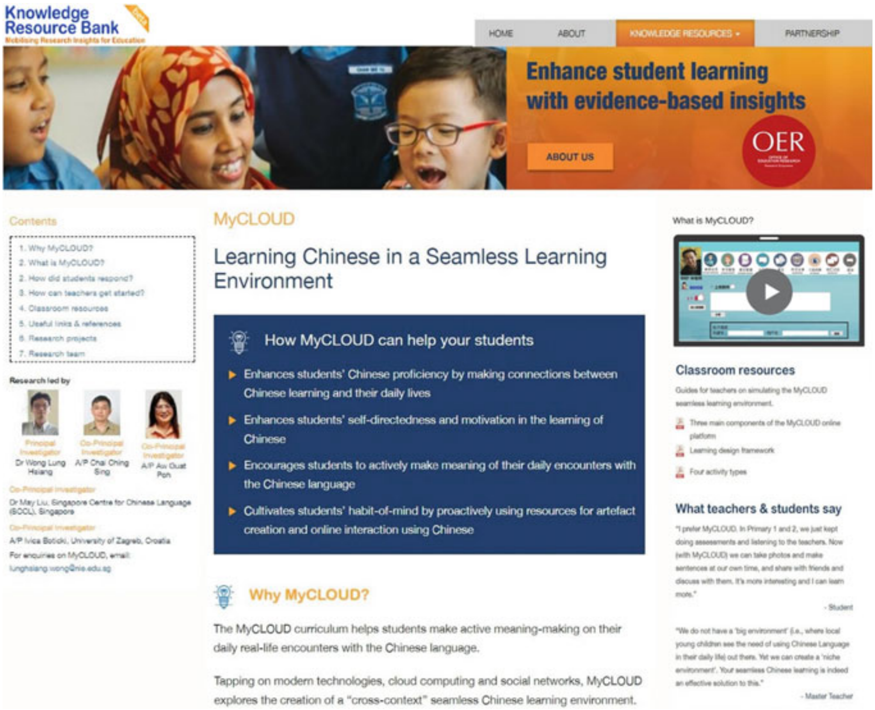

Fig. 3.9 Evidence-based classroom resources from the Seamless Learning project MyCLOUD.[1] *Source* Wong (2012), Wong and Looi (2010), Wong et al., (2012, 2015) on the OER Knowledge Resource Bank portal

[1] This study was funded by the Education Research Funding Programme, National Institute of Education, Nanyang Technological University, Singapore (project no.s OER 17/10 WLH and OER 61/12 WLH).

Teachers' learning and their epistemic change are the crux of any diffusion. PLCs and NLCs are supporting environments that enable teachers to engage in leadership from the middle. The earlier PLCs and NLCs are formed in support of an innovation, the higher the success rate for sustainability.

(c) Strong leadership for middle centralisation–decentralisation strategy through clusters of schools

Key to scaling/diffusion is the middle centralisation-decentralisation strategy that unfolds both at the micro-school and meso-cluster layers (see Figure 3.4: Alignments needed as a system with ecological and apprenticing leadership). Schools, whether through formal or informal networks with other schools, or led by formal superintendents or less formal cluster leadership, enable support for teachers to do ecological and apprenticing work.

3.5.1 Operationalising SCAEL

In operationalising SCAEL, we need an understanding of the monitoring and feedback mechanism supporting the model (see Fig. 3.2: The SCAEL model). To reiterate the tenets of SCAEL, we have earlier presented that the 4Cs occur at all 3 M (i.e. micro-, meso- and macro-layers) layers in the system, repeating themselves as we go up to the next layer. Research data can be collected at all 3 M layers with instrumentation from the baseline to the outcomes- from formative tracking of starting points to stipulated end-goals. Here, we would expect any changes in C4 to be evolutionary and developmental. Within every level of the 3 M layers, centralisation and decentralisation balances are to be monitored for a complete picture of education change at all 3 M layers.

Furthermore, the SCAEL model presents how apprenticing leadership (peer or horizontal level) and ecological leadership (hierarchical or vertical level) create and sustain the three necessary conditions of *community* (software), *conditions* (hardware), *culture* (heartware) while leveraging *carryover* effects (shareware) to bring about desired educational change. These concepts of and interactions among apprenticing leadership, ecological leadership, capability, culture and carryover effects have already been explained above. Moreover, these constructs should be present in the multiple layers of any system (macro-, meso- and micro-levels) for change to be enacted with the alignments and coherences needed.

In articulating an iterative methodology for applying the SCAEL model, we note the key strategic goals underlying the methodology are to (i) bring the sense of ownership by stakeholders into the change process from the onset, (ii) build personal capacity at all levels of the system, (iii) have a systemic strategy for implementation support using formative evidence and (iv) create an ecosystem which enables multiple localities to collaborate and cross-pollinate.

The main phases of the SCAEL methodology are defined below in broad sequence. Critically, the whole sequence should be iterated until the model is ecologically viable and the transfer of findings is accepted by the community.

1. Collecting a baseline understanding (i.e. conduct a needs analysis)
   Data should be collected on potential stakeholders and analysed to identify the highest leverage points of the system as well as its lowest capitalisation points.
2. Developing an initial hypothesis of the SCAEL strategy
   A testable hypothesis should be conceived for the SCAEL strategy.
3. Early partnership of researchers and stakeholders
   Partnerships between researchers and stakeholders should be forged from the onset of the SCAEL exercise in order to develop shared consensus and buy-in.
4. Developing a design model for initial implementation
   A rigorous design model should be developed that facilitates the generation of credible evidence for subsequent decision-making.
5. Implementing design with ecological carryovers
   The design model should be implemented in such a way that leverages successful elements from one ecosystem to another.

Table 3.1 Trajectory of a typical innovation diffusion through SCAEL

Year 1	Proof of concept	Experimental design	Main stakeholders—Teachers and students	Initial community C1 (usually within school with partners)
Year 2		DBR	Increased involvement with school leaders	Focus on Conditions C2
Year 3		DBIR	School leaders, KPs, and teacher champions/leaders	Focus on Culture C3
Year 4	Established resources for practice, e.g. toolkits	DBIR with large scale experimental design	Cluster of schools "sup" leaders, teachers, students	Focus on carryovers C4 with established mature community

6. Collecting evidence
   Evidence should be collected from initial implementations to support improvement to both theory and implementation.

Steps 1 to 6 are meant to be iterative. With an initial model of implementation, evidence is collected to support an initial hypothesis. The innovation is then iterated with the implemented design features and tested with further evidence for progressive acceptance until the community establishes stability and maturity with the model through shared ownership and consensual decision making. Table 3.1 shows a typical trajectory of an innovation.

DBR refers to Design-Based Research and DBIR to Design-Based Implementation Research. These methodologies are but examples of research methods which can be adopted. Through the course of the trajectory, research ownership is increasingly transferred to the schools and teachers, and the community.

Table 3.2 shows the implementation of research/practice through the SCAEL model.

3.5.2 *Community Building*

When the SCAEL model in a given context approaches ecological viability and leaders have built on their understanding of enablers and challenges, further measures should be taken to foster a community that will deepen and multiply translational pathways.

1. Formulate a theory of community growth engagement for the SCAEL model by first reaching out to the core team or influencers, and then fanning out to engage in subsequent outreach. See Fig. 3.7.

Table 3.2 Research–practice implementation details

Characterising construct	Research methods and concepts	Data sources	Outcomes
Community	Track through social network analysis	Social networks Interactions and dialogue	Teacher learning Partnership depth
Conditions	DBR and systematic treatment of conditions	School level Teacher level Student level Across school level	Conditions are refined and adapted in terms of organisational norms
Culture	Phenomenology and observations	School leaders and teachers with student feedback	Cultural change
Carryovers	DBIR and systematic treatment of carryovers	School leaders	Sharing and norms established
Apprenticing leadership	Epistemic change	PLCs and NLCs	Teacher champions and succession planning
Ecological leadership	Distributed leadership research designs for upward and downward percolations	NLCs of school leaders	Levels above and below are informed and alignments achieved

Leaders should formulate a theory setting out how stakeholders are to become engaged (or more engaged) in the SCAEL process. This theory can include:

(a) Key messages (of change process)
These are the core messages to be shared with stakeholder groups that communicate the process of educational change while facilitating mindsets conducive to fostering "innovation champions".
(b) Adaptive communication network map and channels
There should be a strategy for the communication channels and networks through which information about the innovation would flow.
(c) Enabling conditions and barriers/challenges
The theory should include enablers and inhibitors in the SCAEL process.

2. Develop evidence-based practical resources
To engage community and support implementation, practitioner resources that are evidence-based should be developed and made accessible. These can take the form of lesson plans, posters, handouts, assignments, etc.
3. Nurture a community equipped with organisational capability
A community with in-house organisational capability should be developed. This paves the way for subsequent community-building efforts and for more participants to join the community.

3.6 Discussion

The evolutionary nature of change we argue, is inherent to social systems that are natural to our human form of life. The SCAEL model merely makes explicit the change mechanisms and community growth dimensions which complex and nonlinear theories can more adequately explain. Singapore's education system can similarly be described through the C1 to C4 developmental trajectory as follows (see Table 3.3).

It was reasonable that in Singapore's post-independence survival phase, the focus was on hardware, such as the development of curricular resources and the building of schools. At present, we are significantly more focused on people capacity, cultures and the design-of-learning capacities of teachers. Such is the student-centred phase the education system is in currently. The nonlinear SCAEL model emphasises that all C1 to C4 variables have been in action since the advent of the education system, albeit to different degrees (see Fig. 3.1).

Nevertheless, illustrating case examples from Singapore and OER may not sufficiently validate the efficacy of the SCAEL model. The SCAEL model suggests creating an ecosystem which enables multiple localities to collaborate and cross-pollinate. This suggests that a physically larger system with a vast number of localities and provincial sub-systems will better illustrate our evolutionary thesis. Here below, we offer a brief overview of the German education system which has sought to decentralise itself over the past twenty years. We also include a description of

Table 3.3 Singapore's education system and its evolutionary trajectory with teacher capacity as key

Stage	4C emphasis	Research	Schools	Community
Survival	Hardware (C2) • Good curricular resources • School buildings • Centralisation			
Efficiency	Hardware (C2) Software (C1) at individual teacher	Baseline studies		
Ability	Hardware (C2) Software (C1) • Individual and community	Baseline and interventions	Partnership with individual schools	PLCs and NLCs
Student-centred	Hardware (C2) Software (C1) • Individual and community Heartware (C3) Shareware (C4)	Baseline, interventions and scaling	Partnerships between multiple agencies	PLCs, NLCs, and school-to-school networks with ecological partnerships

the German School Academy project which created the mechanisms for schools to systematically iterate their attempts at school improvements. We then show how this process of change in the German education system was made possible by the recognition that accompanying community-building exercises were in order.

3.6.1 The German School System: The German School Academy Project

The German school system offers a variety of different pathways for students based on their abilities and interests: from practical hands-on training at vocational schools to multidisciplinary research at top universities. The macro-level of the education system governing structure is represented by the minister of a federal state with a succession of subordinate institutions at the meso-level, and with the schools themselves functioning as the micro-level (Maurer, 2006).

School-based management has been implemented in nearly all federal states over the last 10 years in the form of autonomous schools with various levels of decision-making power and resource allocations from each state (Uljens, et al., 2017).

In 2000, Germany experienced a shock when the Organisation for Economic Co-operation and Development (OECD) revealed disappointing results for performance and equality in its schools. In the first Programme for International Student Assessment (PISA) report published in 2001, the country tested below average in mathematics, reading and science and was awarded the infamy of having the most unequal education performance among the 43 countries examined (Baumert et al., 2001).

However, about a decade later, Germany was one of just three countries that had improved in both mathematics performance and equity since 2003. One of the most significant changes in its complex and fragmented education system was structural reform of the secondary school system. The key reforms post-PISA 2003 were the standardisation of curricula and the introduction of nationwide tests (PISA, 2012).

The German School Academy is a nationwide independent organisation active in school improvement and professional development in Germany. Its German School Award, a system-wide school improvement programme, was launched by the Robert Bosch Foundation and the Heidehof Foundation in 2006 to highlight inspiring models of schooling.

The German School Award recognises the high-impact, professional standards of learning and teaching across all German states and various school types. More than 2,000 schools have participated, and there have been more than 65 award winners from primary schools and grammar schools to vocational colleges – all types of schools are represented (The German School Award, n.d.)

The German School Award has become a respected voice in education and has set off a nationwide movement of “more successful schools” as it draws attention to innovative policies, the role of principals and their influence on student learning in this reform process. Success stories of student learning as well as of high-quality teaching and leadership have spread from award schools to other aspiring schools.

Award-winning schools live up to quality standards by their sharing their leadership, dealing productively with heterogeneity and creating new structures for learning. School leadership teams lead in collaboration with partners: with other schools, with the community, with research institutions as well as private enterprises and cultural organisations. Evaluation and professional learning for self-reflection help shape the school pedagogic approach. The forms of leadership and routines of distance and engagement are critical input for successful goal-setting for continuous improvement. They have a clear vision of how they want to improve. The school leader ensures that achievement data is gathered and used for enhancing teachers and students learning processes. (Schratz et al., 2018).

In recent years, school leaders have benefitted from increasing autonomy and their use of instructional leadership approaches has risen above the OECD average according to school principals' reports in PISA 2012. Germany achieved above-average mathematics scores in PISA 2012, and its performance has improved significantly since 2000. Reading and science scores have also risen significantly above the OECD average since PISA results in both 2000 and 2003 (Klumpp et al., 2014).

We now examine the reform trajectory of the German school system with reference to the SCAEL model. The limitations of centralised school systems managed by different states reverberated across the country and reached a low point during the "PISA shock" of 2001. The inevitable reform in its education system originated from the community (C1). Looking at school improvement and professional development as conditions of the system (C2) opened up new perspectives at both regional and national levels. We see centralised changes in school curricula as well as the rise of a nationwide movement of successful schools helping influence a change in perspectives on what is possible to achieve (C3). The German School Award demonstrated that ground-up initiatives and the creation of innovative conditions for school improvement was possible in a benchmarked school-centred system without wholesale changes made to the pre-existing ecology (C4). The decentralisation of decision-making processes, shifting from federal state system to regional authorities and towards the organisational school level illustrates the importance of systemic improvement cycles from software to shareware in the 4Cs of the SCAEL ecological approach.

We posit that apart from the German system, the SCAEL model can also explain all other systems be they decentralised at the start or centralised. The 3 M layers apply and balances between centralisation and decentralisation are needed. We concur with recent propositions for leadership from the middle as a balanced approach to system change. The SCAEL model in other words operationalizes the leadership from the middle construct espoused by prominent change proponents in the field such as Fullan (2015), Hargreaves and Shirley (2012).

3.7 Conclusion—Leadership *from* the Middle *for* the Middle

The tenets of change as discussed above are effective from the middle of the system. The driving forces of change up and down the system can be mediated by the SCAEL model. The balance of centralisation and decentralisation forces can be reached through system monitoring and ultimately upskilling the capacity of those involved in the change process. In the German system, the German School Academy project worked from the middle. In the Singapore school system, the Ministry of Education enabled policies to build capacity among teachers and created middle structures such as the Academy of Singapore Teachers (AST) and the National Institute of Education (NIE) to be major leverages for teacher capacity building and community building.

However, many of the policies and frameworks are static in perspective and lacking in terms of evolutionary change processes. The SCAEL framework can work alongside the various policies that have been generated for the middle of the system.

The SCALE model is a process framework that provides a translational pathway from research to practice that cannot be forged without teachers. Research capacity cannot be divorced from people capacity. In education, research impact is based on the growing of communities around learning innovations. The SCAEL model explains why and how teachers' participation in PLCs and NLCs is inextricably linked to educational change.

Going forward, the SCAEL framework can be further operationalized for practical use by school leaders. Toolkits (e.g. instruments) and guidebooks can be developed for leadership from the middle. In order for SCAEL to be practical for school leaders, we need to establish the before and after conditions of interventions utilising the 4Cs—the community, conditions, culture and carryover structures that determine the successful strategies used by leaders across both the horizontal and vertical levels to achieve their desired educational change. For each condition, we need to identify the enablers who enhance the necessary conditions for educational change and the inhibitors who impede or prevent the necessary conditions for educational change. To help school leaders apply the model, we need to develop a methodology, toolkits and strategies for enacting educational change and develop professional learning programmes to help support school leaders in their application of the model.

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Chapter 4
Learning Initiatives for the Future of Education (LIFE): 'It Takes a Village' to Enable Research-Practice Nexus

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Abstract The Learning Initiatives for the Future of Education (LIFE) are outlined in this chapter with an introduction to the historical developments of education research at NIE. LIFE's aims and goals are to support NIE's vision as a future-ready institution up to 2025 underpinned by cultivating and being the custodian of enduring values even in a challenging milieu of change. Foregrounded by the 4 lives framework, this chapter explicates the 'It takes a Village' project, funded by the Temasek Foundation, and delves into how the project paves the way into enabling research-practice nexus (RPP). We discuss the potentials in the science of learning, artificial intelligence, data analytics, and similar trends in the light of the foundations of values, content knowledge and twenty-first-century learning. The NIE aims to be 'Inspiring Learning, Transforming Teaching, Advancing Research' (NIE (2020). 2020 *NIE strategic vision.* https://www.nie.edu.sg/docs/default-source/spaq/nie-2022_6pp_softcopy-final-editsp2020.pdf?sfvrsn=cbb06543_2). The above constructs are illustrated through a project referred to as 'It Takes a Village.' While this project is only at its first phase, we discuss how its next steps can be incorporating the concepts advocated by LIFE.

4.1 Introduction

This chapter describes and discusses on the Learning Initiatives for the Future of Education (LIFE). The chapter begins by making sense of the past and present efforts

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which have brought the National Institute of Education (NIE) to its current position. The NIE is recognized by the QS rankings to be one of the foremost teacher education institutions in the world (QS Rankings, 2018). Since its establishment in 1991 as part of the Nanyang Technological University (NTU), the NIE has always been grounded on values. Cultivating character with attributes such as integrity and caring-ness for the learner/student has always been evergreen principles even amidst current milieus and global change. The chapter also traces the advent of systematic education research in Singapore since 2003 with the establishment of the Center for Research in Pedagogy and Practice (CRPP) (with 48 million dollars of funding over 5 years) to its present funding provisions of 100 million on the average over five years. Since CRPP, there is also the establishment of the Center for Research in Child Development (or CRCD, with an initial 20 million funding over five years) more recently with a focus on kindergartens and early primary years. CRPP and CRCD together cover the K-12 sector of learning, including the teacher education research across the pre-school and typical schooling range. The Education Minister noted that: '… raising pre-school quality; allowing more movement between streams; cutting non-essential curriculum; targeting help at students from lower-income families; expanding after-school care; diversifying schools; and broadening the definition of success' (Ong, 2019).

The aim of this chapter is to retrospectively consider the past and present LIFE's initiatives and make postulations into the future up to 2025 in support of NIE's vision of being a future-ready institution. In the later sections of this chapter, we discuss on the potentials in the Science of Learning (SoL), Artificial Intelligence (AI), data analytics, and similar trends in the light of the foundations of values, content knowledge, and twenty-first-century learning. The NIE aims to be 'Inspiring Learning, Transforming Teaching, Advancing Research' (NIE, 2020). The above constructs are illustrated through a project referred to as 'It Takes a Village', funded by the Temasek Foundation. While this project is only at its first phase, we discuss how its next steps can be incorporating the concepts advocated by LIFE.

4.1.1 Background of the NIE

The NIE is the one and only Ministry of Education (MOE) recognized institute in Singapore for teacher education and teacher accreditation. It plays a national custodian role in the preservation of positive values, as well as framing perspectives for Singapore education. A key catalyst for enhancing the overall capability and quality of teachers and educators in Singapore in terms of pre-service, in-service, leadership development and research, its continued aspiration is to help build a future-ready teaching workforce for Singapore. Toward this aim, the NIE inspires and supports lifelong learning by inculcating a joy of learning in our students and preparing teachers and educators to manage future learning environments through continuous professional development and education research.

The NIE is an autonomous institute of the NTU. NIE leverages on the deep multilateral partnerships with NTU, local schools and the Singapore Ministry of Education (MOE) to provide evidence-informed, practice-focused and values-based programmes and initiatives for teaching professionals and school leaders. The close partnership among NIE, MOE and the Singapore schools forms the cornerstone of Singapore's top-performing education system. As a thought leader in education and education-related disciplines located in Singapore, NIE is also well placed to build and take advantage of east–west collaborations among reputable institutions in the US, Europe and the Asia Pacific regions. NIE's degrees, higher degree and professional development programmes offer global perspectives through international practicum, semester exchanges and a multidisciplinary curricula, while twenty-first-century pedagogies and service learning initiatives aid holistic teacher development.

Before we attempt to discuss the past and how it informs us into the present and future, it is necessary to articulate some future-ready demands, challenges and possibilities from which we take the reference point in designing for the kinds of education we need, including teacher education.

4.1.2 Learning Initiatives for the Future of Education (LIFE)

It is not a stretch of our imagination to recognize that the world in which our children are going into is quite different from the one we have inherited. The explosion in information, the interconnected of global economies, the surge of social media platforms, the rise of machines and robotics, the ease of communications across continents, the volatility of markets and the like are quite mainstream in recent times. The kinds of skills and dispositions needed to navigate these environments, virtual and in physical spaces, become increasingly complex. Boundaries are blurring, and disruptions into sacred spaces and time are also almost inevitable. Stress is increasingly prevalent and obesity in developed countries is on the rise. Poverty remains real in some undeveloped third world countries, and income disparity looms increasingly large. Gig economies are creating new jobs, yet also causing disruptions to traditions which are not well understood to date. Violence and terrorism remain rampant and inequalities an ever-constant phenomena. Ambiguity amidst change also remains here to stay. With recent events such as COVID-19, we realized that the first world countries cannot ignore the plight of under developed third world countries and their healthcare systems as viruses know no borders and the interconnectedness of the world is brought into sharp focus. Such are the complexities of the future world of our children.

With such a challenging milieu for our children, teachers have a severe responsibility alongside parents. Foremost, to reiterate, NIE believes that inculcating values is even more important than ever in helping children to navigate through these complexities. We have all witnessed highly capable individuals succumbing to sexual vices, situations of greed and improper gains and capitalizing on situations where the lines between ethical and not-so-ethical grounds are vague. The challenge for teachers in Singapore is to impart these sound values and character despite having to teach the subject-content necessary to prepare them for examinations, the workplace and life. Critics are increasingly questioning the need to master that much content as stipulated in the syllabus, or whether higher order thinking and criticalities can be the focus through the means of the content.

The Office of Education Research (OER) conceptualized a 4 lives framework that aims to address the challenges described above. See Fig. 4.1.

Values is emphasized in the Life-Wise aspect in conjunction with Life-Long, Life-Deep and Life-Wide learning. Life-Wise also connotes ethical, emphatic wisdom. Life-Wide learning suggests the need for trans-boundary crossings as problems become much more complex, e.g., climate change. Life-Long learning is elaborated in many recent calls as life-span increases, and retirement age gets to be pushed back later as post-career learning is gaining currency. Life-Deep learning has been the traditional space of schooling where content deep specialisations are encouraged. The issue for us at the NIE is to balance these 4 aspects of learning and to calibrate the need according to different learners and their learning needs. The Singapore

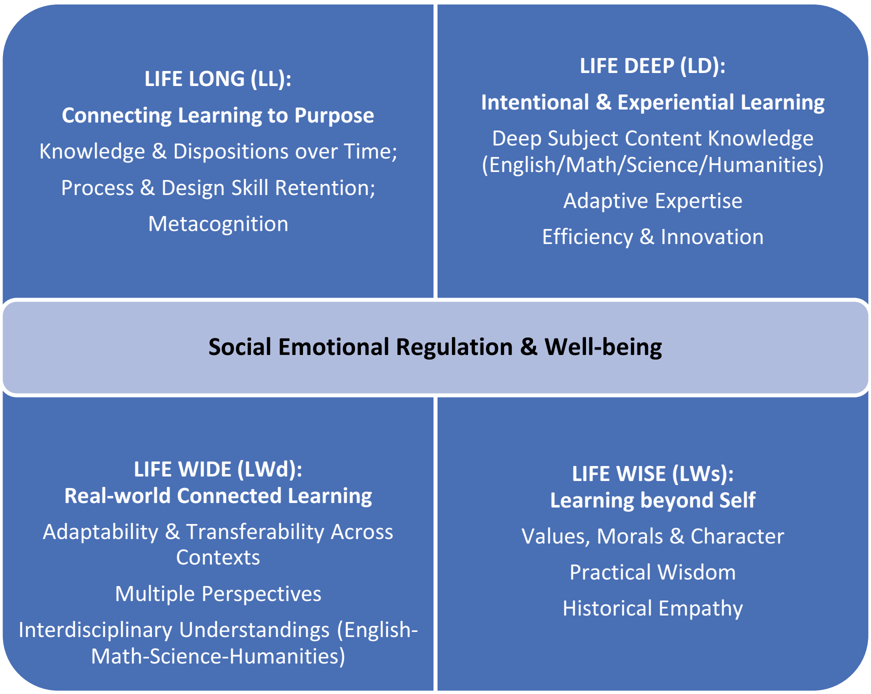

Fig. 4.1 The 4-lives framework developed by the Office of Education Research. *Source* Koh et al. (2018)

Education Minister noted that 'only a passion-driven learning process will be self-directed, lifelong and resilient to disruption because the young person is motivated to learn, unlearn and relearn continuously. In this system, the goal post has shifted from teaching a student enough so that they can graduate, to helping students learning to learn so that they actually never really graduate' (Ong, 2018a). 'The education system must strike a pragmatic balance between opposite yet related perspectives—between [for example] individual aspirations and social needs. We can balance and synergize the opposing tensions' (Ong, 2018a). In other words, the Singapore education system is presently at the crossroads of change and transformation, preparing students for that which is aspirational for both society and the individual. '… [M]astery, passion, guidance, and a multifaceted education experience' (Ong, 2018b) is desirable going forward.

Summarizing the 4-lives learning framework along the desired outcomes for learners, our aspiration for teacher competencies to enable such attainment can be conceptualised as follows. See Fig. 4.2.

In order to prepare teachers for a school system that is progressive yet rooted in strong values, we extend the typical dimensions of values, skills and knowledge to include wisdom. The specific details of Fig. 4.2 would be elaborated in the later sections of this chapter. Based on the above WVSK model, teachers need:

- To develop a *repertoire of skills* that can appropriate pedagogical toolkits for differentiated instruction (at different stages of learners' development);
- To be *sensitive to learners* needs and to care for their well-being;
- To have the *continuous learning dispositions* and competencies to embrace new methods and sciences of learning and to be literate on advances in technologies such as AI in order to appropriate these understandings to different learners;

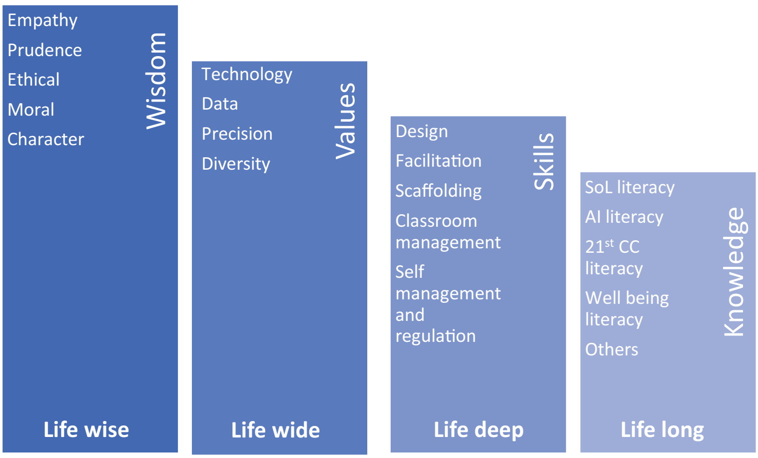

Fig. 4.2 Wisdom, values, skills and knowledge (WVSK) for teacher competencies

- To instill in their learners/students the same lifelong learning dispositions and competencies which they themselves possess and *role-model*; and
- To work with other stakeholders, e.g., parents and other education providers with a focus on the individual child or learner with a view to the learner's well-being and continuous improvement.

The new literacies which teachers need to embrace are Science of Learning (SoL) in education, AI in education, new forms of assessment, differentiated instruction, data analytics and sensitivity to special needs where appropriate (Table 4.1).

Now that we have articulated aforehand the broad strokes of what is needed in LIFE, we take a step back and ground LIFE with the assumptions of learning or how learning occurs, and comparably how instruction should occur with respect to learning.

4.1.3 How Learning Occurs

Learning is the *interaction* between the individual and the environment (Cullingford, 2010) that, or all of the above in a continual-historical process that can be positively or negatively oriented. Negative experiences refer to when the interaction leads to a non-positive process outcome, where the learner concludes with an interpretation of that learning experience negatively. However, positive or negative is relative against a body of established knowledge or normative experiences as reified (Fig. 4.3).

A teacher's role is thus to enable the interaction, albeit in a high-quality fashion, between the learner/individual and the environment (which could be other individuals, content, resources, or just phenomena). The quality of classroom processes such as the interactions between teachers and students has been linked to positive student developmental outcomes (Abry et al., 2013). Thus, a teacher's role is to design for the interaction to achieve the highest quality of thinking, acting and deciding on the part of the learner.

Genes or heredity considerations account for 50% of the learning equation, which up to more recent times cannot be tweaked, and environment accounts for largely the other 50%. We are hypothesizing that the interaction can potentially influence and change both the individual and the environment, making all three aspects of individual, environment and interaction dynamic. As such, every individual is unique with its own identity and there are no identical individuals, including non-identical twins. With the biological genes constant, the interaction with the environment is not identical and hence resulting in similar but identical constitutions (Larsen et al., 2019).

Table 4.1 4-Lives and the new learning initiatives (i.e., LIFE) needed for teachers

	SoLE	AIE—Big data	Assessment	Differentiated Inst	AIE—ITS/Apps	Special needs
Life-Long	Learning to learn	Patterns and profile of learners	Formative and process evaluations	Pacing learning for different learners	ITS, etc	Universal design
Life-Wide	Adaptabilities, structural learning	Trans context sensitive information	Transfer potential	Pedagogies/ designs for adaptivity across contexts	MOOCs and equivalent	Situated learning
Life-Deep	Engagement, motivation and interest		Representational forms of deep dives	Pedagogies and scaffolds within context	ITS, learning companion, etc	
Life-Wise	Perseverance	Ethics of AI and data privacy	Wisdom recognized	Teachable moments		Design thinking

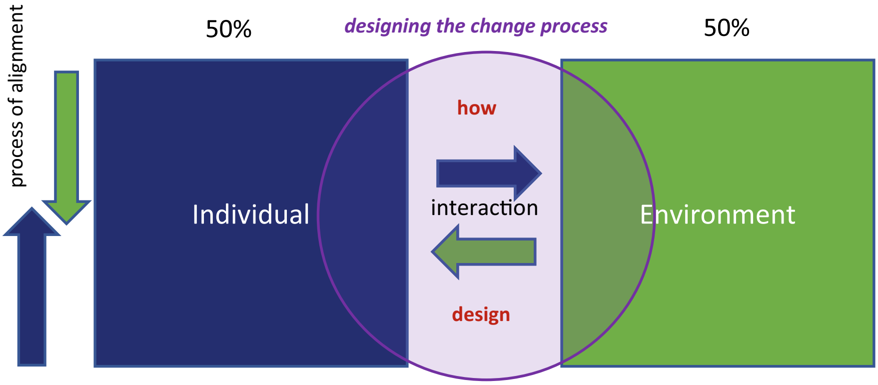

Fig. 4.3 Individual-and-environment dialectics

4.1.4 Overcoming Challenges or Disadvantages Through Learning and Instruction

There are three kinds of disadvantages. The first arise from individual factors, e.g., genetic makeups that are hereditary. Another is environmental that has implications to the individual. For example, arising from low SES, infants are malnourished, and this in turn influences the individual resulting in poor attention, memory, etc. Poor or low quality environments include distracting or distrusting conditions leading to low quality interactions between the individual and the environment. Including other individuals into the 'environment,' the interaction could lead to a low trust culture in organizations, for instance. A third disadvantage is when there is low scaffolding in the interaction between learner and the learning environment. Especially before learners are able to regulate themselves with the agency to decide on how to manage the 'interaction,' teachers and parents play an important role in enabling the child or learner to interact with its object in a dynamical and instructive fashion. Learning to learn or learning to manage that interaction for oneself is typically referred to as metacognition. Higher ability students are more attuned to metacognitive enactments.

Science of learning techniques is able to capture individual factors such as working memory and related cognitive aspects, self-regulatory dimensions and other well-being propensities. To date, there are no established boosting 'pills' or medication widely practiced in mainstream education to increase individual capacities for learning. We are not suggesting that this silver bullet approach is to be encouraged.

There are training applications such as working memory games but these act similar to muscle exercising but have little transfer effects to meaning making or conceptualization efforts with domain specific situations. The environment, on the other hand, lends itself to the policymaking realm where good policies can mitigate social environmental conditions. Good schools and the environments they afford is an example of resources being pumped into schools to enable a better and more conducive learning milieu. Good school environment has much to do with school leadership, enabling teachers to do their pivotal roles of supporting and designing for high-quality interactions.

If learning is largely defined around the interaction between the individual and the environment, a teacher can assume to place constant the two factors, i.e., working on the interaction affordances despite the kind of learner or the environmental constraints or otherwise. Good learning can occur as a function of the interaction, and not the function of either the learner or the environment. The interaction speaks to the coupling relationship between the learner-and-environment. An analogy is the user-interface present in most smart phones. The user-interface is designed in a way that affords fluent and intuitive between the user and the applications used. Decades ago, the operating systems were without an object-oriented drag and drop interface more akin to daily actions and enactments, and a larger general population could not have easy access to computers. Today, the '-and-' is made fluent for most mainstream users. Similarly if teachers had the skills-set to adapt and make fluent learning for all kinds of learners, with the knowledge afforded by science of learning, AI and other literacies to aid them as better designers and careers of learning and well-being respectively, education would make significant leaps in the right direction.

4.2 Grand Hope

With the establishments of CRCD and CRPP, NIE hopes to be able to understand the risks and opportunities of different learners in their developmental trajectories through K-12 schooling and mitigate risks early and prevent the stacking of these risks (see Fig. 4.4).

A functioning workable model for LIFE would have to include:

- *Policy mechanisms* for bridging the gap for the three disadvantages;
  - Provisions that can level up the 'socially' disadvantaged, e.g., MOE kindergartens; bilingual programmes and societal levers; assessment norms that foster diversity of talents; etc.;
- *Socio-technical mechanisms* for enabling quality 'interactions';
  - Time and space opportunities; quality professional and integrated services for learning needs and difficulties; other design affordances at classroom, school, after school and community levels;
  - Data analytics and AI affordances that make visible aggregated data of interactional patterns;
- *Teaching and Learning mechanisms* that level up learning process and learning outcomes;
  - Evidenced-based designs that are situated and scalable; technologically enabled interventions for pre-academic and academic functions;

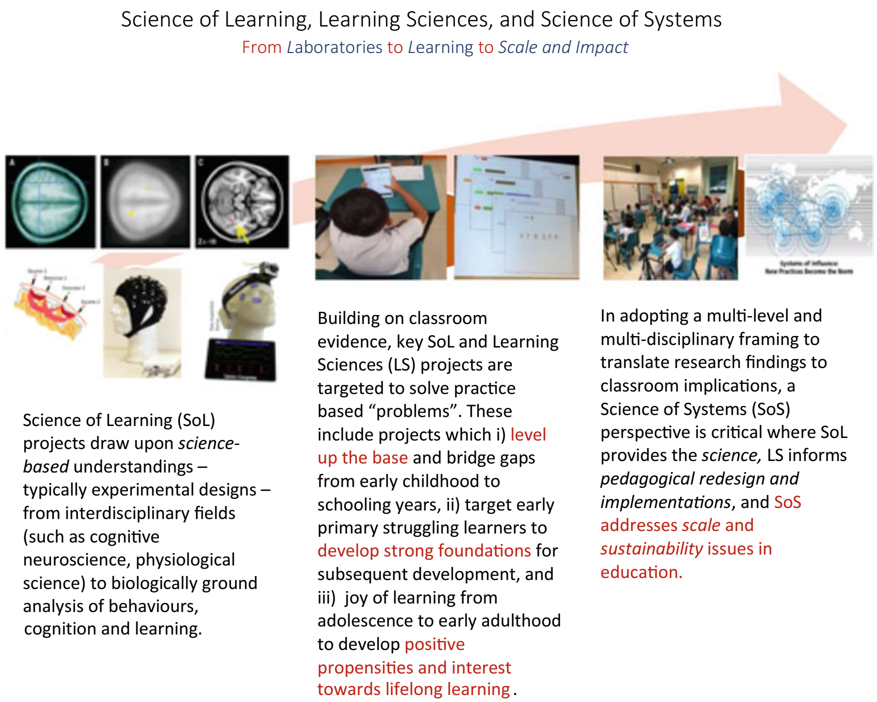

Fig. 4.4 Integrated approach to understand learners and learning developmentally

– Assessment for learning affordances and designs that enable differentiated learning and instruction;
– Data and learning analytics with ITS to enable learning for diverse learners.

From CRPP’s past research, we have understood how learning interventions occur and sustain in schools among teachers. We refer to this as the science of systems (SoS). School leadership plays a critical role in enabling cultures and organizational norms to be changed and sustained in order to sustain desired instructional practices. The learning sciences (LS) refer to the design-based experiments conducted in the last decade on all subjects with implementation traction in classrooms across schools in Singapore. Here, teacher capacities and epistemic change occurs, when they do. The recent emphasis in science of learning (SoL) enables us to venture into learner situations and profiles which observable techniques such as classroom operations do not enable us to yet understand why a learning episode arises the way it does. Hence, ‘below the surface’ methods such as neuro-imaging and other physiological approaches might aid us in unpacking the phenomena. Figure 4.4 depicts these three approaches. We need a concerted and integrated understanding of SoL, LS and SoS.

4.3 The 'It Takes a Village' Project—Findings

It would take the space of a whole book in order to describe all the learning interventions undertaken in the last decade. In gist, the learning sciences interventions expanded learning to outside classrooms (also known as informal learning) with clear linkages back to the subject curricular at hand; delving into learners' intuitive understandings through experiential and embodied ways of learning, including notions of near and far transfer; learning analytics in support of learning progressions with implications to formative and summative assessments, including forms of student collaboration and creativity; and constructing and building knowledge individually and collectively with school structures to sustain these practices among varying learners, including academically more challenged students (at least from the yardstick of summative examinations). Thus instead of describing the multiple classroom and school interventions, we discuss a project which works with academically lower achieving students in a typical secondary school (from which the findings should be generalizable to typical heartland schools in Singapore). The project takes a holistic 'village' metaphor where research-practice partnerships between the school science teachers, teacher education researchers from the NIE, the (National) science center practitioners, and also well-being counselors from the community. The journey of participation among the various stakeholders was far from straightforward as each party forged their own goals before converging on common understandings, language, trust and seeing the student as the center of common concern. Most importantly, in developing this partnership, we seek to acknowledge and respect each other's expertise and knowledge, contributing equally and collaboratively, to influence the services provided for targeted students by taking into account the demographics and contextual factors of the schools. Therefore ideally, this working relationship could work toward a longer term for the purpose of scaling and sustaining educational innovations, to benefit the wider community of the education sector. Figure 4.5 depicts the partnership and the various roles performed.

The school's teachers led in the design and implementation of tinkering activities as advised by the science center with alignments to school syllabus. We were guided by a set of principles for designing tinkering activities shown in Fig. 4.6. Students can start off their projects easily and quickly, have multiple pathways that they can explore and choose to follow through and decide on the varying levels of complexity they want to achieve for the end product of learning. They collaborate and learn with their peers by constructing artifacts. Students provide social scaffolding in learning new ideas in the process. Through cycles of experimenting, failing and doing, they learn iteratively.

Based on these principles, the Tinkering Science Activities included the construction of artifacts:

- Marble Machine (properties of material, friction, forces and energy);
- Light maze (properties of light, interaction of materials with light);
- Digital wearable (circuits and electricity);
- Coolest Building (heat and energy).

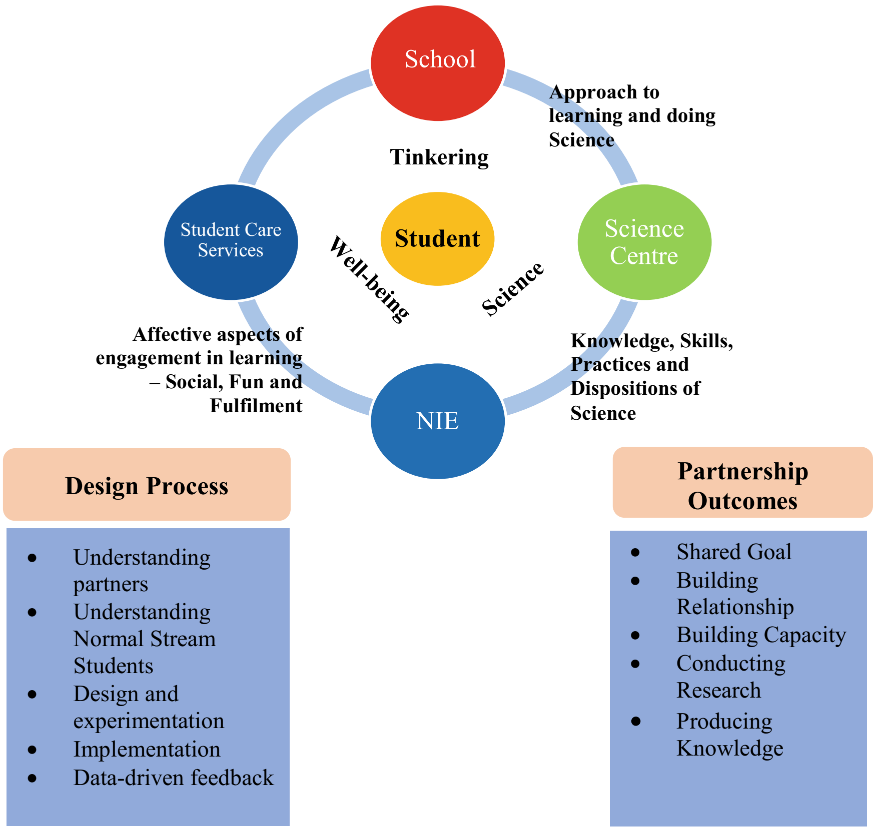

Fig. 4.5 Research-practice partnerships in the 'It Takes a Village' project

Most activities are spread across 4–5 lesson periods with plenty of opportunities for iteration, trial and testing, sourcing for ideas and collaborate with others. Subsequent iterations of the programme included opt-in tinkering programmes with the intention to mentor students created a positive learning environment for student engagement and self-directed learning. Partner-led design and implementation of tinkering activity, extension of the school syllabus and with equal emphasis on students' well-being (intentional mentoring) was planned and discussed among all members of the project team. Implementation was conducted on the classes: Sec 1NA: Basic Cardboard Automata [18 students]; Sec 1NA & 2NA: Advanced Automata (with motor and electrical components) [25 students]. 2-day workshop with 2.5 h per session were conducted by the team.

In this partnership between NIE, schools, Science Center Singapore and New Life Community Services, the partners sought to improve science learning experiences and the well-being for lower progress students in a secondary school. The design focused on how to develop students' competencies, skills and disposition to learn and

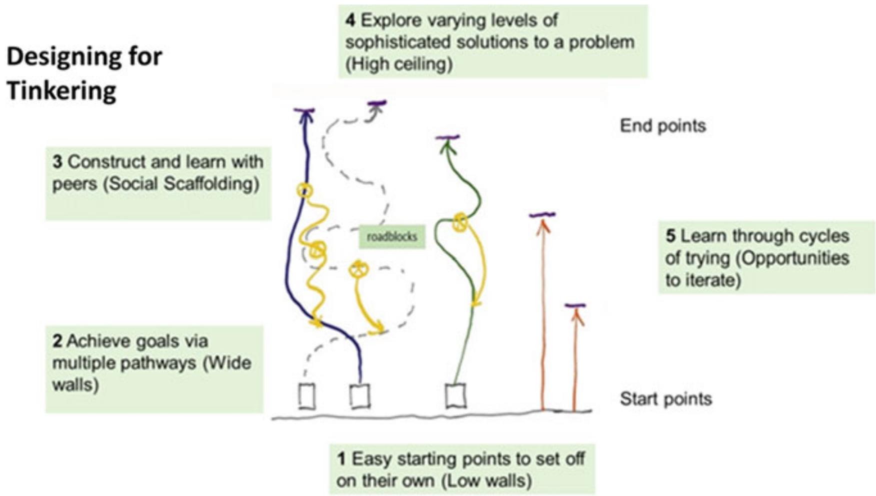

Fig. 4.6 Multiple paths encouraged through tinkering

relearn beyond the canonical knowledge required in school. We posit that designing new experiences to engage students in science learning while addressing their well-being would help them to be more responsive to learning. Drawing upon the expertise and different practices of the partners, we focused on improving the learning of lower progress students, exemplify how the 4 lives framework of Life-Long, Life-Wide, Life-Deep and Life-Wise learning can be implemented.

Life-Long We prepare students for Life-Long learning in developing knowledge and disposition, process and design skills and metacognition. The co-designed programme by the partner provided opportunities for students to learn in depth and breadth, to discover their own interest and strength. In tinkering activities, students explored ideas to solve problems and deepened their learning as they make connections between the ideas. The process of tinkering encourages students to experiment with ideas and pick up design skills to solve problems. At the end of tinkering activities, we encouraged students to reflect on their learning and experiences. This promotes the development of metacognitive skills for them to be aware of their thinking and learning. In subsequent studies in the 'It takes a village' project, we consider if our learners have developed Life-Long learning dispositions or interests or curiosity characteristics resulting from the tinkering.

Life-Wide To prepare students for Life-Wide learning, students learn from multiple perspectives and develop interdisciplinary understanding in the designed activities. Engaging tinkering activities provide learning opportunities to learn across different topics in science and provide multiple pathways of learning. Students work in pairs or groups to approach problem solving from perspectives of their peers by encouraging them to view the artifacts of other groups and sharing their ideas. Students also exercised agency to decide their path and solutions to solve the problems through integration of different science ideas from various topics. In a typical classroom, science ideas are introduced and science facts are prescribed instead of explored, and students may fail to make the connections to relevant ideas to deepen the learning through this direct instruction methods. However, with learning experiences afforded by tinkering activities such as constructing a marble machine, students have the opportunity to assimilate and connect science ideas as they integrate their knowledge. For example, they explore and learn about frictional forces, physical properties of materials that relate to motion, forms of kinetic and potential energy and motion. Students develop interdisciplinary understanding as they solve complex problems that would integrate knowledge and skills. In follow-up studies, we would consider if the depth of science concepts remains in students after the interventions in post-activities six months later, and consider how, and why students have appropriated the concepts, be they cognitive or affective aspects.

Life-Deep As students manipulate objects and materials in constructing artifacts, the abstract concepts in science are made visible for them to make sense of science. This would lead students to have deeper disciplinary and conceptual understanding of the science concepts they learn to apply. Learning is about doing science to deepen their understanding of the methods and practices of science. Students exercise autonomy when they are given a sense of control and take ownership of their created artifacts, which is what tinkering process could provide, in which students choose their materials, experiment with their ideas and decide their own pathways. The iterative processes develop persistence and practice leading to mastery. Such tinkering activities cause students to be more motivated and agentic. The depth and breadth students are exposed in tinkering activities, iterating multiple times to solve a problem, approaching from multiple perspectives, can develop them to be more flexible and creative in problem solving, leading to development of adaptive expertise to solve problems. We aim to observe how these learning outcomes from students can be 'transferred' to regular science class lessons.

Life-Wise Students need to have their character with proper values, morals and wisdom that would enable them to make good decisions for themselves and others, and to become a responsible person who will contribute to society. In the research project, students were able to collaborate with other students, wait for their peers who were not catching up, and help their fellow students along. Students learn the value of respect through communicating, listening, negotiating and sharing with their peers. Solving problems require students to persevere and have grit as they iteratively improve their ideas. At the end, they acquire values of perseverance and hard work. With a greater awareness about themselves, experience gained from participating in tinkering activities and learning from their peers, students can use their knowledge and experience to make good judgments. They have wisdom to make the appropriate decisions in different situations. In subsequent studies, we would venture to consider if learners can sustain their learning in their motivation, engagement, and whether these transfer to regular school classroom lessons.

Social Emotional Regulation and Well-being Participating in tinkering activities in after-school programmes provide a safe and supportive learning environment for students to express themselves with the artifacts they create. The focus is on the process experienced by the students. In the process, they can fail safely—be it a wrong decision or choosing a different approach. By iterating and learning from mistakes, students can pick up from where they fail and move on. Also, students can develop self-awareness by identifying their emotions, recognizing their strengths, gaining better self-perception leading to more self-confidence. They gain social awareness when they take on different perspectives from their peers, appreciate the diversity of ideas and respecting others. Developing these competencies through the process will lead to improvement of well-being of students. Importantly, the science teachers who were involved in the tinkering activities in these after-school curricular time were part of the partnership. From these tinkering observations, we noticed that the same teachers saw a different side of their students, realizing that these low progress students had strengths which they had earlier not noticed. With a different view now of their students, they are now more able to variate their pedagogy in regular science lessons to better engage their learners. (In the Singapore school context, after-school programmes are usually conducted to external vendors, and there is minimal integration between these programmes and class lessons).

The students who were engaged in the tinkering activities exhibited evidence of the increase in motivation level before and after the programmes. Almost all participants would recommend this programme to their friends. Through the categorization of student voices in social emotional learning and creativity with the highest occurrence include:

- Openness;
  - 'To always have an open mind';
- Perseverance and resilience;
  - 'Never give up';
- Working in teams and learning from others;
  - 'it doesn't always have to be a competition'
  - Application;
  - 'How to put what I learnt in class into my life.'

Expression of ideas though different forms. Students also learn about themselves and their abilities, for example: 'I never knew I could….'; 'Do something by myself'; 'I learnt that if I think I can do it I can do it'; 'Make such things'; and 'Making object turns.'

From the post-activity interviews conducted on the student three months after the tinkering activities, these academically low achieving students were able to recount detailed experiences of their learning encounters with specification and critical thought on what they would do if they had a chance to re-do the experiments. Interestingly, the teachers who took these students in regular science lessons were surprised by their levels of engagement, recollection and criticality (which were not seemingly observed in regular science lessons). Below are some of the expressions by the students themselves:

> Yes, I do because by learning like that I could have fun and learn at the same time. Then I would have a memory of this in the future and remember the things I learned today.
>
> Yes, as I can learn more process on what I did wrong in this experience.
>
> A memorable moment is that I feel proud of our design; It was fun making design with my partner as we keep doing trial and error on our circuit.

Our findings from the study showed that students are able to learn aspects of the 4 lives in their participation with tinkering activities. They are more self-aware about themselves regarding their abilities and strengths. The opportunities to fail safely and try again developed perseverance in students. Working with others in joint-problem solving fosters social awareness and learning to respect others. We believe that the process of tinkering provided opportunities for students to develop the values, skills and knowledge for future learning.

This project has a combination of elements found in many of the interventions conducted in the last decade, from cognitive to affective process-outcomes, disciplinary content knowledge, learning in formal and informal environments and sustainability mechanisms in research-practice partnerships. The project is still on-going, and subsequent iterations include getting the teachers to practice the tinkering design principles in regular science lessons, appropriating well-being constructs to assess student holistic performances and dispositions, and whether students are able to self-regulate with interest in science. Science of learning (SoL) techniques would also be employed insofar as students' physiological responses and states, e.g., stress and motivations. Neuroscience methods can also determine how and why learners become interested and motivated, and what happens in the brain when 'transfer' of learning occurs in terms of the brain's interconnectivities in its neuronal networks. Importantly, '[n]ot only can findings from neuroscience research inform educational practices, problematizations derived from educational contexts should inform trajectories of neuroscientific investigations.' (Jamaludin et al., 2019). In essence, observable practices such as the above science tinkering contexts can give us a window into problematizations from which SoL can give us further understandings.

4.3.1 Macro, Meso and Micro-layers of a System (in This Case, the System of a School)

In the past research of the NIE, we realized that for sustainability to occur, teachers need to believe that inquiry practices enable students to achieve both content knowledge for the important examinations and also the twenty-first-century learning competencies required from the MOE. For sustainability, the **MACRO** (for the 'It takes a Village' project) socio-cultural environment (i.e., the context) through which innovations/academics-and-twenty-first learning occurs is the school and its leadership enablements (or otherwise) in supporting teachers in their endeavors within the research-practice partnership nexus. If this project were a system-wide adoption programme, the macro-layer would be the system, and the school or cluster of schools involved, the meso-layer. In this project, the **MESO** mechanisms are those that enable teachers to do the academic-and-twenty-first learning transformations in tandem with school cultures at the science department level within the school. The middle management leadership is in support of transformative pedagogical change process and its sustainability. This includes the supporting persons and structures that enable apprenticeship learning among teachers for epistemic change, and the alignments between pedagogy in the classrooms and the policies/leadership that enables change and sustainability. The **MICRO** layer is the supporting teaching and learning interactional mechanisms (e.g., data and analytics) that enable teachers to do what they need to for transformative classrooms as implemented by their lessons, whether formal or informal, or both.

Due to the historical propensities to responsibly teach to the test, teachers struggle as exhibited by the protocol below:

> S: the teachers are very worried, 'confirm cannot come up one' [in response to teachers' questions to students], 'what if they don't come up with what I want to hear?' …That's always their worry. So that's why, just let go. They just don't want to let go. So we show that, see, you can let go. … And then show them how we make the links. And they're like, okay it's possible. Okay let's try.

Not only is apprenticing work needed among teachers, teacher leaders are needed to align their work with the school's curriculum policies, vision and expectations. In this way, coherence in terms of school goals and pedagogical transformations become possible on the ground among teachers and students. In the process, upwards and downwards communication is needed. Upwards in terms of communications with school leaders and superintendents, and downwards in terms of convincing teachers and parents of the need to change. Making learning visible is needed and outcomes to align with multiple stakeholder concerns.

4.3.2 LIFE's Vision for Academically Challenged Students (Low Progress Students)

The following articulates a systematic or programmatic approach to leveling up academically challenged students which can be learned from the 'It takes a village' project:

Vision—to create future schools in Singapore where Low Progress Learners (LPS) (currently) can perform 'as well as' high achievers in both academics and 21st CC or future-readiness for successful outcomes.

Current problem—there is a perception among the public that elite schools enable better opportunities for success and that there is a clamor toward these schools in admission criteria based largely on exams, e.g., PSLE.

Hypothesis—schooling practices, including assessments are founded on the assumption of 'cognition in the head.' Our hypothesis to level up LPS is to adopt the paradigm of 'embodied and distributed cognition.'

Research Design—adopting a cluster/network of schools with largely LPS and bring them through an 'embodied and distributed cognition' approach(es) and compare their process-outcomes and summative outcomes with high achieving cohorts.

Multilevel Data—much of education research has focused on observable, psychological and behavioral methods situated within the learning sciences paradigm. We hypothesize that augmenting learning sciences with science of learning methodologies across multilevel analyses can bring to the fore learning that is implicit, enriched with insights into movement and emotions that are 'below the surface' of observable learning. An ecological (integrated) perspective to align and cohere multiple sources of data from ***SoL, Data analytics and Translational sciences*** will be key foci areas.

Table 4.2 summarizes on 'where we are,' the goal to achieve, and projects that can be commissioned to achieve the goal.

Broadening or making more general the kinds of SoL (basic science studies) with the complementary translational mechanisms needed, we can focus on the following theme areas:

- Literacy (including dyslexia) and bilingual studies;
- Numeracy (including dyscalculia);
- Motivation and interest (i.e., intrinsic and extrinsic reward regions and mechanisms);
- Embodied and Distributed cognition (i.e., movement, gestures, etc.);
- Development of intuitive resources (i.e., neural correlates underpinning productive failure, for example);
- Physiology related to learning (e.g., stress and well-being, sleep, etc.);
- Metacognition and regulation (i.e., neural correlates).

When studying academically challenged students or low progress students, in order to attain the goal as stipulated in Table 4.2, we inevitably have to study accompanying factors such as literacy and numeracy that are part and parcel of their academic content learning, including aspects of well-being and metacognition (or otherwise).

LIFE™'s 'Experimental schools' are to be adopted in the programmatic effort as depicted by the following principles:

- Adopt a representative 'cluster of schools' (or network of schools);
  - Cluster needs to include kindergartens;
- Policy, socio-technical and teaching and learning mechanisms to be systematically experimented;
  - Across the different disciplinary areas;

Table 4.2 Summary of 'Where we are,' projects that can achieve this goal, and projects that can be commissioned to accomplish this goal

Where we are	Projects that can achieve this goal	Goal

• A rich historical trajectory of education research. Existing projects in key areas of:
• Learning Sciences
  • Disciplinary pedagogies
  • Academic + 21CC
• Science of Learning
  • Bilingualism
  • Numeracy
  • Working Memory
  • Early years
  • Special Educational Needs
	• Embodied Cognition
	• Neurological basis of Movement as an integral part of learning
	• Gestures and intuitive knowledge
	• Emotions and self-regulation
	• Metacognition, and regulation
	• Basic literacies and embodiment in learning
	• 21st CC and embodiment
	• Teacher translation mechanisms
	• Distributed Cognition
	• AI applications for human-and-artificial cognition partnerships
	• Creative collaborations between tools and humans
	• Creative collaborations between humans and humans
	• Assessment in creative collaborations
	• Basic literacies and distributed cognition
	• 21st CC and distributed cognition
	• Teacher translation mechanisms
	• Interest development
	• Embodied and Distributed Cognition Integrated
	• The development trajectories of academics-and-21st CC among LPS
	• Methodologies that enable embodied and distributed cognition
	• Epistemic knowledge in embodied and distributed cognition developed by learners and transfer of learning
	• AI and big data analytics supporting embodied and distributed cognition
	• Assessment practices and transformations in embodied and distributed cognition
		• To create a school-model that can enable LPS to achieve academic 'success' and future-readiness
		• Working model would include
		  • Policy mechanisms
		  • School-classroom T&L mechanisms
		  • New Assessment practices and norms
		  • Teacher learning mechanisms
		  • Human-technology mechanisms
		  • Sustainability mechanisms

- Longitudinal studies from EC to JC2 (or equivalent) based on;
  - Bio-ecological framework (from neural to social measures);
  - Data from multidata (layers and dimensions) sources;
  - Multidata synthesis;

A model of teacher learning and development (Jamaludin et al, 2019) for this programmatic effort for to include the following design principles:

- Creating a dialogical space for expanding teachers' design repertoires where teachers will have access to:
  - Video case studies of learners working on identified tasks;
  - Showing, analyzing and discussing the nature of learners' difficulties;

- Screencasts of brain images, talking through what the images mean in terms of how the brain is developing differently for different learners (perhaps in group and reporting back to the whole class);
  - Links to remediation strategies or platforms, with video explanations of the brain science and pedagogical science that underpins it;
- Debating and justifying why the use of identified remediation strategies;
  - lesson plans for how the designed interventions might be introduced into a class with different underlying reasons for learning differences, with the teacher having access to the data collected;
- Enactments of lessons plans with learners;
- Evidenced based data where teachers can report back on their SoL 'tinkering' and 'experimentations,' and compare their experiences and other teachers or groups in the class; and
- Critique on their own learning process both individually and in groups.

4.3.3 Data Analytics, AI and Assessment

Going forward besides SoL, complementary work in artificial intelligence (AI) in enabling learning applications with machine learning and diagnostics would be useful in supporting academically challenged students. The data that is generated of these students across the system would also aid in constructing a system profiling understanding of these learners accompanying the design-interventions be they in cognitive, emotional, or well-being outcomes. With the adoption of these AI techniques, human cognition can be shared with tools and machines instead of an over reliance on the human. A shared creative collaborative relationship between human and machines as a whole unit of analysis in a distributed manner has significant implications on assessment and its current practices. Transformative pedagogy and assessments in line with embodied and distributed cognition principles need to radically question the status quo and spur work toward future outcomes. With machines doing what they are good at, humans can focus on higher order functions, in particular metacognition and cross-boundary cognition and transfer.

4.4 Conclusion

The process of applying findings from 'laboratories to learning' includes iterative steps of identifying foundational learning principles that would aid student learning (Jamaludin et al, 2019). This includes cognitive mechanisms, e.g., working memory and also affective mechanisms, e.g., emotions and regulation.

It is also important to systematically engage in correlating prevailing classroom practices with learning principles identified with a view to probing and deepening explanatory foundations for successfully situating and implementing learning strategies. Developing *original, effective and specific* teaching and learning strategies; grappling with inherently contextual, dynamic and multiple classroom variables is a necessity (Jamaludin et al, 2019) for impactful educational research insofar as LIFE is concerned.

Finally, developing evidence-based practices through iterating principles and designs; and sustaining these practices and designs through a community of teachers who deeply understand foundational principles and translational mechanisms are ways for effective translation. Working across institutional agencies within the system to scale and sustain improvement practices with teacher professional development (and epistemic change) at heart is the crux to reform efforts (Jamaludin et al, 2019). These mechanisms, when put in place, could very well be the 'pillar' that joins neuroscience and education, where bringing SoL to the classroom may be a bridge that is *not that far*. In the meantime, neuroscientists and educators should develop common goals, establish common language and methodologies, and importantly trust. Building research-practice partnerships with schools and industry to provide evidenced based interventions mitigating the risks across the life-span that can leverage on research to commercial applicational outcomes becomes a possibility in reality.

Tangibly, NIE can lead in the development of a comprehensive evidenced based developmental framework of *risks and opportunities* for SoL in Life-long learning, in collaboration with the universities in Singapore. This developmental framework would consist of 4 age-bins: K to 12 learning; tertiary and adult learning; post-career learning; and elderly learning. A coherent interoperable data infrastructure of cohort data over time of the above comprehensive across the age-bins which can be mined for policy purposes with a view to translating basic research to practice-policy outcomes. Through this, it can begin to build a pillar to join the bridge between SoL basic research and its translational outcomes (forging a bridge between neuroscience and education which was formerly a bridge too far). This creates the opportunity for NTU's multidisciplinary community to come together toward this common goal. With this goal, NIE/NTU can potentially attract the best researchers and practitioners across the world to converge in the 'living lab' in Singapore to bring SoL into practical realities across the life-span through this initiative. With the demographics among Singaporeans suggesting longer lifespans, NTU can be a forerunner in post-career learning and elderly care learning. We hope that LIFE and its endeavors would propel us to new and transformative change that would put our children at the center of why we do what we do.

Finally, fostering collaborative partnerships similar to the 'It takes a Village' project is needed to fulfill the research-practice nexus goals of NIE. See Fig. 4.7.

The present and future NIE research centers (left side of Fig. 4.7) would need to consider how nexus goals are met through partnerships that have sustainability and follow through in the situated context where innovations occur (see center of Figure) with further translations and implications for new assessment modalities and learning

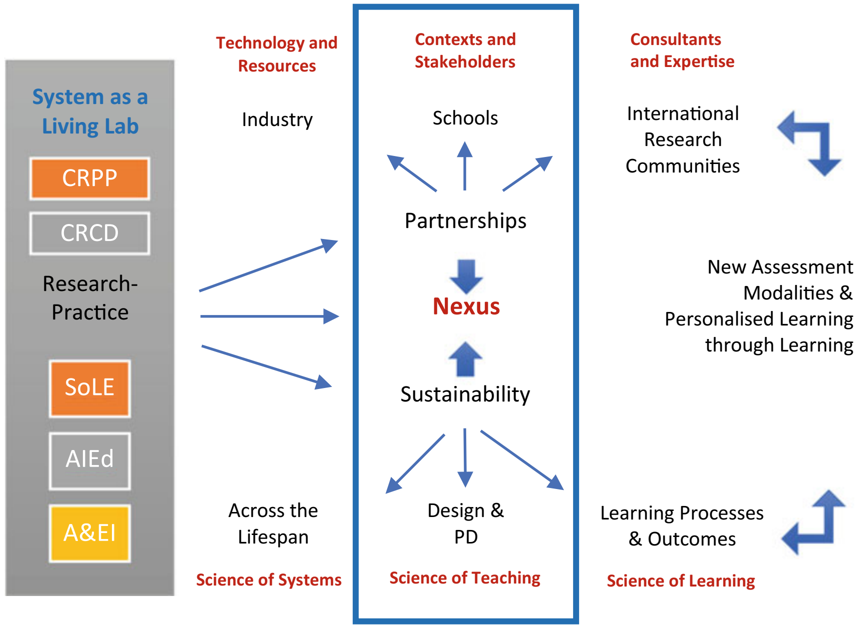

Fig. 4.7 Partnerships toward research-practice nexus

outcomes (see right side of Fig. 4.7). The 'It takes a Village' project delves into details on how 'tinkering' as a process can be embedded into the research-practice nexus partnership design and approach.

Going forward, the Office of Education Research with its LIFE's efforts intends to bring into convergence different sources of data (from neural to social) and various techniques, including AI and other augmented technologies to enable leading in all its varied dimensions socially, emotionally and cognitively.

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Part II
Diversified Changes from the School View

Chapter 5
An Exploration of Contextual Factors in Enacting Making-Centred Learning Programmes in Singapore Schools

Longkai Wu, Sujin He, Paul Chua, and Wee Kwang Tan

Abstract In support for the need of an innovative twenty-first century learning environment in schools, the emergence of the maker movement in education has been viewed as a strategic approach for the global knowledge-based society. The approach of making in learning is still relatively new, but emerging research has documented how making environments support learners through the processes of investigation and invention and in doing so develop students as producers rather than consumers of technology. This chapter explores making-centred learning programmes in three Singapore schools, focusing on how they been initiated and developed; how teachers have perceived the applicability and effectiveness of such programmes; as well as strategic elements that can be adopted to bolster the enactment of such programmes from leadership perspectives.

5.1 Introduction

Although Singapore students have topped the global rankings for international comparative assessments like PISA and TIMMS, studies reveal that students are relatively weaker when solving unfamiliar problems (Kaur, 2009). The exam success-orientated system that has been entrenched in the education culture of Singapore has hindered the development of creativity (Lee, 2007). As a result, the emphasis on extrinsic goals and expectations projected by the school would have inadvertently extinguished the intrinsic motivation and natural curiosity of learners (Honey & Kanter, 2013).

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Moreover, the emergence of the knowledge-based economy demands new curricular forms, pedagogies and assessment methods in an innovative learning environment. Local academics have also noted that there still exist areas for continued development in creating more conducive learning environments to develop students' problem-solving skills (e.g. Fan & Zhu, 2007).

Educators have asserted that traditional schools based on an instructionist, standardised curriculum that is focused on memorisation and rote learning are designed for a vanishing world (Hargreaves, 2003; Sawyer, 2006). Educators believe that schools and other learning environments have to be restructured to educate for innovation and that one has to constantly innovate to create new knowledge, not merely to master existing knowledge. Indeed, many of today's schools are not equipped to teach the deep knowledge that inspires innovation, and the structural configurations of the standard model do not aid in creating learning environments that result in deeper understanding (Sawyer, 2006).

As a result, there is a need to ask, if the traditional way of learning is adequate for the twenty-first century knowledge society, in terms of the problem-solving abilities of the next generation. Instead of a demanding system where high-stakes tests are given high importance, would a learning environment centred on making and creating be conducive to ignite curiosity and interest and keep students purposefully engaged?

5.1.1 Theoretical Underpinnings

The theories of Piaget's constructivism and Papert's constructionism are often cited as the central pedagogical drivers of making-centred learning (e.g. Martinez & Stager, 2013; Resnick & Rosenbaum, 2013). In his theory on constructivism, Piaget explained that humans do not immediately comprehend and use information that is given to them. Humans do not learn as passive recipients of knowledge; instead they need to construct their own knowledge, and understanding will arise through experiencing and then reflecting on those experiences (Piaget, 1952). He states, "Essential functions of the mind are formed by developing a foundation consisting of understanding and innovation and constructing reality" (Piaget, 1971, p. 27). Piaget's work would later inspire Seymour Papert, a mathematician who developed a theory of learning based on Piaget's constructivism.

Papert's theory of constructionism takes Piagetian constructivist theory a step further to emphasise the learner's role as a designer and creator in the construction of external artefacts, especially in ways where computer technology supports those mental constructions. Papert's view is that learning occurs "felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe" (Papert, 1991, p.1). Thus, constructionism theorises that the experience and act of working on physical or digital creations allow students to construct their understanding of various subjects through personal inquiry.

5.2 Background of the Study

Singapore Education System While students in Singapore have consistently performed well and ranked top in international evaluation assessments (OECD, 2011), government leaders recognise and acknowledge the apparent lack of thinking skills and creativity among students (Tan & Gopinathan, 2000).

Students are regularly appraised by a result-oriented system that favours those who perform well in high-stakes and standardised tests. This system is what researchers caution as evaluation practices that will skew students away from the passion of real learning, towards repetitive rote learning (Tan, 2001). Thus, students value little beyond preparing for examinations, as the excessively examinations-focused environment lead students to narrowly define success based on academic achievement (Gregory & Clarke, 2003; OECD, 2009).

Since the early 2000s, the Singapore education ministry has tried to broaden the notion of success, which was for a long time, defined by good academic results (Ng, 2003). Although the government has supported a change from a result-oriented system to one that stimulates creativity and innovation, schools and students still find themselves stuck in a pressurised exam-driven culture where the primary emphasis is still on students' exam results. The ministry has highlighted that success in education should not be measured by academic results alone and that more opportunities and multiple skills-based progression pathways should be available to all students of varying abilities.

In the last decade, Singapore has successfully developed a R&D base by attracting top scientific and creative talents (EDB, 2016). The government has noted a shift towards intellectual capital or knowledge as a source of value and wealth creation and has recommended relying more on technology and innovation as a basis for competitiveness and growth. As Singapore continues to move towards a more knowledge-centric and research-based economy, the education system will similarly face new challenges. Demands for new skills and knowledge will likewise require a system-wide innovation and reform in education. To meet the demands of the knowledge-based economy, new curricular and pedagogical forms, assessment methods and even learning environments must be developed.

Making-Centred Learning In support for the need of an innovative twenty-first century learning environment in schools, we turned to the emergence of the maker movement in education as a strategic approach for the global knowledge-based society. The approach of making in learning is still relatively new, but emerging research has documented how making environments support learners through processes of investigation and invention and in doing so develop students as producers rather than consumers of knowledge and technology.

In making-centred learning, learners acquire skills by active testing and experimentation, which is cognitively and socially richer than the routine following of instructions directly transmitted from the teacher (Espinoza, 2011). Making-centred activities allow for more authorship and agency in the students as these activities treat the development of scientific concepts and skills “as tools to achieve desired ends, rather than ends in and of themselves” (Vossoughi & Bevan, 2014, p. 21).

STEM Applied Learning Programme (ALP) In 2014, the Ministry of Education announced a new programme, the Science, Technology, Engineering and Mathematics (STEM) Applied Learning Programme (ALP), which encourages the application of what is learnt in class to real-world issues. The programme aims to instil in students skills such as reasoning and problem-solving, scientific inquiry as well as for them to pick up new uses of technology such as programming skills. The STEM ALP programme shares similar objectives with the pedagogy of making in its intention of helping students understand the relevance of what they learn in class to the real world through interactive and hands-on experiences.

Design & Technology (D&T) Students learn through working with design-and-make projects, guided by a design process that recognises design needs from real-world experiences. In D&T, students identify design needs from real-world problems, conduct research and acquire the skills and knowledge to turn ideas into reality. In doing so, they cultivate design dispositions like empathy and sensitivity, which are needed in design practices. With that, they learn to seek out how things work to solve ill-defined problems.

5.3 Methodology

The research team utilised a descriptive mixed-method case study approach. Students were surveyed in their experiences in the various learning environments. The focus group interviews were audio recorded. Extensive field notes were also taken during the initial classroom observations and during the focus group discussions to ensure that data could be cross-checked with the audio and video recordings.

In our study, we explored the following question:

1. To identify the characteristics of schools that are involved in making-centred learning spaces
2. To investigate the contextual conditions in enabling the building of making-centred learning spaces in the school settings.

The students who were selected for the study are between 13 and 15 years old. Lessons were conducted for three periods over 2 weeks for 6 months. For this study, the lesson observations were conducted in two secondary two classrooms. The researchers, after conducting sessions of classroom observations, together with the teachers, selected the participants for the focus group discussion based on the participants’ attendance, achievement and overall participation in school.

The three case schools that were selected were based on their involvement in making-centred activities or have emphasised the importance of hands-on learning in their schools. Hands-on activities play a key role in maker education and form an underlying principle that underlies our research in the following schools (Table 5.1).

School A School A's strong D&T culture was one of the factors that paved the way in supporting making-centred learning in the school. The strong D&T culture was shaped by the vision and leadership of former school leader, "Bob" who viewed D&T as a vital part of education. He did not subscribe to the negative stereotype that D&T was for the academically less inclined students and firmly believed that D&T in future would go beyond just technical studies. Back in the 90s, Bob foresaw

Table 5.1 Overview of the Three Participating Schools

	School A	School B	School C
School type	Boy's school, admits students of varying abilities	Mainstream co-educational school	Co-educational specialised school in Singapore that caters to low-progress learners, runs on a customised, technical-based curriculum that is designed for hands-on and practical learning
Special characteristics of school/Niche area	Active in organising activities related to D&T and robotics within the school and frequently hosts other schools in their zone	Was one of the few schools that introduced computer studies as a subject back in early 2000	There is less emphasis on academic-focused methods, and lessons are tailor-made to provide students with practical applications for subjects taught in the classroom To engage students meaningfully, teachers harness different pedagogical approaches which emphasises skills-based activities and practical learning in a real-world context
Why the school was approached for the project	The school had been designated a centre of excellence (CoE) due to its excellent D&T results in the "O" Level examinations	Today, computing is integrated in several core subjects in a hands-on manner. The school tries to introduce computational thinking concepts across core subjects as they believe that these concepts can support inquiry in other disciplines and can help empower students tackle complex problems	This school was selected because of its unique curriculum of balancing academic and industry needs while providing a hands-on, authentic learning context

(continued)

Table 5.1 (continued)

	School A	School B	School C
Types of making-centred activities that we observed	During their STEM ALP lessons, students used the Arduino to build the seas perch (underwater robotics to build an underwater remotely operated vehicle)	The STEM ALP lessons were planned based on based on the school's niche area in clean energy and environmental technology. Students used the Arduino to build the seas perch (underwater robotics to build an underwater remotely operated vehicle)	Students in school C were involved in designing a virtual campus (VC) as part of their new media club activity. Students worked on the VC as part of their CCA for two periods each week over 1 year

that electronics, design thinking and problem-solving skills would be incorporated in future D&T curriculum and insisted that the students should acquire those skills, even though it was not officially in the syllabus. He had even proposed to the ministry to include electronics in the syllabus, but the ministry was not ready to adopt it then.

At school A, D&T was taught with the objective of empowering students and equipping them with problem-solving skills and design thinking skills. Problems were presented in class, and students were invited to come up with creative solutions in response. Many of the students were from the NA and NT streams, but Bob believed in them and expected them to be just as capable as students from the express stream. Bob had high expectations of them and the confidence he had in them made them feel more self-assured. Students were required to work through all the various steps in problem-solving and that allowed them to come up with creative ideas. In the ideation phase, students were given the freedom to come up with original, imaginative solutions, without the confines of restrictive constraints.

Bob was instrumental in promoting a strong problem-solving, design thinking D&T culture in the school, and his vision made way for more making-centred related programmes to be run in the school. When Bob retired, the subsequent school leaders made sure that the school's strong background in D&T and design remained strong and that the school would continue Bob's legacy in engaging students in D&T.

Another factor that influenced the school's development of making-centred spaces was the school leaders' analysis of the students' learning styles and choices. To cater to the learning needs of the students, the school had analysed their tertiary choices and discovered that a large percentage of the students ended up in engineering-related courses. The school administration decided to take a more deliberate approach to help the students develop their engineering skills, and it was by adopting strategies based on the understanding of how boys learn. The belief is that boys learn and behave differently in educational settings, and such differences merit educating them in a way that they learn best.

The basic principle in an all-boys school, as school leader E explained, is to adopt "practices in understanding hearts and minds of boys". School leaders and teachers had researched, consulted experts and also attended workshops before implementing strategies to engage boys and to educate them in a way that suit their learning styles. Some strategies are to

- Engage them using hands-on activities
- Introduce competitions and challenges in their learning
- Apprenticeship programmes can help boys develop mastery in that area
- The physical space is also important as they should be able to apply the theoretical concepts and contexts that they have learnt.

Bob was instrumental in promoting a strong D&T culture in the school, and his vision made way for more D&T-related programmes to be run in the school. When Bob retired, the future school leaders made sure that the school's forte in D&T and design thinking remained strong and that the school would continue Bob's legacy in engaging students in D&T.

School B School B's computing background plays a strong role in the school's learning culture. The school started offering computer studies in 2006 and is now offering computing as an "O" level subject. According to school leader T, the role of computing is highlighted in the school and explained how computing can be used as significant tool in any subject or field of expertise. For the last five years, the school has been trying to integrate computing into core subjects, instead of having computing as a stand-alone subject. T highlighted that the students do not study "computing for the sake of computing" as the students would not know how to apply it.

From School B's experience, infusing computing into core subjects has been an effective way to engage students. The computing department collaborates with the Science, Math and D&T departments and uses computing tools to help students learn through a hands-on approach. For instance, when the teachers found it hard to engage students during biology lessons, the computing and biology teachers came together and developed a package to teach concepts about digestion. The students were first taught digestive concepts, followed by the programming tool, scratch. The students, now equipped with both biology concepts and basic programming, were asked to work on a project to create a storyboard on the movement of digestion. The teachers found that it made lessons more interesting and engaged students more effectively. The students had to internalise what they were learning and began to understand the seemingly dry concepts better. More importantly, the teachers can determine if the students have fully understood the topic by looking at their story boarding and their thinking process.

T explained that they did not want the students to see computing as just another programming tool, but for them to see it as a platform for creative innovation, to cultivate analytical and problem-solving skills. The school's philosophy echoes Mishra and Yadav (2013), who wrote that "computational thinking can foster creativity by allowing students to not only be consumers of technology, but also build tools that can have significant impact on society" (p. 11).

The school also offers an extensive STEM applied learning programme where the students get to engage in many hands-on activities. The concept of computational thinking is also infused in STEM lessons, where students are led through a process of problem-solving, analytical thinking and then the creation of an artefact. Often, the programmes are organised in collaboration with technology companies, so students get to go on learning journeys with actual companies to experience an authentic hands-on learning experience.

Teacher sharing plays a role in the development of making-centred spaces in the school. Some of the teachers are straddling between two subject departments. For instance, a teacher could be teaching both Science and Computing and collaborating with the Math department. The teacher would share resources, experiences and influence other teachers to embark on a cross-curricular instruction between multiple subjects. The cross-curricular approach could be beneficial to teachers who feel that the topics that they are teaching are too dry and hard to grasp and are thinking of introducing a hands-on approach to help students gain a better understanding of the material. As explained earlier, infusing computing into core subjects has been an effective way to engage students.

As some teachers are also new to computing, the process of sharing with others would help them to internalise their knowledge. School leader T shared that in the last year due to teacher sharing, the humanities department worked with the computing department and got students to make short animations and games. The teachers are encouraged to not only share within the school but to share with other schools and communities. This culture of sharing also extends beyond the teachers to that of the students. The students are given opportunities to share in other schools and also at other community activities.

School C Lessons are usually centred around hands-on activities in School C as students are more engaged when they see the practical applications to what they are learning. The students who were observed in this study were part of a tech club who was involved in designing a virtual campus (VC) of the school. The project was helmed by another NIE researcher who facilitated the process and based the design and principles of the learning space to articulate the key features of the maker culture. The idea was to give the learners the room to experiment, to take risks, to explore their own interests and play with their own ideas in free-structured learning. Creating a spontaneous learning environment, the facilitators gave students the freedom and autonomy in designing the VC based on their own design and ideas.

The initial two sessions were slightly structured, as the researchers understood that the students and teachers were new to this pedagogical approach and that the students might not be able to adapt to it at the start. Then, as the students grew familiar to this approach, the facilitators got them to start exploring on their creating their own ideas. The students were free to build what they wanted, and the facilitator would be available to help and support them when needed. Some students required more encouragement than others, but most students were eager to try out and start exploring on their own.

The facilitators tried not to intervene unnecessarily, even when it appeared that the student seemed stuck at a problem, as intervening too early might take authorship away from the student and result in the learner giving up prematurely. By observing the students' personalities and characters, how they worked and by talking to them about their ideas, the facilitators tried to understand what their ideas might be and then make recommendations based on these ideas. In the process, even when the student had reached an impasse, the situation served as a good learning opportunity as they figured out how to resolve the problems on their own. With perseverance, some of the students even saw how they could complexify their designs.

The learning environment was influenced by Papert (1993) to "create the conditions for invention rather than provide ready-made knowledge". However, creating such a learning environment is challenging, as the facilitators shared about the struggles of realising this:

> Initially the teachers found it a struggle trying to grasp the concept of allowing the students decide what they want in the environment........they wanted everything to be prim and proper………So the students felt like there's no motivation to do what they wanted so they struggled a lot. They felt very suffocated so to an extent that hampered their progress initially. It was only when we were able to convince the teacher to let what the students wanted that they changed.........Also they are more confident that they are able to come up with such detailed product so they don't mind doing [what the teachers wanted]. So it's a different approach. Initially they were pressured ....They feel compelled to do it so it's different, different form of motivation.

The teachers had to take a step back and allow the students to take ownership of their own ideas. If the teachers were hesitant about a student's, they would ask the students to articulate their thought processes and allowed time for more iterations and meaningful discussions. This helped the students in feeling confident about their own abilities, especially in further iterations. The teachers' approach became less task-oriented; they supervised the students to make sure that they were not off task and allowed for those who were on task to work independently.

5.4 Findings

The implementation and enabling of making-centred learning spaces involves changes at the teacher and school level. In Singapore schools, these efforts are still nascent and from our findings run up against a range of structural challenges.

In analysing the focus group responses of teachers and school leaders, the following main themes had emerged. They are (a) Teacher training and development, (b) leadership (c) how schools conceptualise making-centred learning.

5.4.1 Teacher Training and Development

A change in classroom culture and pedagogy that supports students as producers, rather than consumers of knowledge and technology, cannot occur without substantial teacher training and development. In building the teachers' practice in their pedagogical enactment, there should be sufficient training designed to support teachers in effectively implementing such a change. Teachers who have never experienced these making-centred practices in their own education will have difficulty implementing them in their classrooms.

In the study, we observed that there are two main ways that the teachers could benefit from training: subject knowledge and pedagogical knowledge.

For the STEM ALP lessons, two STEM educators, trained by the Science Centre, were assigned to each school. The STEM educators help to customise the programme to the school and help with the facilitation of the lessons. After two years, the Science Centre would pull out the STEM educators from the school, and the teachers would have to facilitate the lessons on their own. The STEM lessons made use of the Arduino, an open-source platform used for building electronics projects. The user would ideally need some basic understanding of electronics and programming although it was not totally necessary, as the main idea behind it was that the user would start learning how to use the platform by doing and by experimentation. Most of the teachers did not have prior experience, and most were uncomfortable with not having basic knowledge of both electronics and programming. Not only is preparing for lessons time-intensive, they did not have the time to start experimenting on their own. As a result, they needed the support of the STEM educators. One teacher explained "ALP is not like teaching in class, we take the textbook and we just start teaching". Another teacher was worried that once the science centre pulled out the STEM educators from the school, they would have trouble coping. To get around those problems, school leaders encourage the teachers to look for training opportunities and most importantly to collaborate and learn from each other. He says that the "most important thing is to build a culture of collaboration. It's not just me dishing out the resources, but we are all experts together. I am the HOD, but I'm not an expert in everything, so we tap on each other's expertise, so we try to build a culture of sharing, we share all the resources". School leader T described how the school tried to manage teacher training, by starting small with one department and conduct regular training sessions with not only the students but also with the teachers.

Of crucial importance in making-centred learning in terms of pedagogical approach is a shift away from dispensing ready-made knowledge to an environment that facilitates exploration. It appears that not all teachers are ready for this pedagogical shift. Some teachers adopted a more task-oriented approach and were conservative in giving the students autonomy. For instance, they reminded the students to "sit down and listen", when students were discussing amongst themselves. A facilitator felt that it was difficult for some teachers to give students autonomy as "Teachers being teachers want to feel that they are being in control, want to have a sense of reassurance of what is going on".

Also, learning in such spaces goes well beyond traditional classroom teaching, emphasising the role of non-hierarchical participation, where learning does not just reside in a single authority (i.e. the teacher). We noticed that some students were learning very quickly, and their understanding of the subject matter was more than that of the teacher's. Some teachers were very uncomfortable with the fact the traditional roles of teacher–student relationship were being subverted.

5.4.2 Leadership

The requirement for strong and visionary leadership is important in supporting educators in introducing or expanding making-centred learning. For all three schools, the vision of the school leaders, both present and past, plays a crucial role in the possibilities of establishing and implementing of making-centred learning. The central notion that the school leaders shared was that the idea of making-centred learning was explored to meet the learning needs of students with different learning styles. The school conducted their own research internally and found that making-centred learning could "allow students to have platforms to catch on what they are interested in at such a young age".

With the school leaders' understanding of the importance of such learning spaces, they ensured that the involvement and empowerment of staff were necessary, and where necessary, to provide support for changes to grow from the willing participation of all teachers. For instance, one school would encourage the ownership of making-centred learning in all departments. The school leader had to convince and encourage all teachers from all departments that making-centred learning was essential for students to pick up 21st cc skills. They realised that older teachers who were more conventional were more resistant, while younger teachers who were more daring and willing to try new approaches, were not so experienced and lacked subject knowledge. The school's strategy was to adopt a "community of learning", where they would organise discussions and deliberately break the teachers into groups and mix the young and old teachers together. They found that these discussions as a group on teaching methods were effective as the teachers could influence and learn from each other. From the discussions, the school leaders, as well as the older and younger teachers, got to understand each other's "mental models". The school leader observed that from the "community of learning" it evolved to "a community of sharing" and from there, a "sharing program" where all departments have teaching packages so they work in groups to develop teaching packages. He cited an example: "The older teachers will say, 'I don't know computers very well, I am not a digital native', the young teacher will say, 'Never mind I will do this package for the class, I'll share with you' …. through the community of learning we also have a community of sharing so of course … all should have sharing program and all departments have teaching packages so they work in groups to develop teaching packages".

5.4.3 *How Making-Centred Learning is Conceptualised and Implemented in Schools*

Because teachers are the primary implementers of making-centred learning, they play a significant role in ensuring a smooth transition between the intended and implemented making-centred programmes. Teachers' acceptance of change and level of commitment are crucial to successful implementation. Before the teacher officially does the implementation, they need to process and operationalise the new initiatives. The ways in which school leaders communicate with teachers are instrumental in the teachers' execution of initiatives. School leader D shared that having dialogue sessions with the teachers is important and that the school is very "mindful" before rolling out any changes. He says: "Teachers experience school leaders first. MOE has a lot of policies but how we want to roll it out in the school is something we cannot take .... Because if you don't think through and you are very careless in rolling out certain policies, you will affect the teachers. And that will affect the students".

Allen and Penuel (2014) have called attention to the role played by wider contextual factors, such as examination demands and curricular constraints, in influencing or affecting the ways in which a teacher expressed or enacted their beliefs or understandings in classroom practice. The following excerpts demonstrate how these examination demands have affected teachers' perception: "No matter what we do, we must always remember students are taking their exams and it's the results that bring them to the next phase of their life. They can be very good, but the 'o' levels cert won't say this student maybe 25 points but ALP excellent. It's not written there".

Ultimately, it appears that the grades that students will graduate with are of paramount importance:

> The process is important, the deliverables are also important because ultimately they have to meet the exam requirements ....So as educators we must always go back to our KPI. .... Of course we want to equip them with as many skills as possible. Cannot - results never mind, government say focus on skills.. they do need the results at last in these few years.

Teachers are also concerned about the expectations that they need to fulfil as a teacher and the repercussions if they were to adopt a non-traditional pedagogical approach:

> I think teachers have syllabus to teach, they have expectations to fulfil. You tend to be more guarded when it comes to instructions. So there's still this teacher mentality... especially with the older teachers, that if I don't open my mouth and give them the knowledge they won't learn.

The ministry has addressed that these perceptions have made STEM ALP a non-examinable subject, a move that educators deem "reassuring". Teachers are generally appreciative of this move by the ministry and one commented that "students will probably be more receptive towards ALP since they're not being assessed". Still, teachers did feel that a balance was needed in terms of assessment and some form of assessment should be in place to get students "a bit more interested in whatever they are doing. To get them to take it a bit more seriously but also to give them feedback. To let them know if they are on the right track". A teacher commented that some students did not take ALP seriously as it was not graded and would work on developing a qualitative assessment system that would provide some feedback for the students. He explained: "The feedback is very important if not they just play around and then go off. We want them to take away so after going thru, playing exploring, understanding what's the take away. We want them to internalise, verbalise".

Apart from making ALP lessons non-examinable, educators were keen to make STEM ALP lessons more "fun for the students". One tactic was to ensure that the physical space of making-centred learning is catered for

> the [normal] classroom and the ALP classroom is different. Normal classroom is like a square box. Students sit in neat rows and columns whereas in ALP its very modern. It's painted orange because I read that orange stimulates creativity and the tables are all hexagonal. …... Then it's air-conditioned... Even the tasks given are different.

5.5 Conclusion

Our research affords the investigation of making-centred learning spaces as avenue in formal Singapore school settings for students to establish their interests, to regain their individual agency and to possess the knowledge, skills and means to accomplish their designs. A making-centred learning space could be an entry point for learning in semi-informal context, supporting meaningful learning and engaging student interest. This underlying motivation applies equally well to the structuring and design of any system, be it mechanical, institutional or social.

While school is conventionally seen as an institution of learning and not of play, we wish to shed light on how it may be possible to integrate play and learning in a making-centred environment and, doing so, make room for creativity, collaboration, self-initiated learning and intrinsic motivation, inspired by interest-driven learning. It also means being aware of the activities to develop and unify the students' understanding of various aspects of the surrounding world in the classroom (Pramling Samuelsson, 2005).

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Chapter 6
School-Based Niche Programmes in Singapore

Sau Kew Chong

Abstract In this chapter, the authors describe niche programmes as organised by schools in Singapore and their emphasis in the 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. In these programmes, learning is authentic and prepares students for skills and dispositions that are relevant to the workforce. This chapter attempts to highlight the importance of niche programmes which are sometimes characterised as sites of semi-formal learning opportunities. This relatively less documented focus of the Singapore education system presents an aspect of the schooling system that is often lesser-known to international readers. The chapter also highlights the importance of niche programmes which are sometimes seen as sites offering semi-formal learning opportunities. While not all schools across the education system are achieving well academically, each school can have a niche that potentially meets the needs and aspirations of particular students with particular interests and particular attitudes.

6.1 Introduction

Education occupies a central place in Singapore. Academics in the field of education reforms have long noted the strategic construction of the education system as part of Singapore's larger political, economic and social goal of nation building since its independence in 1965 (Sharpe & Gopinathan, 1996, 2002). Indeed, education in Singapore has vital roles in equipping its people, its key human resource in a country devoid of other natural resources, with knowledge and competencies to stay competitive in the knowledge-based economy. A brief analysis of the four phases of Singapore's education system—survival-driven (1965–1978), efficiency-driven (1979–1991), ability-driven (1992–2011), and student-centric and values-driven education (2012–)—reveals the wide-ranging nature of its developments, from

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academic to non-academic curricula and students to teachers' professional developments. Of particular interest to this chapter is the growing emphasis of education reforms in recent years on the provision of holistic education for students that have resulted in an increase in and broadening of programmes in schools. While education reforms have yielded more learning opportunities and richer educational experiences for students, the uptake on this varies across schools. An enduring response from schools since the last two decades has been the adoption and enactment of niche programmes.

The niche programmes were introduced in 2005 by the state's Ministry of Education (MOE) to support schools in developing their strengths and distinctive areas of competencies that would enhance students' educational experience (MOE, 2010a, 2011). The niches commonly reside within school activities, occurring as co-curricular activities (CCAs) such as clubs (e.g. design and innovation), performing arts (e.g. choir and dance), sports (e.g. rugby or basketball) or in non-instructional specialised programmes like design education, robotics, language and communication or environmental education (MOE, 2012a). Funded by the MOE and organised by schools, the niche programmes attempt to foster students' interest and agency in learning environments that are frequently viewed as informal or semi-formal.

The niche programmes were introduced under two major initiatives of the ability-driven education, specifically the 'Thinking Schools Learning Nation'[1] (TSLN) and 'Teach Less Learn More' (TLLM). A common thread underlying these initiatives is the focus on creating 'greater' quality in education, in particular, in generating better classroom interactions, learning for lifelong skills, developing students' character through innovative teaching approaches and strategies, and enacting these through effective pedagogies (MOE, 2007). In order to stay relevant in the globalised future, schools are encouraged to experiment, innovate, and redesign pedagogy. Programmes such as the niche programmes which involve integrating the twenty-first century competencies into co-curricular activities and leaning towards a pedagogical orientation that acknowledges diverse talents, abilities, and multiple ways of meaning making are gaining currency in schools. Hence, while not all schools across the education system are achieving well academically, each school can have a niche that potentially meets the needs and aspirations of particular students with particular interests and particular attitudes.

This chapter will provide a detailed case account of one niche programme that has been integrated into a school-based co-curricular activity. 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 serves as a niche programme. As a precursor to understanding the case study, a review of the literature on what counts as niches in the school setting will be presented first.

6.2 Niche and Its Relevance to Educational Setting

The term 'niche' is commonly associated with metaphors like 'specialisation', 'uniqueness', and 'market segmentation'. While a study had been conducted on niche areas in Singapore schools (Goh, 2006), the focus had been on the development of school niches rather than an in-depth investigation of a school-based niche. Goh's (2006) work examined how the niche theory, which has widely been used in the field of marketing, is applied to the education system in Singapore. Niche marketing, as Goh defines it, is a specific form of marketing with its own type of customers and products. While the market share may be small, Goh, citing Linneman and Stanton's (1991) concept of niche in expanding marketing influence, argues that the adoption of niches can benefit organisations which are not performing well to thrive in a highly competitive and saturated market environment. A key feature of niche marketing that is worth noting for understanding school niche programmes is specialisation. Specialisation accentuates the distinctive competencies of an organisation (Goh, 2006), making it different from its competitors and allowing it to survive in the market.

In the educational context, the strategy of specialisation or differentiation has also been taken up by school leaders as a means to respond to competition in a productive way. In Jabbar's (2015) study that looked at strategies which school leaders used to compete in the market-based reforms in New Orleans, she noted that schools buffered competition by either engaging in monopolistic competition or by creating a niche. The latter may take the form of developing specialised programmes which may be academic or non-academic programmes within their schools. In some cases, the schools may involve their whole school to fill a niche (Woods et al., 1998). Such strategies to establish niches in schools may provide parents with more choices and promote better matches between students and schools (Jabbar, 2015). In fact, Jabbar's study found that schools, which offered some form of niche programmes or specific extracurricular activities (the former name for school-based CCAs in Singapore), were able to cushion themselves from competition with other schools for students. Conversely, the complete focus on academic curriculum and exclusion of niche extracurricular activities tended to limit schools' ability to compete. Yet, despite the instrumental value of niches and their ability to reduce competitive pressure between schools, Jabbar's study did not reveal an explicit correlation between the uptake of niche programmes and educational quality though she observed that the motivation for taking up niche programmes could still be triggered by the belief that niche programmes can contribute to the academic curriculum.

6.2.1 *Niche Programmes Within the Singapore Education System*

In contrast to niches in market-driven school reforms, as discussed above, school-based niches in Singapore stem from the perspective that greater diversity of schools could potentially give students more learning opportunities and possibly multiple and varied areas of excellence. According to the MOE (2012a), these niche areas can be in the domains of sports, aesthetics, information and communication technology, character education and environment education. Conceptualised originally as the Niche Area Scheme in the 2001, the niche programmes are envisioned to provide a variety learning opportunities yet distinctiveness to the school system and to allow students to enroll in the school's chosen niche where they have special talents or abilities (Teo, 2000). In so doing, this would also create greater flexibility in terms of widening school admission policies, particularly for students with talents or abilities but lack excellent academic results.

Within the education system in Singapore, nowhere was the idea of niche programmes articulated more prominently than in the student-centric values-driven phase. The theme of school-based niche programmes was revisited and identified by the then Minister of Education Heng Swee Keat during the Workplan Seminar (2012) as a platform for developing interesting activities (e.g. visual arts, wushu, and environmental education) that would provide students with a learning experience different from that in classrooms. Crucially, niche programme could serve as a site to help students build social-emotional skills. This approach is consistent with the MOE's overarching vision of achieving '*Every School a Good School*' by creating diversity among schools where each school has its own niche and peak of excellence. The idea of developing niche programmes in schools has also been actively tapped into as a means to imbue students with values and 'soft skills' like respect, resilience, perseverance and integrity. As of 2012, there were 191 or about half of the schools in Singapore had a niche area; the goal was to have every school to have a recognised niche as a way to spur students to excellence (MOE, 2012a, b). The MOE has been steadfast in this endeavour and has committed $55 million over the span of five years to support schools in developing their niche area (MOE, 2012b).

6.2.2 *Informal Learning in Niche Programmes*

Given the affordances of learning opportunities in niche programmes and the emphasis on holistic nature of learning in school education, learning that resides within classrooms and class time-tabled hours alone are less likely to support activities that are increasingly valued as lifelong and lifewide where learning, in the case of the latter, occurs in multiple contexts within a student's life like the school, home or the community. In this regard, it is helpful to think of organising learning beyond the traditional confines of formal didactic instruction or outside of the formal official educational establishments. A plausible response to this has been the adoption of informal learning, resulting in a growing interest in studies on informal learning, and exploring what counts as learning in everyday life, including how everyday strategies can be drawn upon in educational setting (see Livingstone, 2001; Papen, 2005; Colardyn & Bjornavold, 2004). Suggesting such an approach can provide schools with some ideas for improving or strengthening the support for student learning.

While interest in informal learning has been strong over the past decade, the term has been defined differently depending on the research perspective one takes. Writing with a perspective on directive control of learning, Livingstone (2006) views learning as a continual process and any form of learning—formal or informal—can be identified based on the primary agency ('*Who is the teacher?*' or '*Who is the learner?*') and the type of knowledge structure (Is the knowledge *pre-established* or *situational*?). From this perspective, informal learning is defined as any activity that involves the pursuit of understanding, knowledge or skill without externally imposed curricular criteria (Livingstone, 2006). This form of learning may occur in any context outside of the standard curricula established by institutions of authority such as a university. Learners in informal learning have a great deal of control over the objectives and content of what they are learning, the processes of acquiring knowledge and how their outcomes are to be evaluated. Accordingly, two types of learning have emerged: self-directed learning and collective learning.

In contrast to Livingstone's model of informal learning that places emphasis on the regulation of learning, Rogoff et al. (2016) focus on how informal learning is organised in a particular environment. Rogoff et al. question the reductive definition of informal learning as simply 'learning that occurs outside of schools' (p. 357) or 'an alternative to formal, didactic instruction' (p. 356). They argue that '*how* learning is organized and supported' should take precedence over '*where* learning occurs'. For Rogoff et al., the conception of informal learning takes into account the following features:

(a) Informal learning is non-didactic but interactive and is embedded in meaningful activities, serving a real purpose.
(b) Informal learning is motivated by learner's initiative, interest or choice rather than being imposed upon by external demands.
(c) Informal learning does not involve assessment external to the activity.
(d) Informal settings have learning and innovation as goals.
(e) Informal learning settings provide guidance to newcomers through social interaction and/or the structure of activities to encourage newcomers' participation.

Added to the above features of informal learning, Rogoff et al. outline several informal settings that vary in their degree of focus and ways of engaging play, instruction, collaborative or individual activity, contributing to 'real' productive goals and linking with larger community. This understanding is relevant in the extension of the dichotomy of formal and informal learning. The data of the study on which this chapter is based suggests that in addition to the two distinct categories of formal and informal learning, we need a concept of semi-formal learning to examine the learning phenomena in niche programmes or school-based CCAs which contain elements of both formal and informal learning of varying proportions interacting with each other. It is worth noting that Rogoff et al.'s work on informal setting also include the aspect of formal learning though this is less emphasised. A few of the informal settings which Rogoff et al. outline are voluntary settings with an institutional focus like after-school programmes, innovative schools focusing on children's initiative and choice, and institutions that embrace both instructional and voluntary leisure focus such as science centres.

6.2.3 Social Learning as Investigative Lens

Within the field of learning research, different versions of social learning have been posited, most notably that of psychologist Bandura (1977) who sees it as learning through observation or imitation and that of Mark Reed and his colleagues (2010) who view social learning as a change in understanding that arises from interactions with others. This chapter draws mainly on Lankshear and Knobel's (2011, 2013) concept of social learning, as first articulated by Brown and his colleagues (Brown & Adler, 2008; Brown et al., 1989).

Lankshear and Knobel's version of social learning problematises the conventional distinction between knowing and doing, assuming instead that our understanding of concepts and processes is socially constructed through conversations about the matter in question and through grounded and situated interactions. This perspective focuses on how we learn rather than simply what we learn, thus bringing to the fore learning activities and human interactions around which the meaning of activities is created. Learning is therefore seen as participatory and collaborative.

Social learning is distinguished by two features—'learning about' the subject matter and 'learning to be' a full participant (Brown & Adler, 2008; cited in Lankshear & Knobel, 2011, p. 218). Such learning experiences are acquired through the process of legitimate peripheral participation and are integral to 'mastering a field of knowledge' (Brown & Adler, 2008, p. 19). Becoming a full participant in the field requires one to learn not just the relevant content and concepts but also the ways of acting, talking, and being of established members of the field's community of practice.

For Lankshear and Knobel, the symbiotic relationship between 'learning about' and 'learning to be' contributes to 'deep learning'. 'Deep learning' is conflated with 'real understanding' which involves applying one's knowledge, including transforming such knowledge for innovation (Gee, 2007; as cited in Lankshear & Knobel, 2011, p. 219). This suggests learning as demand-driven, motivated by passion and need(s), which according to Brown and Adler, involves participating in the practices of the community through what Dewey called 'productive inquiry' or through the process of acquiring relevant knowledge and skills 'just-in-time-and-just-in-place' to carry out particular tasks (Brown & Adler, 2008; cited in Lankshear & Knobel, 2011, p. 220).

6.3 Methodological Approach

The niche programme that operates within the school-based CCA, Design and Innovation Club, is drawn from a larger ethnographically informed study that investigates what counts as school-based CCA participation. This methodological approach foregrounds the contextualising features of the research under study such as the niche programme or CCA curriculum, school culture, teacher roles, and the ways of participating in CCAs, including its niche programme. These features were examined to provide an analysis of CCA discourse using concepts of social learning and informal learning. Drawing on the use of multiple research tools—participant observations, semi-structured interviews, observational fieldnotes, and artefacts—the ethnographically informed discourse analysis generated insights into the meanings of CCA or the school's niche programme from multiple stakeholders and insiders' views, thereby capturing a range of phenomena that were reflective of our perspectives as researchers as well as those of teachers and students.

6.3.1 The Case Study: Design and Innovation Club

Design and Innovation Club was started about a decade ago with the aim to provide students at Handley Secondary School (HSS; a pseudonym) with learning experiences beyond the classroom academic curriculum (Wong, Teacher Interview, 19/07/2013). A range of projects, competitions, and accolades characterised this CCA club which was also the school's niche. Each year, the club members participated actively in a few major projects which were organised by the tertiary institutions in Singapore. The members were distributed across different projects, all of which culminated in competitions. Once a competition ended, the teacher in charge became deployed to oversee a new project while members moved to and participated in another project of their choice. At the time of data collection, there were three ongoing projects. One group of students prepared for Formula One (F1) in School Competition, another group worked towards the Green Competition, and the last group worked towards the Earthquake Competition.

Our visits to Design and Innovation Club revealed students working intensively in their respective teams of three or four. The students who were working on the Green Competition and Earthquake Competition had to build a structure using materials provided by the organisers on the actual day of competition. We noticed that the students often built, experimented with and configured and reconfigured their structures till they obtained the most strategic one during their CCA sessions. As part of the preparation for their competition, the members from the F1 in School Competition and the Green Competition created presentation slides and developed their team's portfolio. The members, who were preparing for these competitions, were often seen in pairs or threes reading, designing and editing on their computer screen while at the same time discussing with their peers aspects of the tasks which they had to do for their competition. While the teachers who took charge of the club or niche programme were physically present during every CCA session, their role was often less visible whenever the students discussed about their CCA tasks or competitions.

Based on the theoretical framework and the data gathered through classroom observations, interviews with teachers and students, and artefact analyses, CCA or the situated niche programme can be construed as a social practice since it is an activity involving people and institutions (school, tertiary institutions, and the MOE) and is culturally distinctive of the schools in Singapore. Within this sociocultural frame, the notion of context can be used to interpret how activities within the club or niche programme are enacted at the school and what purposes they serve. Bloome et al. (2008) define context as

> … a set of socially constructed relationship among one event and other events, among people in one place and people in other places, between one social institution and another social institution, between one time and other times, and so on (pp. 30 – 31).

Drawing on this notion of context and the key features of social learning, the club or niche programme's activities are examined as contexts for identity exploration.

6.3.2 Context for Identity Exploration

In line with Brown and Adler's (2008) emphasis on the importance of 'learning to be' a full participant in the field's community of practice, this section demonstrates how participation in the school's niche or CCA goes beyond 'learning about' the subject matter to explore their identity and/or identities.

Passion is an integral motivating force in supporting students through several competitions every year despite the complexity and intensity of each project. In our interview with Mrs. Wong, one of the teachers who took charge of the niche programme of Design and Innovation Club, she commented on the influence of passion on her club members.

> I think it's the passion that keeps our CCA going. The students may not like books but if you focus on their interest – fire their interest, they will look for it. With the kind of the support you give, they will build on it. With the success that comes with the prizes and recognition, their self-esteem goes up. Over the years, I have seen students developing in this way. (Mrs. Wong)

When prompted on whether the absence of competitions would make a difference to her students' participation, she went on to hypothesise.

> I think the interest will still be there. If you ask them to sit, do and read in class, they will really feel bored. If you engage them in doing all these CCA tasks, they find learning meaningful. So, even though there is no competition, if we give them a project, they would be most willing to embark on it and then learn from it. (Mrs. Wong)

The notion of passion, in part, explains why members would commit themselves to their project willingly and diligently even if there were no competitions. This finding corroborates with the fieldwork data of students spending their extended CCA and after-school hours at their workshop, preparing for their competition every day with their team members.

The data gathered also reveals other types of dispositions that arose from students' participation in their CCA and niche programme. Accounts from Jan, as indicated in the transcript below, show how traits like perseverance and persistence were developed from her participation at the niche programme of CCA. Jan, a secondary three student, shared aspects of her learning experiences with the researcher while preparing for the Green competition.

> Researcher: When you were in secondary one, you participated in several competitions. In what ways are these competitions very tough for you?
>
> Jan: Whenever we did the stuff wrongly, we need to redo the whole structure that we were constructing.
>
> Researcher: So, you have to get them right?
>
> Jan: Yes.
>
> Researcher: And arrive at the perfect structure?
>
> Jan: Yes. If our seniors [students in Secondary Three or Four] found anything wrong, they would ask us to redo everything.

This brief exchange provides a glimpse into one of the ways in which Jan had been socialised into becoming meticulous, persevering, and persistent through her participation in a series of competition-driven activities, especially in 'correcting' and refining the structure that she had built. Prior to our interview, Jan also recalled how she had initially wanted to give up building the structure she was working on after several failed attempts to get the 'right' one. However, Jan persisted. She said, 'I persevered and kept thinking of ways to configure and improve my structure to withstand the maximum weight. I did it!' (Student Interview, 23/08/13).

Jan's case illustrates how learning experienced within the school's niche or CCA club can enable one to explore different identities—from a novice, on the periphery of established members' (Jan's seniors) practices, learning how to build a 'perfect' configuration and becoming an experienced member who had persevered and striven to improve the structure for the competition without having been told to do so.

In the context of identity exploration, passion and persistence, as we have seen here, are vital attributes that contribute to members' successful participation in competitions at the club or school's niche. Embracing these elements not only shapes, reinforces, and gives meanings to students' roles and responsibilities within their club, constituting them legitimately as members of their CCA, but also identifies them as members of being part of the larger school's (Handley Secondary School) community. Thus, the students within the niche programme of their CCA club are seen less as solitary individuals working towards competitions.

A slightly different case of how members are being enculturated into the communities of practices of the club is seen in the retrospective account of Dan, a secondary three student who was preparing for the Earthquake Competition. In the exchange below, Dan elaborated on his participation and experiences with the club.

Researcher:How do you feel after participating and winning competitions?

Dan:I guess it's helping to build my character. I learn that I can't rely on other people.

Researcher:You have become more independent?

Dan:Yeah. I am a senior now. They [Dan's juniors] need to rely on me. It [CCA] gives me more responsibilities.

Researcher:Does it change you as a person?

Dan:Yes. I have started to speak up more and articulate my ideas.

Researcher:Can I say that you are more vocal now with your ideas?

Dan:Yeah.

Researcher:Is there anything from your CCA that helps in classroom learning?

Dan:I think it's my Biology class. My Biology teacher won't feed you with answers so you actually have to say your opinions. So usually in classes, there will always be debates. If I didn't have the confidence that I gained from D and I [Design and Innovation Club], I don't think I could actually voice my views. I guess I have found myself in a way. It is only through D and I that I realise that I can only do better if I am confident.

The transcript in the above reveals how Dan views his involvement in the practices of his club or school's niche as having enabled him to become a more independent, responsible, and confident person. Dan also attributed his confidence in taking decisive stances in his Biology class to his learning experiences gained from his club, hence allowing him to participate more fully and effectively in his lessons. This building of confidence and movement beyond the boundary of the community of practice of his CCA to that of the academic class was facilitated by the fact that the classroom in question valued and promoted an inquiry-based approach towards learning. It may be said that CCA supports specific traits to be developed and such traits have currency in disciplinary academic learning, as seen in the example of empowering Dan with the confidence as a resource for acting, talking, becoming, and being a member of his Biology class.

Dan's account also demonstrates how CCA can serve as a context for allowing its members to nurture particular qualities in others through particular roles and responsibilities they assume. Dan's recount in the following transcript shows how he supported one of his team members while the team member was struggling with the decomposed task of cutting pieces of wood for the structure of a model to be built.

Researcher:How do you relate to your Sec 1 and 2s in your club now?

Dan:My method of leading is actually talking to them like a friend. My peers told me that I need to get my juniors practise what they are bad at. I can't really lead this way. I support them from the back.

Researcher:That's interesting. Can you say a little bit more?

Dan:For this Earthquake project, you cut and glue all those stuffs. I found that one of my juniors is really good at gluing, even better than me at one point! But, he is really bad at cutting, especially those small dots. Then, I felt that I should give him a bigger job to make him feel more important and make him feel more confident since he is good at gluing the parts of the structure together. I did and now he is actually doing well!

The interview data sheds light on how a member of the club acquired the established practices of CCA (e.g. becoming confident) from an experienced member not only through the process of legitimate peripheral participation but also through an acknowledgement of his strength as significant to the overall team's goal of winning competition. Dan's recount shows how he, as a full-fledged member of the club, developed and enhanced the strength of a beginner by being a mentor to him. Dan capitalised on his junior's strength—gluing—and assigned him a larger task that illuminated his (Dan's junior) strength rather than focusing on the latter's weakness. The larger task, evident from the data, has the effect of enabling his junior to see the relevance of doing the smaller part, specifically by gluing the parts of the model structure. Dan's approach resonates with our earlier account of Mrs. Wong foregrounding the importance of providing relevant support to students to develop their interest. Dan's support to his junior expounds on this, as seen in his recognition of what the latter *can* do and achieve, rather than focusing on his junior's deficit. In Dan's view, this move consequently built his junior's confidence and self-worth.

This insight suggests how confidence can be reproduced (from a novice to becoming a full participant) through member participation in the club. It is crucial to note that the way in which confidence is recontextualised and reproduced across different learning sites, both through space and time, is not replicative but is adapted and negotiated and has the particular effect on 'facilitating ongoing learning', expanding on the previous knowledge (Hager & Hodkinson, 2009, p. 620).

6.4 Conclusion

This chapter has illustrated how one niche programme operationalizes within the informal and semi-formal contexts of learning of school-based CCA, providing students with learning opportunities and experiences, and preparing them with the skills and dispositions that are becoming highly relevant for the twenty-first century workforce. The varied accounts 'soft skills' from the examples of Jan and Dan suggest the possibility of drawing upon niche programmes or CCAs as resources for developing students into what the state envisions—a confident person, self-directed learner, concerned citizen and active contributor (MOE, 2010b). Such desired outcomes of education are indeed very much appreciated in the knowledge economy of the twenty-first century where participation at schools and workplaces has become increasingly dynamic, involving shifts of identities yet maintaining attributes that define who a person is.

In closing this chapter, I call for greater attention for research and practice in investigating the extant school practices like the school-based co-curricular activities, niche programmes, fieldtrips or even work with the community. Such places can serve as integrated platforms for building one's dispositions, seeding the interest for developing passion for disciplinary academic learning, and mastering a skill or craft in an authentic way. Often typified as informal or semi-formal learning, this form of learning inherently thrives on personal networks such as those involving students of different age groups or academically streamed classes in schools and between mentors and students. The mentors can be former students of the schools, school counsellor or an expert related to the niche area of the school. Future research can explore how people in such networks support students to bridge learning in informal or semi-formal context with that in formal setting.

Note

1. The 'Thinking Schools Learning Nation' (TSLN) and 'Teach Less Learn More' (TLLM) are two initiatives introduced in 1997 and 2005, respectively. While TSLN argues for the provision of conditions for lifelong learning and embracing the innovative spirit for sustaining the continued success of Singapore (Goh & Gopinathan, 2008), TLLM exhorts educators to reconceptualise the role of teachers and their teaching in light of the educational developments that have emerged since the mid-nineties.

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Chapter 7
Exploring Out-of-Classroom Structural Affordances for Learning: A Case Study of a Co-Curricular Activity

Yusuf Osman, Imran Shaari, and David Hung

Abstract The study delves into how the structures afforded by an out-of-classroom structure within the schooling context enables an authentic learning experience for students. This chapter examines why and how the structure-and-agency afforded by both the activities in the out-of-classroom structure and the agency of the person(s) involved produced a productive relationship, and hence an authentic learning experience.

7.1 Introduction

Many researchers agree that individual's learning varies significantly across contexts as each individual has differing abilities in solving different problems ranging across different settings (Lave et al., 1984; Nasir, 2000; Saxe, 1991, 1999). In schools, for example, learning can take place around formal environments like in classrooms, laboratories or lecture theatres. The benefits include providing real interaction between the teacher and the students with the teacher available at hand to give the on the spot practical help to students and help address any students' queries. Students would receive immediate help and support in helping them correct their mistakes in the classroom's assignment as well as help in getting the right answers for the topics being taught by their teacher. However, there are limits to learning effectively in such formal environments. For example, it is difficult to teach students effectively tacit skills such as collaborative and communication skills in the classrooms where real-world learning experience is limited (Duffy & Cunningham, 1996).

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Learning that took place informally outside of the structures of formal environments, on the other hand, might plausibly be an avenue for the learning of such skills to happen effectively (Hung et al.,). These works adopted the social constructivist notion that knowledge is socially constructed as a meaning making process, situated in the coupling between the agent interactions and the environment (context). They further suggest that the coupling can offer bridging between the formal and informal learning where active agents act as brokers, emphasizing structures that oriented the learners towards their potential by leveraging on their prior experience.

While study in the realm of formal and informal learning focuses on the cognition and meta-cognition that enable the bridging of the two contexts (Hung et al., 2011, 2012a, 2012b), our exploratory study reports structural affordances enablers as the impetus for the coupling between contexts to possibly happen. In particular, Co-Curricular Activities (CCA)—activities in Singapore's schools undertaken by students outside the class timetable but are not part of high stake examinations—is the focus area of study. CCA offers an important feature because it enables students with greater volition to experiment and explore without the pressure of performing for grades. Our assumption is that students performing CCA activities are more willing to take risk as opposed to when they engaged in graded classroom activities.

7.1.1 The Niche Programme Policy in Singapore

Since 2005, to create diversity within the schooling system in Singapore, the Ministry of Education (MOE) has been encouraging mainstream secondary schools to develop Niches in particular fields they are strong at in an effort to cater to the diverse capabilities and talents of its students (MOE, 2007). The Niche Programme supports mainstream secondary schools with good development programmes in their Niche. These schools can admit up to 5% of their secondary one students intake on a discretionary basis through the Direct School Admissions exercise. This enables a more diverse range of students' achievements and talents to be recognized, beyond the academics. Schools that obtained Niche recognition from the MOE are able to receive an extra funding of $150,000 every 3 years to develop its Niche (MOE, 2012). In order for a school to obtain recognition from MOE as having a Niche in a particular area, the school will need to demonstrate a very strong potential in, and have a proven track record of achievements in its declared Niche, have in place a comprehensive and workable development plan to ensure the Niche continues to be sustainable in the future and show that they have a set of selection criteria for discretionary places which is transparent and merit-based (MOE, n.d.). We will be looking at one of the mainstream secondary schools in Singapore that obtained its Niche status in 2013 and investigate its student's development within its Niche area that it is highly focussing on as a school.

7.1.2 CCAs in Schools

Co-curricular activities (‘CCAs’), under the purview of the Ministry and schools, are an integral part of the Singapore education system (MOE, 2011). CCA is a platform that consists of activities that students took part outside of the formal classroom curricular hours and beyond the physical space of the classroom but yet are still within the purview of the school’s authority. Students participate in at least one CCA from the following categories: Sports and Games, Uniformed Groups, Performing Arts Groups, and Clubs and Societies. CCAs are intended to help nurture qualities such as resilience, tenacity, confidence and perseverance (MOE, 2011).

The wide-ranging activities offered to the students through CCAs allow students’ learning to be maximized as they are actively engaged and work collaboratively in activities such as sports, performing arts or robotics club (Ash & Clayton, 2009). Learning in CCAs may take place in an authentic physical space (e.g. an internship in an engineering or a business firm) or a simulated space through experiential learning sites (e.g. Makerspaces in schools or museums) or virtual worlds. Such learning involves demolishing the epistemological divide between knowing and doing, experiencing knowledge acquisition and creation by operating on materials and knowledge in a complex, authentic and situated setting. In this chapter, we would like to unpack the learning that takes place in CCA.

7.1.3 The Case of Henderson Secondary School

Henderson Secondary School (HSS) is a mainstream secondary school established in 1974. It is located in a neighbourhood with a number of rental flats around it and attracted primarily students from its neighbourhood. The students came from largely the lower to middle socio-income group in the area. The school was recognized by the Ministry of Education (MOE) in April 2013 for having a Niche programme in Design and Innovation. Since 2009, the school has worked out and implemented its Design and Innovation (D&I) programme for its lower secondary students with the view to nurture students who embrace excellence, creativity, innovation and enterprise that is founded on character development and the school’s values of honour, hard work, helpfulness and healthfulness.

The school develops a (D&I) programme for its students by collaborating with Singapore Polytechnic’s School of Architecture and Built Environment. Singapore Polytechnic has trained its teachers for 3 consecutive years after the first pilot training in 2009 to come up with a (D&I) programme suitable for its lower secondary students. The (D&I) is a 30 hours programme where teachers teach students the design thinking methodology (IDEO, 2015) as well as communication skills. Apart from having a specially designed (D&I) programme that is catered for its lower secondary students, the school also organized an annual (D&I) carnival held on its premise where it allows its students to display the skills they derived from participating in the programme.

The school also infuses design thinking, a way of thinking inculcated in the Design and Innovation programme through other academic subjects such as mathematics and science as well as co-curricular activities (CCAs) such as modern dance club, Info Media Club and Design and Innovation Club. For example, in the Info Media Club, students went through the design thinking process of discovery, interpretation, ideation, experimentation and evolution in order to create videos for competitions participated by the club. This process helps them to select a topic, share prior knowledge, craft interview questions, craft action statements, brainstorming and experimenting with a storyboard by experimenting with different techniques, angles and lighting.

A CCA that the school offered that practises design and innovation rigorously in its programme is the (D&I) club. Students in this CCA usually participated in competitions such as National Earthquake competition, Clean Water Challenge, Introducing and Demonstrating Earthquake Engineering Research in Schools (IDEERS) as well as F1 in schools competitions. Students in this CCA are required to work collaboratively in teams to solve a simulation of real-world problems and then make an oral presentation to the judges. The school has won many accolades in such competitions winning awards such as Merit Award and frequenly came in 1st or 2nd position in such competitions. In particular, the school has represented Singapore consistently internationally in the F1 in Schools Worlds Finals from 2010–2012 (Henderson Secondary School's Website).

In this chapter, we will focus on studying a final year student in Secondary 4 who has went through the Design and Innovation programme, has been in the Design and Innovation Club since Secondary 1 and has actively participated in F1 in Schools competitions since he first enrolled in the school. We will study how his participation in his CCA and in particular his participation in F1 in School competitions have inculcated in him twenty-first century skills such as working in teams, leadership skills and communication skills.

7.2 Literature Review

7.2.1 Classroom Structures

Classroom structure features learning that takes place within the physical classroom and within the classroom curriculum hours. Learning in such setting is usually bounded by a set of stipulated curriculum, for example imparting theoretical maths lesson in an abstract mode or through the use of analogy in the classroom or ill-structured problem (Kapur, 2010). It involves high stake academic examinations that could be influenced by past academic performances, routinized classroom practices and structured assessments.

The classroom structure is beneficial because it is physically bounded under the purview of schooling authorities and may appeal to students who were more dependent on their teachers in their learning (Lage et al., 2000). Such setting involves efforts geared to meet the standards of mainstream academic performance. While such structure is efficient in relaying textbook knowledge to students, this might be in itself insufficient to help students apply the knowledge garnered in the classroom to real, and authentic settings (Hung et al., 2011, 2012a). To supplement classroom learning, relevant out-of-classroom experiences are encouraged.

This study delves into how the structures afforded by an out-of-classroom structure within the schooling context enables an authentic learning experience for students. The chapter examines why and how the structure-and-agency afforded by both the activities in the CCA and the agency of the person(s) involved produced a productive relationship, and hence an authentic learning experience.

7.2.2 Out-of-Classroom Structures

Research have found that individuals in many cultures demonstrated complex thinking in activities outside of school that they may not easily perform in a classroom- or school-related setting (Carraher et al., 1985; Lave & Wenger, 1991; Nasir, 2000; Rose, 2004; Saxe, 1991). Out-of-classroom structure refers to the informal setting outside schools where teachers have little say and may have other players such as the learner himself, family members or out-of-school trainers who help to form the setting for students to learn. Learners may have more influence over the activities they participated in and may be able to apply the knowledge they have learnt in the classroom to an authentic setting in such structure. This setting is an inclusive platform that embraces diverse learners. For example, researchers (e.g. Rosebery et al., 2005) have found that teachers may be able to better support learning in school if they are able to build on the understanding students gain outside of the classroom. Understanding these structures may help us understand how they may be appropriated into the classroom to assist learners who may not be able to learn effectively in the classroom setting.

7.2.3 Studying the Plausibility of Interaction Between the Classroom Structure and Out-of-Classroom Structure

Our study explores possible structures that integrate both classroom and out-of classroom structures within the school boundary. While there are many benefits afforded by out-of-classroom structure to students who may not be able to learn effectively in the classroom setting (e.g. Hung et al., 2011, 2012b), it is difficult for us to observe the learning that takes place in out-of-classroom structures when it happens outside the school's boundary. This study focuses on out-of-classroom structures that are characterized by the feature of classroom structure where the activities are bounded within the school authority's parameters. However, these activities are students controlled, with no formal assessments, no fixed curriculum and no fixed pedagogy. Learning in such activities are situated, influenced by active agents within the situated contexts. Students learn situationally in music or sport practices which replicate the actual setting of these events (Northern Illinois University, Faculty Development and Instructional Design Center, n.d.). Examples include military band studio, training facilities such as gymnasium and art studios.

7.2.4 Situated Learning in CCAs

Situated learning provided the empirical premise for the constructivist approach in asserting that learning takes place in specific contexts involving real activities. (Anderson et al., 1996; Greeno et al., 1992; Lave & Wenger, 1991). It is a learning approach that is essentially about creating meaning from the real activities of daily living (Stein, 1998) where learning happens relative to the teaching environments.

Students would thus be embedded in authentic environments that mirror as much as the real world as possible while learning. Examples of where situational learning activities could happen would be the field trips to unfamiliar environments like the zoo, internship experiences where students are immersed and physically active in an actual work environment and in laboratories used as classrooms where students are involved in works that replicate actual work settings (Northern Illinois University, n.d.). In such authentic environments, every human thought is made to adapt to the environment in situated learning (Clancey, 1997). Activity, context and culture function as sites for which learning takes place situationally (Lave & Wenger, 1991) as students learn in such authentic environments.

However, the authentic environments in which a student is learning needs to be authentic and be made personally meaningful to them for them to be able to learn effectively in situated learning (Kalchik & Oertle, 2010). For example, a student would be interested to study a specific content like mathematics if they understood it as a context for which it could prepare them to do engineering mathematics in preparation for their desired professional goal to be an engineer in future.

Situated Learning also involves a site of authentic context that incorporates authentic problems. Students would be forced to develop problem-solving skills once they are embedded into the context. Authentic problems are typically ill-defined but involves emphasis on problems students might encounter in everyday life (Anderson et al., 1996). Authentic environments or contexts thus need to feature learning both the abstraction and specific concrete examples with authentic problems driving the learners to learn within a specific context. How can we understand the facilitative structures that help students to learn in authentic environments that feature both abstract and concrete examples?

7.2.5 Structural Affordances in Situated Learning

Educational literature considered learning affordances that occurred informally as a feature of situated learning (Haines, 2015; Kessler, 2006, 2007). For example, informal usage of tools and experimenting with them as a form of situated learning for teachers (Haines, 2015), independent experimentation and reflection (Paltridge, 2000). However, these affordances are individually experienced by the learner. How then are we able to understand how the environment in its interaction with the individual may help the individual learn within the context in which one is in?

Lave (1996) argues that people learn effectively not purely by putting them in situated context. Instead, people also need to be embedded in social relationships and tools to help them learn well in her study of how people used school mathematics to real-world situations like grocery store shopping. Here, we could see social relationship and tools as another affordances that a learner could partake in to learn effectively within contexts. Haines (2015), on the other hand, raised resource such as 'space to write' as positively impacting how teachers may help students to learn to use tools like blog and Wikipedia. However, how a teacher may teach the student is shaped by how the teacher has experienced herself using such tools. Experience thus is an affordance that learners could depend on to learn effectively in contexts. While the literature has discussed how one may learn alone and with others (e.g. social relationship) in contexts, there are no studies that explicitly study the design affordances that allow for the interaction between the collective environment and individual environment that facilitates situational learning.

This chapter aims to fill up this gap by exploring the structures that may enable situated learning to happen in school. To study the structures as enablers in situated learning, we are adopting Giddens (1984) 'duality of structure' to understand the structures that exist within the school as the students learned situatedly in a certain out-of-classroom structure. Giddens' duality of structure will be used to help us unpack the affordances that facilitate situated learning by students in CCAs. Through this lens, we will be able to investigate the interactive process between the social structure and agent. In using Gidden's duality of structure, we assumed that the learning that takes place in the CCA context features a reciprocal interaction between the students as individual agents and structural features of the CCA.

7.3 Methodology

The research employed a case study approach (Yin, 2003) as it enables an in-depth understanding of the kind of structure established (Johnson & Chrispeels, 2010) as students participate in the practice of an out-of-classroom structure. It was executed over six months and explored the nexus where structure and agency coalesced. The study's focus was on the corollary consequences as students participate in the Co-curricular Activities (‘CCA’) as an out-of-classroom structure situated in a mainstream Singapore secondary school.

CCA, under the purview of the Ministry and schools, is an integral part of the Singapore education system (MOE, 2011). CCA is the context in which this nexus will be investigated as it involves activities that students took part outside of the formal classroom curricular hours and beyond the physical space of the classroom, but yet still are within the purview of the school’s authority. Students participate in one CCA from the following categories: Sports and Games, Uniformed Groups, Performing Arts Groups and Clubs and Societies. CCAs are intended to help nurture qualities such as resilience, tenacity, confidence and perseverance (MOE, 2011). The CCA teachers, who are also academic subject teachers, may not have the necessary skills to conduct the CCAs. As such, schools frequently have to engage service providers from the community to serve as, for example, coaches, artists, or trainers.

The unit of analysis in this study was structure; no attempt was made to select the case for claiming generalization. Multiple data sources were used that include the school, the CCA activity, a competition the school participated and excelled in, a polytechnic the school engaged for its programme, the teachers managing the CCA and the students who participated in the competition through the CCA. We also accessed the publicly available documents with regards to the school, CCA and the competition. We conducted formal interviews (individual, pairs and groups), attended a design and innovation related carnival in the school and observed events. Interviews were used as primary data as they provided opportunities to explore the contextual richness of the interviewees’ insights that would have been missed otherwise. We also make use of documentary data, not readily accessible publicly, provided by the school in our study. Table 7.1 summarizes the participants, data sources and data collected.

We discuss the findings in terms of Giddens’ duality of structure after much coding and analysis of data and transposed it in the light of educational theories. In the light of the milieu of the twenty-first century skills, we postulate that perhaps Giddens’ duality of structure may help us learn how one might be able to manage and navigate the interaction between structure and agency particularly in the context of the CCA and through that context enables one to learn twenty-first century skills. This may help us understand how one may adapt between structure and agency.

Not all data sources are reported in this chapter while the explanations and descriptions in this chapter required the need for all the above observations and interviews.

7.4 Study Context

After much consideration, we chose to focus on the structure–agency relationship pertaining to the participation of students in competitions in which students joined as a member of a particular CCA group. F1 in Schools competition is a ‘global multi-disciplinary challenge in which teams of students aged 9–19 deploy CAD/CAM

Table 7.1 Data sources and types of data collected

Data sources	Data collected
P—Interview with principal who is familiar with the school's overall culture and strategy	School's structure which drives the type of focus each CCA might plausibly receive from the school's management
T—Interview with two teachers who are in-charge of the CCA in which most members in the school were part of when they joined F1 in schools competition	The club's structure put in place to attract and retain students in the competition
S1—Group interview with three students (14–15 years old) in the design and innovation club who had participated in the F1 in schools competition	Reasons for students joining and continuing their participation in the competition. From the student's perspective, how school structures have a role in their continued performance in the competition
S2—Interview with a 15 years old student who has been participating in the competition in the school for 3 years since secondary one and is leading the team in the competition	The structures and agential concerns of the student as he participated in the competitions throughout the times he has been participating in the competition
SP—Interview with two polytechnic staff	The relationship between the programmes the polytechnic had with the school to student's learning capacities
D1—Niche application submitted by School to the Ministry of Education	The reasons why the school select its Niche. How F1 in schools lends credence to its application for a Niche school status.
D2—Powerpoint presentation slides given by school on its programme	The overall programme direction in the school and how activities are plugged into this strategic direction
D3—Lesson plans on design and innovation lesson	How the structure planned out by the school was executed in class
D3—Public documents online	Policy pertaining to school's Niche programme and its activity. Policy on the F1 in schools competition
OB1—Observation of school environment, CCA group and the CCA room location	Reasons that contribute to students' active participation in the CCA
OB2—Observation of school's held design and innovation carnival	Details on how the activities in the carnival help improve students' disposition

software to collaborate, design, analyse, manufacture, test, and then race miniature compressed air-powered balsa wood F1 cars' (F1 in Schools Singapore, 2013). The competition was organized to offer an interesting way to learn science-, technology-, engineering- and maths-related subjects as well as to increase the intake of students taking up engineering courses and profession (F1 in Schools Singapore, 2013).

This competition thus offers schools that lack the resources needed to implement and design interesting programmes, a real alternative for its students to learn academic subjects such as science and maths in an interesting and enriching manner. The school allocated minimal budget for the competition. As the school is located in a relatively old neighbourhood with a number of rental flats around it, most of its students came from the lower to middle socio-income group in Singapore. The school has managed to win the National Championship in the F1 in Schools Competitions several years consecutively. The school had also represented Singapore several times in the World Championships in F1 in Schools competitions (Henderson Secondary School, 2013). Thus, we believe that the school's context can offer insights on how the relationship of the structure–agency operates such that it brings value to both the individual student and the school as a collective.

In making sense of what makes such a school sustained its performance in such competitions consistently and how the structure–agency relationship may manifest in such setting, we used data from interviews with the teachers-in-charge, students in the Design and Innovation Club who were involved in the competition, the school's principal and other available documentary data.

7.5 Data Analysis

The data were subjected to open, axial and selective coding (Neuman, 2006). Initially, the data were divided into smaller paragraphs that fit into manual system cards to make it more manageable. The system cards were labelled to represent key ideas of the paragraphs. The labels were analysed for similarities and clustered into sub-themes. For example, cards with labels like 'design thinking', 'collaborative journey', 'platforms', 'competitions', 'company' were put into a sub-theme called 'Collective Structures'.

In axial coding, the sub-themes were clustered and analysed. Literature on structure and agency (e.g. Giddens, 1984; Shilling, 1992) provided focus, for example Giddens' conception of 'structure' referring to a set of rules and resources on which human agents draw to enact social practices and his assertion that human agents do not have to behave as others do. This step looked for similarities between the sub-themes and the descriptions, and the underlying arguments of the literature. Subsequently, the sub-themes were reorganized into three main themes.

Finally, selective coding was performed on these themes to analyse how they linked the individual agent and the collective. We turned to Giddens' (1984) 'duality of structure', a central tenet of structuration theory, to frame the linkages between the individual agent and the collective structure that exist in our results. Giddens (1984) posited 'duality of structure' as referring to the 'rules and resources'—equally as one that was drawn upon in the production and reproduction of social practices and is itself the vehicle of system reproduction. We recognized that the 'rules and resources' were embedded within the collective structure and the individual agent structure and used this lens 'duality of structure' to investigate the resources embedded in both the collective structure and individual agent structure. Subsequently, we analysed how the resources in such structures interact using the same lens.

7.6 Findings and Discussions

Through the data analysis, we identified a collective structure that can be seen to 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.

For students, the multiplicity nudges a disposition to explore, making choices, persevering through ups and downs and being creative in managing a variety of disciplines in a particular competition. As the students draw on and use this social structure, they generate and sustain a collective competence in organizing and learning together to leverage on each other's strengths to achieve the common stated shared objective. The enactment of such dispositions, however, demonstrated differently from one individual agent to another, depending on the individual structures that have been established before the individual agent comes into contact with such activities afforded by the collective structures.

We drew from examples where the students reflected on their journey from participating in CCAs that expose them to the multiplicity of planes over time. The examples were stated as standalone and abstracted for analytic convenience. The experiences were hardly sequential, but often overlapped and interactions were complex. The researchers had asked the students, teachers, principal and partners pertaining to their experiences in the CCA that helped students propel to a high level of success. The following are examples of some quotations which have assisted us in developing the theme of multiplicity of planes. They revolved around how the students in the CCA have been able to attain a high level of success.

7.6.1 Examples of Multiplicity of Planes Imbued Within the Collective Structure

Researcher: After winning in the National Finals, your team went on to represent Singapore in the World Finals. Can you describe to us your learning experience participating in the World Finals?

Student: In the World Finals, we are the only high school participating. The rest are universities' students. So, their knowledge is more advanced than us. While we are looking around at their pit place, we talk to them. They taught us about Physics' terms—that help for the competition.

Researcher: Can you describe to us what you have learnt, apart from engineering, while participating in the competition?

Student: We do not only learn engineering but also business. For example, we have to do marketing. We have to approach companies to sponsor us. It can be monetary or souvenirs. From there, we learn and improve our business skills. We also learnt to communicate well with the public and improve our marketing skills.

An interview we had with the Principal further confirmed what had been mentioned by the students earlier. For example, in the following interview, the Principal shared with the researcher his aspiration for his students while putting them in the competition.

Researcher: What do you expect your students to realise and learn by having them participate in the competition?

Principal: Our Secondary Two and Secondary Three students competed against college students in the competition. I want them to realise that when it comes to real stuff, it does not matter where one is studying. It's a level playing field.

We also spoke with one student of his participation(s) in one or more CCAs and of working in teams. He shared with us the following:

Researcher: Can you describe the degree of your CCA participation in school, apart from being involved in the competition?

Student: This year, I was also a Peer Leader. I have to lead a Secondary One class. I was also in F1 in Schools; I was the Team Manager so it taught me to lead other people. I can then implement these skills as I lead the Secondary One(s) students. They would be comfortable with me. Since I could lead very well in F1 in Schools, I could pass these skills to my juniors too.

Researcher: What were the challenges you faced while being in the competitions?

Student: First of all, it is time consuming. Staying back after school. I had to bring my own computer to school for one to two weeks. And, there were problems with our communications. Sometimes, we may say things wrongly; maybe they (other team members) did not get what I am saying but we did manage to get along well as a team.

During the competition, we were quite nervous. Most of the time, when it is nearing the competition date, we would ask ourselves-- 'are we going to be good enough?', 'is it done?' or 'can we make more improvement?'

Researcher: What is the composition of the team?

Student: In the competition itself, there were 2 categories-- the easier category and the official category, which is much tougher. We usually put one Secondary 3 student with the Secondary 2s so that they can guide their juniors. These groups go for the easier category. For the official category, we had a mixture of Secondary 3s and Secondary 2s. But since the Secondary 3s are going to Secondary 4 next year and we have to graduate, we were not able to help them a lot. So, we are hoping to pass on our skills to the Secondary 2s. That is why we have the mixture.

Researcher: How have your teacher (s) play a role from before you participated in the competition and then while you went through it?

Student: From the beginning, the teachers scouted us. We would not know about the competition prior to this. Then, we gave it a try. It was then, that I became interested to join the competition. Our teacher has lots of experience as he has actually went for all the World Finals. As a result, he was able to share his skills with us. For example, he shared with us how we can make the car better.

The teacher we interviewed also shared equally with their students of their role in the competition, in particular from the inception of the participation of their students:

Researcher: What do you do look out for in students joining the competition?

Teacher: When we look for students, we are not looking for whether they are intelligent. We are looking at their attitude towards the way they do things. When we see they have a very

> positive attitude, we want them. Because I think, skills and knowledge can be trained. But, the attitude is something that is difficult. So, I think there are potential Normal Technical students who possessed these qualities and we want to reach out to them as well.

We have suggested that the empirical success of these students indicates that social structures imbuing multiplicity planes help student's learning of societal life skills such as being able to relate to others, perseverance and learning beyond the formal curriculum. Giddens (1984), Ashley (2010) and Shilling (1992) have discussed similar social structures as being able to reproduce itself when the individual agent interacts with it. In our cases above, the working ethos of the society were modelled and replicated by the students in the competition. In particular, Giddens (1984) introduced the concept of 'practical consciousness' to describe situations where actors found it difficult to describe what they know of their social condition to others explicitly. In our analysis and discussion above, we have attempted to show that students' success is attributable to 'designed opportunities' developed by schools in addressing structures manifested at the societal and organizational levels (Dornbusch et al., 1996). These structures were consciously accounted for in the design of the CCA-related activities.

In multi-level competitions, multi-disciplinary competitions and multi-CCAs, we have witnessed, for example, students worked together in managing communications and conflicts. It appeared that the division of labour was decided on the willingness and capability of each individual to bring resources like computers. Knowledge and skills were passed down tacitly from senior students to junior students with ease. The former have practical experience from participating in the competition previously, but it might be difficult for them to explain to the latter in words what they have went through. Putting them side-by-side allowed the 'practical consciousness' of the senior students to be learnt by the junior students, tacitly.

We thus view the designed opportunities as choices an individual agent is able to select from and are purposely organized and directed to achieve certain educational goals instead of being crafted in a haphazard and loose manner. The collective structures which we described are purposeful, with structures put in place to help any student who took part in it to, at the very minimal, achieve the purpose it was meant to be. This, however, does not mean that collective structures were static. Instead, it was persistently re-shaped by individual agent who tends to shape the collective structures as much as participating in the designed opportunities shaped him. This is in light of the framework of 'duality of structure' which we adopted from Giddens (1984) and appropriated to our context as: rules and resources where one draws on from externally. However, for an agent to be able and/or willing to start 'mak(ing) use' of the designed opportunities, we need to study the structures within the individual agent.

7.6.2 Individual Agent Structures

Giddens (1984) conception of agent's 'transformative capacity' is about individual agents getting things done through making use of available and accessible resources. For our study, strong family support stood out as the individual agents' structures of 'transformative capacity'. It was an important resource because drawing out from this resource allowed the agents to have the flexibility to join the available designed opportunities offered by the collective structure. For examples, our conversations with the students about their motivation in joining the CCAs were peppered with elements of a supportive family:

> Student A: ..the teacher asked if I would like to join as I am eligible. I then asked my parents and relatives and they said, "Oh, why don't you give it a try?"
>
> Student B: My family was actually intrigued because it's a competition they never heard of…. They were quite fascinated about it. I told them about the competition....They supported me mentally and physically because they knew that this competition is something I like. I am actually more inspired to join the CCA because of my uncle. He is now an engineer. Yes, actually, I was inspired by him. Because he says that those engineers are the ones who create everything and without engineers, nothing is possible.

Further, a student also shared his friend's experience who quit the CCA as his parents were not keen on it:

> He is not in F1 already as he was asked to focus on his studies. His family does not really support his involvement.

The findings above supported Shillings'(1992) discussion about power, the resources and rules embodied in the structure within the individual agent, from which the agent derived to intervene in social life. As rules and resources are drawn from oneself to make things work, he has the ability to coordinate and control the activities he is participating in (Giddens, 1984; Russell et al., 2011). For our study, we witnessed the individual agent's ability as 'compelled creativity', an enabling disposition of 'make do', as mentioned by the Principal:

> I mean, I strongly believe that adversity is the mother of invention. So, these are kids who came from a lower Socio-Economic Status and sometimes they do not get lots of things that others have but they always find a way to make do, come up with things, and make things. So, they have that in them. And perhaps, that accounted for why they were quite successful in many of the competitions that they took part in…

To convince ourselves, we seek input from a student about the statement and the following was mentioned:

> The expectations are quite high because in the World Finals itself, we are actually one of the two teams who are still in Secondary school. The rest are in Junior College or University. To us, even though we are still schooling in a Secondary school, we can still compete with students from the Junior Colleges and Universities and are still able to get a very good ranking in the competition.

We believed that the Principal designed his school activities purposely to leverage on the students' compelled creativity as he continues:

> Although, if you just purely look at their academic achievements, they may not be impressive academically when they were in Primary Six compared to students who came from the other so-called elite schools. So, we thought that this might be something that's worth looking at a bit more detail. So, talking to the staff and students, they all seem to think that this is an area that we could work towards…"

The students who we have witnessed as having the compelled creativity did not overtly outline their intentions. They did not consider how the CCA was going to support their academic work and then use it appropriately. As the preceding two sections illustrated, the students still benefit from the collective structures that were already available by partaking in them. The individual agent structures embodied students' lives and experiences with respect to the designed opportunities afforded by schools. Thus, these initial findings suggested overlapping or interactivity of structures within a schooling system. We offer an overview of the overlapping structures in the following section.

7.7 Implications for Learning

7.7.1 Structural Coupling (Fit)—How It Can Possibly Occur?

To explain the overlapping of both the individual agent structures and collective structures, we put forth the process of 'structural coupling'. In the process of 'structural coupling', both the individual agent structures and collective structures were seen as animate beings that actively interact with each other in the course of CCA participation. This mirrored the 'duality of structures' as proposed by Giddens (1984) where 'rules and resources' were both embedded and reproduced in the social practice. In this study, the social practice referred to was the CCA participation by the students. The social practice was enabled by the coalescement of both the individual agent structure (the students) and collective structures (the teachers, principal and programmes in school), generating positive outcomes. Students in our study were willing to 'sacrifice their time', pressured themselves to perform well in both studies as well as the competition even though they admitted that being in the competition was both stressful and was taking lots of their time. This was possible because the school had teachers who were very approachable and facilitated the students' work in school while they were participating in the competition. Both students and teachers were actively engaged and committed to the competition, and this partnership between the students and teachers works well as they shared the same level of heightened commitment to the CCA.

This deep commitment to the CCA by both students and the teachers also facilitated the students' drive to get things done independently. Students were able to get companies to sponsor their participation in the competition and generate marketing documents without their teachers' direct supervision and formal guidance. This process leads to 'structural coupling' where students were able to get things done by tapping and building on the available social capital that was embedded in the ‘designed opportunities’. For example, a student displayed his ability to capitalize on the ‘designed opportunities’ when he approached a fellow participant, a University student, during the World Finals to learn more about scientific concepts that may help his team build a better car prototype for the competition. This act elucidated his ‘adventurous spirit’ in his individual agent structure, without which, he might not have the courage to approach a stranger with assumed better knowledge than him and learnt from the later to improve his team’s car design. The active involvement by the student assisted the school as a collective structure to access social capital outside the school, such as the sponsors approached by the students. It may help the school to implement future collaborative education programmes with the sponsors.

Finding the fit on how the individual agent, through its individual structures, interacts with the collective structures by capitalizing on the ‘designed opportunities’ to benefit itself leading to a structural coupling relationship, and hence maximizing the learning experience is our desired goal.

In sum, we have projected a dialectical model on the basis of duality of structure (Table 7.2). We put forth resources in both collective and individual agent structures as pertinent tools in the ‘duality of structure’ that took place as the individual agent joins and sustains his participation. Table 7.2 may offer a more nuance approach of how the ‘duality of structure’ can be empirically studied. Future research have to delve into structures as embedded ‘rules and resources’ in the individual agent that are repeated in social reproduction. These ‘rules and resources’ are both the

Table 7.2 Dialectical model on the basis of duality of structure

<table>
<tr><th colspan="2">Collective structures</th><th colspan="2">Individual agent structures</th></tr>
<tr><th></th><th>Principles</th><th></th><th>Principles</th></tr>
<tr><td><u>Possible Designed Opportunities:</u></td><td rowspan="4">Access to diverse people as a strategic resource
Access to organized and diverse learning platforms with stated objectives</td><td rowspan="2"><u>Possible Interactions:</u>
Family’s support</td><td rowspan="5">Internal compelling—as a resource</td></tr>
<tr><td>Multi-level competitions</td></tr>
<tr><td>Multi-disciplinary competitions</td><td>An adventurous spirit</td></tr>
<tr><td rowspan="2">Multi co-curricular activities (CCAs)</td><td>Positive familial role model</td></tr>
<tr><td></td><td><u>Compelled Creativity</u>
The restricted resources an individual agent had to draw from within himself to ‘make things happen’</td></tr>
<tr><td colspan="4"><u>Structural Coupling:</u>
– Actively engaged
– Harnessing independent learning
– Tapping and building social capital to learn</td></tr>
</table>

medium and the outcome of the practices of the individual agent (Russell et al., 2011)—focusing on rules and resources as enablers rather than constraint.

7.8 Conclusion

We extend the use of duality of structure concept in structuration theory by introducing the notion of dialectical model. The dialectical model describes the features of both individual agent structure and collective structure and subsequently how both interact in the process of structural coupling to benefit both student's and school's learning in the CCA activity. The dialectical interaction (or fit) which creates a structural coupling relationship is the crux of productive learning according to our hypothesis of this chapter.

Possible outcomes from the interactivity of both collective and individual agent structures may include: increased personal disposition of students, appointing student champions and institutionalizing engaging alumni. Through the interactivity, students managed to perform well in the competition. They were able to learn time management through participation in the CCA as they were compelled to manage their time to excel in studies as well as other activities that they participated in school. Participation in the CCA also helped the students to improve their communication skills through avenues in which they were required to do presentations. Student Champions may be appointed amongst the senior students so that they were able to play a mentoring role to their juniors in the CCA. Having such Student Champions in leadership positions such as a Peer Leader or a Team Mentor may allow the school to sustain its performance in the CCA as the knowledge garnered by the senior students maybe captured and practised by the junior students, tacitly.

Students who had participated in the CCA and subsequently graduated from the school are another resource that the school have tapped on consistently to remain competitive in the CCA. Moving ahead, the school may consider institutionalizing its alumni network. This would help build a sense of deeper ownership among the alumni to the school and encourage more of them to share what they have learnt with their juniors in school.

Apart from its students, we also found in this research the importance of having resourceful teachers with the relevant CCA-skills to inspire students to learn more about the skills and knowledge needed to excel in the CCA. However, not all teachers would possess the same resources or skills. Schools could therefore establish a common platform for fellow teachers to share resources pertaining to the knowledge and resources they garnered throughout their years of experience in CCAs. This allows for easier collaboration between the school, companies and institutes of higher learning in the event the teacher leaves the school, together with all his knowledge and contacts. This may be kept within a secured school intranet system.

This research also surfaces various limitations that the school would want to look into to improve its CCA programmes for its students. The resources that the school are currently depending on maybe easily adopted successfully by others as the 'designed opportunities' were in fact programmes that were crafted by external entities such as corporate entities for the participation of others. The school depended fully on Student Champions to spread tacit knowledge gathered from their experience. This might backfire if these students were not well liked by their peers. Other students whose interest might not be in line with the school's Niche might feel left out if the school does not with equal vigour scout for similar opportunities for such students. There is also a possibility that students do not actively engage themselves in the CCA, and as a result, the CCA stagnates and the school might possibly falter in comparison with the rest of its competition. In the light of such stagnancy, the school might need to scout for more stimuli activities to motivate its students. To conclude, the study of both individual agent structures and collective structures and its interactions is useful in helping schools create sustainable programmes that are beneficial to both schools and students. We have managed to lay out the underlying principles that make such learning programmes sustain itself by studying its resources and studying its various implications.

7.8.1 Practical Implications for Schools

7.8.1.1 CCA as Potential Learning Platform for Students

In this chapter, we have shown that CCAs have the potential to create the need to learn. It is a platform that recognizes different talents, apart from academic talents. It is able to spark the interest of students to learn by providing distributed expertise in the form of designed opportunities, bringing alongside a community to support the students' activities as well as encouraging healthy competitions among the students. CCAs is thus a good learning platform for students, especially for those who are not high performers in the academics, to build confidence, work in teams and learn communication skills, all essential skills needed for the twenty-first century. CCA is a productive learning platform that may possibly be drawn into formal classroom learning to encourage productive learning amongst the students.

7.8.1.2 Drawing Links from CCA to Formal Classroom Learning

In drawing the links from CCA to classroom learning, teachers may try to create the same conditions in CCAs such as providing distributed expertise to the students, create the need for students to learn and encouraging healthy competitions in class. However, it might difficult to see such implementation in classroom learning as classroom learning can sometimes be constraining because teachers have to cover the syllabus and are limited by the assessment modes mandated by the formal schooling system.

Alternatively, teachers may try to draw productive linkages between CCAs and Classroom Assessments (CAs). Presently CCAs and CAs are quite separate. There are little linkages between the two. CCAs are often subcontracted out to vendors. Teachers in charge of CCAs do not know deeply of their students' experiences.

To address the issue of linking between CCAs' learning and CAs' learning, teachers may draw upon students' experiences in CCAs as a lead in to topics they are teaching and get students to share their CCA experiences in class as a way to connect the two 'worlds' (CCAs and CAs).

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Chapter 8
Fostering School-wide Knowledge Building Practice: Leadership by the Middle Managers

Teo Chew Lee

Abstract To deepen and sustain an innovative practice in a school, each layer of players within the organization—students, teachers, teacher-leads, head of department, school leaders, play different roles in contributing and advancing the vision and practice of the innovation. Not only that, the way these 'mid-layer leadership' interacts to create a coherent force in moving the innovation culture is critical. In this study, we look particularly at the role of middle managers in deepening and sustaining a twenty-first century teaching and learning practice and knowledge building within the ecosystem of the whole school. We look at this practice as it did not particularly receive top-down or bottom-up support at the on-set of the project in the case studies below. The decision to embrace and experiment with the practice was taken by the middle manager and much of the navigation, strategizing and advancing within the organization relied on these middle managers as well. In this chapter, we analyse the work of three middle managers to understand the realities of leading from the middle through identifying key dimensions, strategies and approaches adopted as well as the tensions they experienced as 'mid-layer leaders' in sustaining knowledge building practice and culture in their school.

8.1 Introduction

"Leadership from the Middle' is defined as an adaptation of strategies that increases the 'capacity and internal coherence' of the middle layer within an organization with the goal of achieving better performance (Fullan, 2015a, 2015b). Leaders in the middle, their advantage and work are characterized by their deep understanding of the local community and context. Ironically, their challenges are also entrenched within the familiarity of the community and context. This means that most of the time they have to rely on collaboration instead of leadership position; they also have to enact through a network of professional and personal relationships more than that of authority.

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Such leadership is particularly important in advancing more innovative teaching and learning collaborative practices for the twenty-first century which requires a coordinated shift of different areas of teaching and learning, e.g. curriculum, pedagogy, assessment, bought in by different stakeholders in the school. This middle leadership within a school is deemed to be ideal in forging an effective partnership upward towards more senior management within the organization to gain support and downwards to a team or a community to sustain practice. The goal of this 'middle leadership' is to connect leadership to school improvement, strengthening the coherence within the organization in relation to goals and needs through community building. The middle is supposed to mobilize and develop pervasive capacity, while at the same time, the middle works within its schools more effectively and becomes a better and more influential partner upwards and downwards to the centre.

The case studies are derived from a knowledge building project. We traced the role played by middle managers in schools with the knowledge building innovation in their school. In tracing the work of this middle leadership, we attempt to explain what is at the heart of every level of effective school's 'middle' by identifying their roles, strategies and approaches, especially in the building of professional learning community to sustain innovation. We also triangulated the challenges and tensions they experienced as 'mid-layer leaders' in sustaining and scaling knowledge building practice in their school.

8.1.1 Background

The innovative practice that forms the basis of this study is the knowledge building practice. Knowledge building theories, pedagogy and technology define a focus on the generation and continual improvement of collective ideas in a community. When translated into a classroom, knowledge building practice signifies an effort to place students' ideas at the centre of teaching and learning activities (Scardamalia & Bereiter, 2006). Knowledge building pushes the modus operands of classrooms into a knowledge creation paradigm where the teaching and learning culture requires one that is full of research, development, generation and shaping of new practice by teachers (Kozma, 2008). In Table 8.1, we defined the possible of continuum in terms of curriculum, pedagogy and assessment in relation to the three paradigm with the aim of helping us understand the role of these mid-layers leaders in navigating the school landscape to bring about knowledge building culture.

Knowledge building practice focuses on making students' questions, ideas and learning explicit and allowing teachers to bring these ideas and questions to the centre of the classroom work. Teachers and students then engaged in a series of knowledge building process such as formulating questions and investigation, researching, summarizing and synthesizing to forge deep learning. As students constantly work in an environment rich in real and authentic ideas, they develop a community mindset to constant check their ideas against peers and authoritative sources, as well as constantly figuring out ways to develop and improve their explanation to problems.

Table 8.1 Possible continuum of alignment across curriculum, pedagogy and assessment required based on the three paradigm of knowledge acquisition to knowledge deepening to knowledge creation paradigm (Kozma, 2008)

	Knowledge acquisition paradigm	Knowledge deepening paradigm	Knowledge creation paradigm
School process and structures	Process and structure focuses on increasing ICT skills, and school-based and national exams results, mainly on building strong numeracy and language literacy	Process and structure focuses on improving the understanding and problem solving skills of students and connecting their learning to real-world problem and contexts	Process and structure focuses on research, development, generation and shaping of new practice knowledge

(continued)

Table 8.1 (continued)

	Knowledge acquisition paradigm	Knowledge deepening paradigm	Knowledge creation paradigm
School alignment across curriculum, pedagogy and assessment	• The curriculum (commonly known as scheme of work (SOW)) defined in each subject emphasizes on facts and concepts within each subject that is to be acquired by students • Teaching is mainly on delivery of content defined in SOW. Didactic teaching and teacher-centric learning activities are more common though information may be presented in an interesting manner • Instructions/pedagogy are usually of the one-size-fits-all sort that targets at whole class having similar experience and learning, meaning it has to work for everyone in a class of 40. There is usually an emphasis on orderliness and standardization • School-based assessments are composed of traditional pen and paper mode. Mainly comprise of factual recall and the application of knowledge to solve simple and familiar (versus complex) problems • Accuracy and linearity (e.g. vary one thing at a time) is emphasized • Students are tested frequently and receive regular feedback on progress	• The curriculum/SOW identifies themes based on concepts that organize the subject area. It emphasizes understanding of these within and across subjects and their application to solve complex real-world problems • Curriculum/SOW defines both the soft skills and process skills to be developed in students, but content goals is foregrounded • Approach to implementing curriculum attempts to respond to contemporary and local contexts but the balance is tilted towards completion of SOW • Introduction of open-ended questions and problems that anchored in real-world contexts in teaching, but with limited complexity • Classroom activities involve the application of key concepts to solve problems • Attempt to create synergy across subjects • Assessments (class tests or quiz) may composed of a few extended, open-ended questions. It may include multipart problem-based projects that contributes to year-end results. However, system will still rely on summative assessment • Project-based projects embed concepts that correspond to real-world situations and tasks are integrated into the learning experience	• The curriculum/SOW has themes that define concepts and principles of the subject area. However, the curriculum is deemed to be responsive to student goals and learning • It emphasizes on the development of soft skills and process skills as much, if not more than the content goals • Approach to teaching includes enculturating students to build on their knowledge and explore new topics framed by principles defined in curriculum • Collaborative projects and investigations involve searching for information, collecting and analysing data, generating knowledge products, is the norm • Assessment tasks consist of investigations, reports, presentations, creative works and other knowledge products • Project products are evaluated through self, peer, and public review, as well as expert review. Assessments also emphasizes student goal setting and self-monitoring

Such KB classroom develops in students: resilience, collaboration, communication, creativity and critical thinking, which are mostly explained with a suite of analytics. There are currently some 15 schools in this project working to implement and disseminate these ideas-centred approach to teaching and learning. The description below defines broadly the conditions to keep KB practice alive in school and the need for us to understand the concept of leadership from the middle in such context and background:

- School-led transformative practice: Though the idea-centric practice are compatible with the grand vision of future learners and teachers as designers as defined in the ICT masterplan policy, but KB practice are mainly initiated by schools and not by the ministry that focuses on equal implementation path for all. The schools are taking up the initiatives in their own right and in teaming up with researchers, other schools and international network.
- Deepening and Sustaining: The essence of knowledge building work requires both of continual innovation and spread so that new ideas and new knowledge continue to energy the work of the community. Many schools are interest in pedagogies that engage students and teachers in real-life problems and develop twenty-first century competencies but struggled in defining new educational term as such 'design capability' and in balancing between what needs to be 'tightly monitored' and what needs to be 'loosely scaffolded', and finally, what needs to be 'let go of', especially in the area of curriculum, pedagogy and assessment (Fullan et al., 2014).
- Ecological coherence: An innovative practice like knowledge building requires a constant (re)alignment of visions and directions from within the micro- (classroom), macro- (school) and meso- (system) (Toh et al., 2014). In realities, such the alignment has always to be bootstrap within micro- and macro- and at its very best supported by a broad direction provided by the policies so that innovative practice could take root.

8.2 Method

This qualitative study aims to understand the role of the middle managers in leading an innovative project, knowledge building practice, within a school ecosystem. We focused on what these middle managers actually do to effectively lead the innovation from the middle. The leadership from the middle in this particular innovation is particular interesting because it fits the description of an effect that is recognized by the school leaders or the system, nor has it been well received by teachers. Participants included the head of departments and lead teachers from four schools in the knowledge building projects. Data were collected using semi-structured interviews and were analysed by coding. The interviews touched on the middle managers' roles, strategies and approaches in the following areas process/structure; curriculum-pedagogical-assessment alignment, PD and resource design (Table 8.1).

8.3 Literature

The concept of leadership from the middle challenges the notion of traditional leadership model that relies on the idea of one or few great man having exceptional traits and characters to lead; or emphasizes the idea of leadership behaviour; (iii) emphases on the situatedness of the leadership (Shamir et al., 1993). Leadership from the middle moves away from leading by authority and position, though it will never really deviate from these two component of leadership. Middle leaders understand the environment and people; they focus their leadership through collaboration and enact their leadership through building communities of professional and developing personal and professional relationships (Fullan, 2015a, 2015b).

One of the key strategies to be adopted by middle leaders is the development of professional learning communities for successful school reform (DuFour, 2007; Huffman & Hipp, 2001; Zhang et al., 2011). This strategy works in both ways: first, professional learning communities created greater leverage for capacity building towards transformational leadership where people are continually learning how to learn together". Studies provide consistent results that teachers who are feel supported as a community in their classroom practice were more committed and effective (Little, 1993; Rosenholtz, 1989). Second, in a symmetrical way, teachers who functioned as learning communities have shown a greater ability to foster similar collaborative learning in student that leads to better learning.

8.4 Analysis

The three middle managers featured in this study is on similar trajectory in their leadership journey of KB in the following ways:

(i) All three middle managers were involved in the project >5 years. All of them are from our first two schools who seeded the work of the KB network back in 2010.
(ii) All three middle managers have been involved as principal investigator or co-principal investigator in major funded knowledge building research project. They all have been serving as the project leads in their respective school and in these schools, the KB practice has been integrated fully in at least one department.

We studied their reflections and interviews and identified for a collection of repeated instances from the data in relation to the areas of (i) process/structure; (ii) alignment of curriculum; (iii) alignment of pedagogy; (iv) alignment of assessment; (v) professional development and resource, paying special attention to those that provide insights to the concept of middle leadership in innovative practice in managing conflicting culture, dynamics and tension. We then try to look for connections between two or more sets of codes to establish pattern and generalization.

8.5 Findings

In this segment, we coded these middle managers' experience and perspective in unpacking the role they play in the areas of (i) process/structure; (ii) alignment of curriculum; (iii) alignment of pedagogy; (iv) alignment of assessment; (v) professional development and resource; (vi) technology.

8.5.1 Professional Development: Redefining Goals and Purpose of Professional Learning Community

The interview shows that these middle managers are constantly caught in the midst of conflicting cultures, pressures and priorities among the different demands in school, continued to forge ahead to position themselves as the possible influence in the areas listed in Table 8.1. These middle managers are able to maintain focus on they could control over what they have little influence and turn constrained by tensions inherent in the role and in the system and increasingly accountable for outcomes into opportunities for KB work. In this study, these middle managers are constantly defining process/structure and meaning of their Kb project work quite differently from the other teams in the school.

> For the Science team, we used to be here (teacher pointing to the middle part of paradigm 2 in curriculum alignment) as of 2015 -we are very much here but we have not really talked about it, like connecting to real world. But I think for the past 2 years effort is put in by the team, for the science dept.
>
> For the KB plc (professional learning community) - ours is a lot more than just connecting ideas n real world problem, we do that as well, so this is encompasses this…if I am doing this, I am definitely doing this (pointing to paradigm 2 and paradigm 3). For KB practice, over the years we have very gradually, very gradually, progressed. We have come to a state that we no longer fear, we are able to make changes quickly we are not afraid to try. The KB, the PLC has given a chance for me to tell the teachers that we try it first. We see how it goes then we go on. I would say that flexibility is there. for school. We would say we are here.
>
> Last time they used to be afraid to even attempt, the fear of what if we cannot do this, what if it affects the students results. It is very much orientated towards exams, but what the top management has done to bring teachers together, de-emphasise on exams. shifting the mindset, to move away from constantly looking at the numbers has helped bridged…

8.5.2 Bridging Pedagogy That Cantered on Students: Whats Now, What's Not and What's Possible

These middle managers, though remained apprehensive of the challenge and obstacle in bringing knowledge building to their teachers, showed unwavering commitment to improving students' quality learning. The following is one of the middle managers' reflections on how KB pedagogy is necessary for her normal technical students (the least academically inclined students in school). Their goal remained fixated on promoting innovation and ensuring that ICT supports and enhances students' learning. Their measurement of shift usually revolved around 21CC, for example 'we might measure the way students begin to be more curious and asking more question. They are not afraid to let their ideas be heard. They are also eager to hear their peers' ideas'. The following snippets of interview shows how the middle manager reflected on what they see as a successful in their own class and in their teacher team.

> …. I have all the resources. I have all my resources there. Touch of a button I've got powerpoint, worksheet, everything. I'll deliver a good lesson. My children will have outcome when I look at their worksheet, if I look at their assessment I'll know how much I've done and I'll analyze it and I can make them do amendments and ensure it's all done. But I think …I can't do, I almost think it's a static lesson. I want something more dynamic for my children. A little bit (more), wherever possible I want them to do a little bit more of thinking for learning. I think that's the onus on me, for later on even when they go to the poly or JC. I think this is important.
>
> When they (teachers) go in with authentic problems/ ideas/ issues to discuss with students. Allowing students space to share their ideas. Critique/ challenge each others ideas and collaboratively synthesise knowledge together with the students.

One distinct pattern that emerged in this group of middle manages is the need for them to constantly reflect and review on what is 'not KB' in order to advance the kb pedagogy in their school.

> This is my new challenge… I am kinda the reminder to tell them this is KB and this is not KB - try not to do this, we should think of the task given, how does this make the child a critical thinker. That kind of question raised in the meeting - it is very good, it makes the whole team think about how to make changes in terms of the changes in the ALP.
>
> Challenges are two forms, one is within a team, there are different definition of KB, it is not about right or wrong, we know we have different way of thinking about it, so do I come in to facilitate and change the KB style to be my form or do I let them… when should I come in. and sometime when they think different way, might not be KB, example. like guided inquiry, is that a KB? maybe? maybe not.

8.5.3 Assessment: Measuring Success in a Meaningful Way

These middle managers continuously seek and use evidence to inform change and develop practices with the aim to improve students' outcomes. They engaged long hours of conversation with researchers to understand outcome and to formulate ways to improve the implementation. They would also almost for sure set up their own data collection mechanism to understand impact of KB on their students. However, above all these, all the middle managers in this study articulated what the students' shift meant to them with or without quantitative results from examination.

> When I asked my students to rate their learning experience using KF. Many gave the positives. They liked the idea of being able to read their friends inputs, discover new thoughts and built

upon ideas. That in itself created the dynamism and synergistic learning. I also noticed a certain level of maturity in my students' acceptance of ideas as they progressed on in their KF lessons. Their willingness to work on ideas as a collective rather than as individuals and in working out new ways of thinking. That's success to me.

For students…there maybe different stages, success, they know the subject much better, for now. or…they started to see the value of coming together. No longer just I (referring to students) know, I have to do group work. Now is, maybe they are not enjoying yet, but I(referring to students) see the value of doing group work, not that you do one I do one. they do together, or maybe they might be doing one part each but let's think of ways to help each other, to fine-tune.

On measurement? For qualitative there is no issue, we can always use interview and reflection. For quantitative, we use the analytical tool to show tightness of their ideas and another one is for them to trace their input. For school-based results? I heard from HOD, to them they love KB but our exam doesn't cater to that.

Interviewer asked: "So do you then see a need to actually trace students' results to see what the benefit these approach has on students?

In terms of results, it is easier to reach out to people, no matter how dynamic we are, the national exam is very confined. I see the need for students to be confident about their learning. of course from management perspective, they want to see translation of results.

8.5.4 Redesigning Curriculum

Most middle managers are more conservative in this area. All of them marked the curriculum work in KB and in their school within the knowledge deepening paradigm.

When teachers have the curriculum map at their fingertips and they are comfortable and competent to navigate students' ideas, discussions and collaboration under the umbrella of the syllabus and still meeting the assessment requirements.

Using KB Principle to map the trajectory of KB work: We saw a consistent reference to knowledge building principles across all case studies. Such principle-based approach means that the middle managers might be more focused on core values and principles of the actions and they are most likely to be able to leave teachers the challenge of interpreting and adapting classroom and pedagogical decisions to accommodate their different contexts and possibilities. Teachers are expected to continually improve procedures derived from principles, leaving the teachers to explore further through discussion and peer review in the professional learning team.

I want to challenge them to not just talk about the two principals, they are always talking about idea diversity and improvable ideas. We are so comfortable with this, we are a kind of mature school - it is time to do something more or something better, this time round we must start to look at quality of ideas, see how we can challenge the children to think deeper and get them to use the promising tool how will this translate into their characters. I understand we may not achieve all 12 but I certainly believe we can go beyond three that is my gut strong feeling - maybe we do touch other principles, is it strong enough for them to feel that they are doing this. If you ask them, they will say, yes, I am doing this, yes I am doing this. But the other principles, it is more like a touch and go.

We are more principle based, we have procedure but procedures can swap. To me KB, you must be flexible but professional enough.

8.5.4.1 Strategies and Approaches

(i) **Modelling KB practice, tackling the toughest challenge**
These middle managers used modelling of the pedagogical practice as way to address resistance to change. A common characteristic we found in these middle managers is their interest and focus in knowledge building classroom. They willingly took on the challenge to design and implement knowledge building lessons in their class and even took on the challenge to work with the tougher class, i.e. academically weaker classes. The mentor their teachers by partnering them in class, took time to systematically study and analyse students' notes with their teachers. In doing so, they ensure that their teachers understand their role in implementing knowledge building practice. Based on their personal understanding of KB, they then navigate the way to explain the practice to their senior management and to their peers.

(ii) **Constantly reviewing and adapting connected strategies to realize school's vision and capacity for change**
Successful middle managers understand how change processes work in their school and how people within the school respond to changes. With this knowledge, they then put in place planning and resourcing including mentoring structures, professional learning conversation, defining Syllabus Instructional Objectives, research partnership. One of the most important move by successful middle managers is to align knowledge building to existing school initiatives.

> We've had a school-based initiatives on "assessment for learning" and on "communication". This is a school wide practice so I have to get teachers to see that they are working on KB and also working on these initiatives. I am very much guided by the need to include everybody in identifying their own practice with KB. They need to know they are already doing it then work on it more… Teacher need to monitor and evaluate students' progress to identify AFIs in learning. Students can also be train to chart and track their own progress (Self-monitoring) to identify their AFIs in learning.

(iii) **Building relationship, getting buy-in is more important than getting things to happen**
These middle managers constantly bring in their knowledge of their teachers' current belief and practice to help the teachers engage with knowledge building ways of teaching and working. These middle managers usually emphasized on building relationships based on trust, and their priority is to make the teachers feel supported and understood. They are never in a rush to introduce just another 'innovative pedagogy'.

> It is important for my department teachers to work and collaborate with one another to share ideas and build ideas to have a good KB lesson. I want the teachers to also be a community of knowledge builders as well to sharpen our competencies.

8.6 Discussion

Leading change is complex and involves a number of stages (Fullan et al., 2005). Analyses of middle managers' response indicated that they are constantly engaged in extended discussions related to knowledge building practice throughout the implementation. We saw these middle managers' KB work aligned closely with schools' vision and in three ways that is very much aligned to the concept of leadership from the middle. Two of which are more familiar and in line with the literature on leadership from the middle, they finally seemed to have emerged as an important overlap between such leadership and that of knowledge building community.

- Culture building: First, they see their kb work situated in the school to build a certain culture of response to failure, test and trial and of working together. They identified problems in the implementation phases that needed attention; they would generate possible solutions, revisit issues they have faced at different points in time and show a genuine interest in the work of their students and teachers. One of the key things they do is to constantly revisit the relevance of Knowledge Building in education and learning and in relation to their whole-school approach.
- Community building: Second, their model of kb PLC across all case studies showed that to be a potential way to influence the other PLC in the school, to focus on systematically understanding students learning through the artefacts collected in school. A great deal of their work is negotiated within a community model, celebrating small success with their department teachers; these are also consistent in their meetings with teachers (which are not included as data in this study. Finally, middle managers' involvement reveals many connections between community and individual work that serve to deepen and sustain the practice within the school. They are always creating opportunities and structures for teacher to help to influence and develop other teachers.
- Continuity as an organizational principle: Rooted in the knowledge building principles, the notion of innovative continuity initiated by these middle managers reflects a strong spirit of 'ownership' to design the dimensions including curriculum, pedagogy and assessment, PD. The coordinated effort in these dimensions seemed to form the basis for their leadership. This principle-based continuity (refer to Table 8.1) provides directions to forge two interrelated areas: (i) the horizontal spread that link learning and teaching experiences between and across teachers and students; (ii) vertical deepening and growth that enhances evidence-based practice by linking advances in research to classroom practice. This continuity built on a strong set of principles establishes the opportunities for increased meaningful connections between teachers and students. It is not just about relationship building nor is it about foreground students' voice in a flux where we get into the post-modernistic entanglement. It is about integrating important educational themes across topics, levels or even across disciplines, across initiatives (continuum of curriculum). It is about focusing on the developmentally appropriate attainment and assessment of students competencies (continuum of assessment) and promoting the connection between research and practice ('continuum

of alignment of curriculum, pedagogy and assessment'); and finally, it is about enhancing leadership, role modelling and mentoring ('continuum of PD') (Table 8.1).

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Part III
Diversified Changes from the Systems View

Chapter 9
School-to-School Networks for Sustaining Education Innovation Change: Situating Teacher Leaders at Every Middle of the System

David Hung and Monica Lim

Abstract Educational innovations enacted into any system is challenging especially if the interventions are to be sustained by the stakeholders themselves.. This chapter documents a study on a network of schools over the course of three years of their journey involving learning technologies in two subject disciplines. School-to-school networks over and above teacher-to-teacher networks were formed and teacher leaders emerged in the course of the implementations. The concept of leadership from the middle (LftM) is proposed at three levels of the school cluster system. The chapter argues that LftM and teacher leadership involving systemic thinking, ecological leadership, and apprenticing among teachers are central tenets for sustainable change. School leadership is juxtaposed with teacher leadership with the trust relationships between the two. The chapter also discusses policy-to-practice translational implementation issues, including the supply of shared expertise and resources, as schools transform toward inquiry-based learning practices for twenty-first century learning.

9.1 Introduction

The Singapore education system has been seeding education change in schools in the last decade in tandem with international trends such as twenty-first century learning, including the movement toward inquiry-based learning. The office of education research (OER) is commissioned by the Ministry of Education (MOE) with funding to engage in classroom interventions across schools in Singapore with such an intent. The purpose of this chapter is to describe 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. Leadership from the

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Middle (LftM) is a key leverage to be situated within the levels of the system with teacher leadership working in tandem with school leaders. The unique proposition of Singapore's school system is that it has a tight relationship with policy from the MOE enabling research–practice–policy nexus to be actualized, but not without the need to 'work-out' the tensions and challenges within a fluid landscape of change. The chapter discusses this complex phenomena and how alignments are forged within and across levels of a system-in-flux, yet identifying the core essential dimensions where change matters most in the pursuit of the purposes of change at both macro- and micro-levels of the system. System change can be challenging (Levin & Fullan, 2009) and few reported studies can depict the innovation change process at a national systems' level with policy to practice leverages.

The research intervention studies that tinker on classroom pedagogy, including informal learning are based on design principles such as the use of multiple representations, disciplinary oriented linguistic scaffolds, three-dimensional spaces such as immersive worlds for the aiding of visualization of concepts, discussions and annotations, argumentations and also gamification. Many of the interventions are supported by technology and require a re-design of lessons to afford better use of its features, but more importantly, deepening learning processes and outcomes. As such, teachers usually have to forsake their traditional and accustomed instructional practices and undergo a journey of 'risks-taking' from their aforehand successful practices and embrace an innovative stance supported by peers and other intervention researchers working alongside them. The school leadership in creating the supporting enablers and fostering of innovative cultures in imperative in sustaining teachers' efforts in both the teacher dialogues and classroom enactments over time and across curricular topics.

As Singapore's education system, since independence in 1965, came from a centralized system of curriculum planning and enactment in schools with national high stakes exams at various stages of K-12 spectrum, the variation of pedagogical practices across schools is relatively smaller relatively to other school systems internationally. As such, we posit that teachers' behaviors and mindset in responding to innovations and change is quite similar across schools and representative. This chapter reports on a study on a network (cluster) of schools and the innovation journey it went through over five years, although the documentation process was over three years.

9.2 Literature Review

We position the concept of leadership from the middle (LftM) and teacher leadership as the anchors supporting school-to-school networks around innovation cultures and change. The journey of innovation cultures is not just recent but have been embarked upon for more than a decade. The adoption of technology in learning had in the past been situated in 'future schools' as exemplary in learning environments and experimentation. Over a trajectory of a decade, these schools have transformative cultures for teaching and learning that are sustainable and even when school leaders change, teachers are still engaged with learning with technology. Over the decade, future schools have also been partnering other more typical schools in scaling up or scaling out the innovative practices within subject disciplines. The policy of future schools has ceased since financial resources to these schools are over and above typical schools and because of a more equitable landscape of schools, alternative ways of bolstering innovative pedagogies through school-to-school networks for the sharing of resources and cultures may be viable. School-to-school networks in our study differ from teacher-to-teacher networks. While the latter is embedded in the former, school leaders are involved in discussing resource and infrastructural concerns, for example, how lead teachers (or teacher champions or leaders) belonging to a particular school is shared as an expertise resource to the other partnering schools. Not all schools have the same technology provisions for domain-specific lessons, and the sharing of equipment such as iPads can be afforded through such means.

School-to-school networks can be described as a system structure from the middle. The top being MOE and the bottom being individual schools. LftM also advocates a middle-out systemic strategy balancing the tight-but-loose dynamics of any system. Thus, at any level of a system, there is a middle-out, and up and down interaction. Fullan (2015) suggested that schools are an example of the middle if we use a within school district or cluster-of-schools focus. Figure 9.1 describes the middle at every middle of a national system as depicted by our own work (Koh & Hung, 2018). In our earlier studies, we discussed how ‘teacher’ (broadly conceived) leaders play a pivotal role for brokering and facilitating the upwards and downwards alignments amidst the innovation change process. We connote the need for ecological leadership in mitigating tensions and challenges from all the demands of existing norms and practices and the ones from the new (see Toh et al., 2016). Particularly nuanced in east Asian cultures is the need for brokering and communicating upwards the ‘chain of command’ as innovations can emerge from the bottom (of that particular middle), and it takes courage for these teacher leaders within a culture where power distance is accepted and practiced (see Hofstede, 1997). Some scholars conceive the nature of teacher leadership as an influence-lateral, upwards or downwards regardless of whether it is formal or informal leadership (Hairon et al, 2015; Hung et al, 2020). These teachers, positioned at various roles (Barth, 2001) in the overall system, make impact to educational change. We use the term ‘teacher leaders’ broadly, and these could include heads of disciplinary departments in schools and where they may be deployed in other roles within school clusters and possibly at the ministry of education.

Another significant role of teacher leaders is to engage in mentoring and apprenticing work with other teachers within professional learning communities (PLCs) within and across schools (Hung et al, 2020). Apprenticeship is an important process of beliefs change (Hung, 1999). These functions go beyond dialoguing to ‘walking-through’ innovation change lived experiences from PLCs to the classrooms and vice versa. The process of apprenticing aids teachers to work together as a group supporting each other in the re-design of lessons, working out the curricular sequencing issues, potential questions posed by students, how to facilitate the lessons,

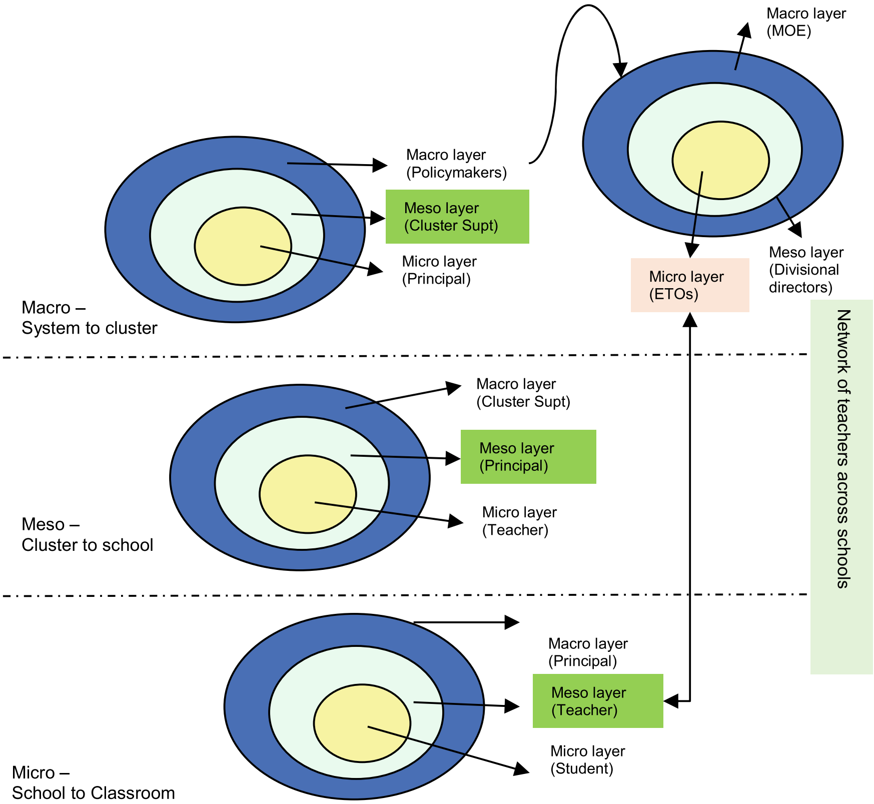

Fig. 9.1 Leadership from the middle as interpreted by the author with a middle at every sub-level of the national system

and make connections within the curriculum, and also prompting for metacognition. Such patterns of lesson enactments are quite different from traditional norms, and certain degrees of handholding of teachers are necessary. However, these experiences can be rather awkward for senior teachers and facilitating for trust and reciprocity is crucial. This is quite a leap of faith for many teachers as there could be more junior teachers who are better at using technology and seemingly more adaptable in how lessons are carried out. Senior teachers may be more proficient in domain-oriented lessons with content and student understandings, and the successful preparation of student outcomes (i.e., for summative assessments). These teacher leaders need to have an intimate understanding of the current cultures, how to manage teachers' expectations and their formal positions within the school and system, and how to guide peer teachers in their innovation change journeys. Much wisdom in handling power distances, what counts as successful practices, and socio-cultural dynamics between learning and work performances.

Before we describe the findings to be reported in this chapter, we summarize the tenets of school-to-school networks as reported from earlier studies conducted in Singapore (Koh & Hung, 2018).

- The formation of school-to-school networks goes beyond teacher-to-teacher networks where school leaders collaborate to provide for teacher learning and innovation change opportunities and the sharing of resources;
- A shared vision, and operationalized into implementation pathways, for inquiry-based learning of key stakeholders in the across schools network;
- Sharing of a common language, norms, and trust within the network across teachers, and between teachers and school leaders;
- Leveraging on the expert knowledge and credibility of resource persons in the network, including the sharing of physical equipment and spaces;
- Sharing of tacit knowledge within the network that translates the planned curriculum into (successful) enactments;
- Developing relationships within and across schools with teachers and school leaders by persistent interactions in the context of educational innovations;
- Leveraging on ministry policies as they become translated to schools and classrooms and to bring alignments between policy and practice; and
- Leadership from the middle is a construct that can be useful and operationalizable for the educational innovation change journey for the network of schools.

9.3 Methodology

The main method of data collection was through interviews and observations. Interview transcripts are analyzed, and thematic patterns are coded and tagged for narratives, and data is organized into meaningful ways for the drawing of conclusions. Interviews were conducted with the participants comprising: Cluster Superintendent, Principals, Vice-principals, Key Personnel of schools, Lead Teachers (LT), and Teachers. To document the study, a case study approach was adopted with interviews, ethnographic observations, and follow-up focus group discussions (FGDs). Table 9.1 shows the interviews and observations conducted.

Figure 9.2 shows the journey of the primary and secondary schools in the network/cluster of schools over time.

The journey undertaken by the ‘S’ cluster of schools comprised 3 primary and 5 secondary schools and across disciplinary areas in science and geography. Within the leadership structures, the cluster superintendent set up a school-based leadership team (SBLT) in each of the primary and secondary schools, respectively. The SBLT is the systemic planning committee for the network of primary or secondary schools, respectively. Another committee is the school-based project team (SBPT) which coordinates the science and geography, respectively, according to curriculum and teacher needs. Both the SBLT and SBPT committees are in constant dialogue and coordination functions to strategize the overall (school) leadership supports with the teacher (curricular) enactments.

Table 9.1 Tabulation of data collected in the school year by quarters (Q)

Sessions	Pre (planning)	During (implementation)	Post (review)
Deep learning committee (DLC) meetings	Q1	Q3	Q4
School-based leadership teams (SBLT)	Q1	Q3	Q4
NLC (SPID/SLS network session—cluster sharing by SBPTs)			Q4
School-based project teams (SBPT—combined schools meeting)	Q1 (1 per SBPT)	Q3 (1 per SBPT)	Q4 (1 per SBPT)
PLC/PLT (professional learning team/subject-based team in each school)		Q2 (1 per SBPT)	Q3 (1 per SBPT)
Subject-based lesson enactments		Q2 (2 per SBPT—2 teachers enacting lessons for 2 weeks)	Q3 (2 per SBPT—2 teachers enacting lessons for 2 weeks)

The findings reported in the next section would illustrate why such a school-to-school unit of analysis is needed as a socio-infrastructural supports needed to enact change at the individual school level. The SBLT is operating at the macro-level of the case study findings, whereas the SBPT is functioning at the meso-level of the network of schools system as described. The research questions for this study is as follows:

Macro:

1. What structures (school-to-school networks) and organizational routines are needed to enable school-to-school network to enact inquiry-based practices (referred to as deep learning from the stakeholders point of view) and to spread within and across schools?
2. What are the planned and enacted partnerships formed between NIE researchers and the school-to-school network? How did they evolve and what were the challenges, and possible resolutions?

Meso:

1. How can we leverage on Leadership from the Middle (LftM) in the 3 M (macro-, meso-, and micro-) layers for making inquiry learning work in school-to-school networks?

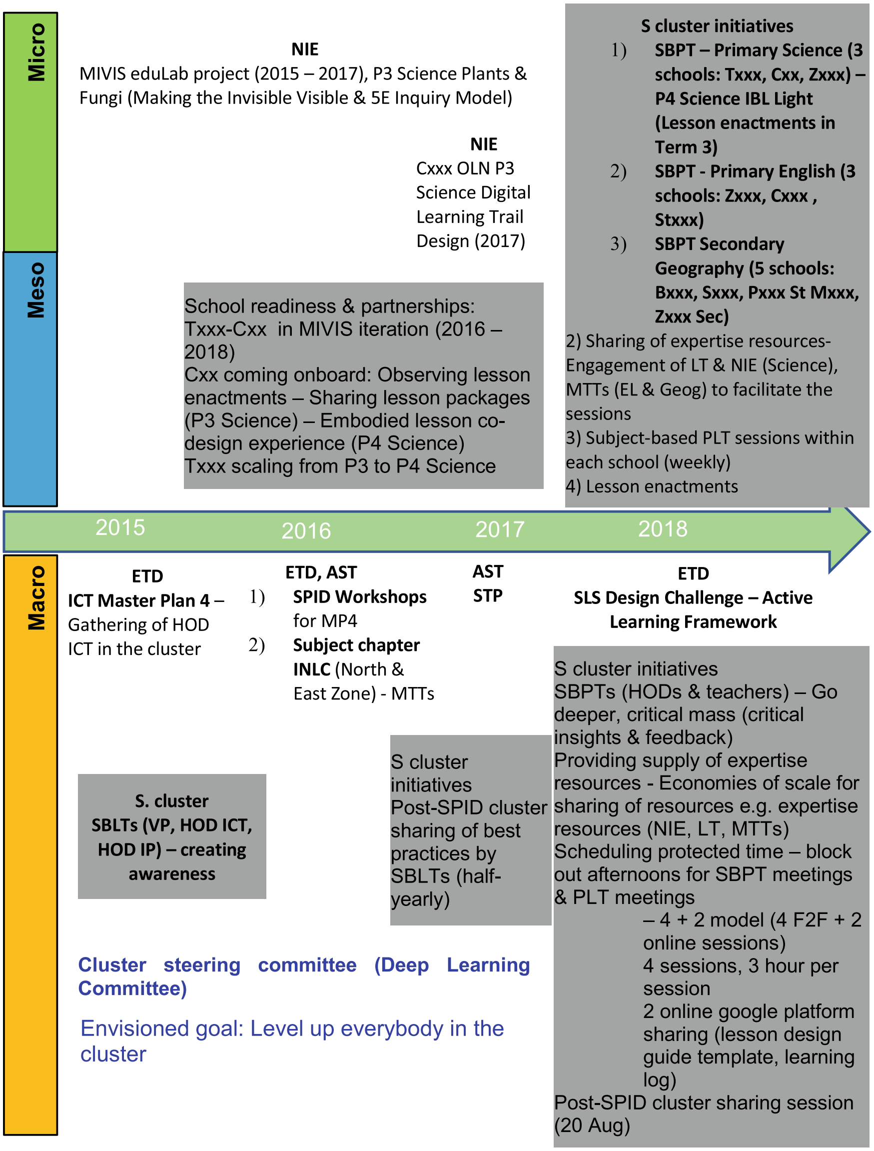

Fig. 9.2 Timeline- and inquiry-based learning events

2. How is leadership from the middle planned and enacted at classroom, school, and school-to-school levels through system, ecological, and apprenticeship leaderships, respectively?

3. How do middle (teacher) leaders build, enculturate, and facilitate for the sustaining of inquiry-based practices (deep learning) to sustain within schools and transfer across a cluster of schools?

Micro:

1. How do teacher learnings (at all levels) and epistemic shifts occur within the change process?
2. What are key leverages and construct for sustaining middle leadership development change?

9.4 Findings from the Study

The findings are reported below in the form of Tables 9.2, 9.3, and 9.4, due to space constraints in this book, according to the macro- (cluster leadership, i.e., SBLT), meso- (i.e., SBPT), and micro- (i.e., as implemented in the school's department where the subject disciplinary enactment takes place) layers of the school-to-school network, although there is significant overlaps in terms of teacher reported issues.

Macro-Layer Within the interviews, we conducted with the school-based leadership team, it was understood that the schools in the network had to devise a strategic plan which systemically planned toward how the respective schools were to undergo the innovation change process. This change process required schools to understand where the teachers were at with respect to teacher willingness to change and whether there were sufficient resources at the cluster level to enable this change from planned to enactment. The SBLTs also planned for resource allocations which can be spread across the schools for the intended vision and goals as shared and agreed among the school leaders with the specific subject departments at hand. The resource planning was based on an accurate understanding of the implementation issues that would occur within the respective schools as far as teachers' time and constraints were and to organize for ways to mitigate these challenges. The reported issues are as presented in Table 9.2.

The SBLT had to plan for protected time for teachers to undergo the change journey with an argumentation of resources and teacher leaders from across schools to cope with current needs and also future goals and outcomes needed. In other words, the foremost function of the SBLT is to create the structures that would permeate the schools to foster innovation change and cultures in terms of creating teacher buy-in, and also to free up teachers with time and space to go onto this innovation journey. Within this larger structural and cultural change structure, plan out the teacher supporting mechanisms and resources needed to hand-hold the teachers and to open up all possible channels of communication upwards from the teachers, downwards to the teachers and students, and also sidewards to peer leaders and peer teachers in lateral ways. Systemic thinking is needed for members of the SBLT to plan the work and enactments over time and for schools to come on board the innovation change journey progressively.

Table 9.2 The macro-layer reported findings

Theme	Key points	What worked?
Challenges	1. Time 2. Buy-in	• Taking time to co-design lesson and take risk for 1 topic cycle, e.g., P4 IBL light
Teacher outcomes and learning needs	1. Design capacity (adapt, re-design, differentiate instructions) 2. Facilitation skills 3. Epistemic shifts (change instructions and mindset) 4. Analyze student artifacts	• Cluster collaboration for bouncing off ideas, embodied experience of lesson co-design and engagement in iterative cycles • Gathering of student artifacts via technological affordances (google sharing, NearPod, SLS) • Change in teachers' beliefs about students through lesson enactments • Teachers develop questioning strategies
Strategies	1. Protected time 2. Open discussion 3. Share on-the-go 4. Working the talk	• Engagement in professional dialogue to listen, learn, question, critique each other in the design-enact-reflect cycle to build their design competencies • Collective sense-making
Openness	1. Conversations 2. Open sharing culture 3. Apprenticing	• Deep conversations revolving around design frameworks (SLS active learning framework, 5E inquiry) • Teachers open classrooms to each other to observe lesson enactments to learn from each other

Meso-layer: At the meso-layer, all sorts of preempted implementation issues arose from the interviews with the middle management of the schools. Issues such as the honest view that teachers and middle managers 'don't have time to take risks' (see Table 9.3). These are interviews conducted at disciplinary subject levels at the individual schools. Due to implementation challenges where there are only a limited number of teachers who can enact existing needs of schools and how teachers cannot find time beyond their current functions to undergo experimentation, albeit recognizing that learning new things is always good. Challenges such as teachers going on maternity leave and having a bare minimal number of teachers left in the department to cope with all the demands is of real concern.

At this level of enactment, school-based project teams (SBPTs) functioning with members across schools come in useful. Where constraints are experienced within local schools, help and other forms of enablement can arise from across schools. Here, it is important to note that concerns by heads of departments (in science or geography)

Table 9.3 Meso-layer reported findings

Theme	Key points	What worked?
Challenges	Don't have time to take risk	• Taking time to co-design lesson and take risk for 1 topic cycle, e.g., P4 IBL Light
Teacher outcomes and learning needs	1. Ecological leadership 2. Apprenticing leadership	• Growing teacher leaders in small groups, e.g., 1 LT, 2 teachers • Teacher leaders becoming the forerunners in enthusing the other teachers
Strategies	1. Culture envisioning. Enculturation of practices 2. Sense-making with teachers 3. Need for expert other to scaffold the process (facilitation/reflection) 4. Strategic planner	• Start with values and beliefs, going back to first principles (AST T&L guide) in enculturation • Unpacking frameworks with teachers to make sense for lesson co-designing, enactment and review, e.g., SLS Pedagogical Scaffold Active Learning Framework
Openness	1. Open culture 2. Apprenticeship	• Trust building • Professional dialogues • Collective wisdom • Walk the journey—role modeling what it looks like

highlight issues and gaps in an ecologically coherent fashion to the SBPT committee in the hope to reconcile implementation challenges with the goals espoused in the innovation change journey. Lead teachers from other schools come in to assist and to apprentice other teachers from schools within the network. The SBPT engages with the school and teacher leaders within respective schools in envisioning exercises and to aid schools in space and capacities for fostering open cultures and a shared language. The SBPTs also bridge the policy language of the MOE and teacher on the ground-classroom enactments of everyday practice, operationalizing frameworks for teaching practice and what are school's mission and goals on curricular enactments.

Micro-layer: The micro-layer is to the authors the most significant layer as this is where the 'rubber hits the road' and the core where change occurs or otherwise. The reported findings in Table 9.4 appear to have overlaps with Tables 9.2 and 9.3 as the interviews conducted on Principals, middle leaders and teachers are similar. This is a good phenomenon as it shows that participants in our study understood the importance of tenets such as keeping an open culture, transparency, and mutuality or trust. This includes the opening of classrooms for peer teachers and school leaders to observe and to peer-learn. It also means open dialogues on how to differentiate instruction to different profiles of learning, with concerns not just on academic matters but also those of social emotional learning.

Table 9.4 Micro-layer reporting of findings

Theme	Key points	What worked?
Challenges	1. Buy-in 2. Carry overs 3. Orchestration at the macro-layer 4. Supply of expertise	• School-to-school network by design • Engagement of 1 LT for Science, 2 MTTs for English, 1 MTT for Geography to facilitate SBPTs • Blocking out time for SBPTs and PLTs to meet
Teacher outcomes and learning needs	1. Design work at the heart 2. Developing capabilities for skills transfer	• Lesson co-design in SBPTs and PLCs on 1 topic cycle • Inquiry, questioning and design skills acquired by teachers in SBPT through facilitation by expert other and group interactions
Strategies	1. Enabling structures and organizational routines 2. Core team facilitation	• Cluster for schools—collaborative benefits at cluster level without comparing—everyone learn together • Critical mass—HODs + teachers in SBPTs for coming together, going deeper—school ownership, subject-department operationalized • Economies of scale—sharing human resource expertise, expert knowledge, critical friend • Feedback loops—Set the frame for learning, key learnings (reflection logs, PLTs, SBPT, and post-intervention cluster sharing sessions, reflection on success and failures)
Openness	1. Open culture 2. Ecological and apprenticing leadership 3. Deep connection	• Iterative cycles of 'design, critique, reflection, enact, reiterate' • See possibilities in lesson design (through SBPTs)

School leaders also know where real change would occur for the betterment of students and the desired outcomes. One of the school Principals mentioned clearly that the cluster was in support of the schools rather than schools for clusters. The latter connoted that in time past, there could be situations where schools were serving the needs of a school cluster who in turn was serving the goals of MOE. But now in an almost inverted sense, MOE and clusters were serving school needs, in particular with respect to sound teaching and learning goals for inquiry-based learning and twenty-first century learning outcomes. In schools, school leaders work with teacher leaders to create the innovation cultures needed for both teachers and students. A reasonably good proxy of change begins with the language used in role modeling the appropriate behaviors and sorting out the new norms of engagement.

Within the protocols distilled from the interviews, we also noted how schools and departments recognized the need for a stable supply of expertise and resources from the network or cluster in order to sustain the innovation change journey which is resource intensive and also rather challenging for teachers. The interviews also pointed to the need of a critical mass of teachers and experts coming together to embark on this innovation journey, with a distributed teacher leadership in place.

Within this socio-technical structure of teacher learning, the interview protocols also suggested that teachers were also appreciating the career pathway afforded for teaching to be specialized in pedagogy and teaching goals as they advance from beginning teachers, to being senior teachers, then lead teachers and possibly even as master teachers in the education system. Opportunities as afforded by this innovation change journey afforded a substantial way not only to learn but to be recognized for the transformative work done.

9.5 Discussion

Leadership from the middle espoused the middle of the system as a middle-out approach to improvement and change. In the above sections, we have appropriated the LftM concept 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. While schools need to enact the policy imperatives of the MOE, we have found in our past decade of observations that often schools alone (or by themselves) have major challenges in enacting change. Thus, partnering with other schools with similar change agenda and vision may be a possible alternative. Hence, while the policy intent is good and futuristic, the implementation pathway that enables and sustains change is at the 'schools' level. The innovation change is also not able to be sustained just by teachers or the community of teachers alone. In particular, we observed that the power distance cultures existing in this system requires the mutuality and trust by and from school leaders, with the intentional building up of teacher leaders to broker and mitigate tensions between the old and the new. The old being the current models of enactment which leads to successful outcomes for the exams per se, and the new being the competencies and dispositions needed for the twenty-first century. The old and the new have overlaps and may not be necessarily discordant, and our observations suggest that some schools have reached a point where new models of enactment also achieves examination performances of the old. This also suggests that recent reforms in assessments in examinations have also been more open ended and cannot be attained by rote means.

To sustain the new practices, there is a need for teacher beliefs to be transformed (Biesta et al., 2015).

Through the school-to-school networks, teacher leaders are observed to be: building trust and rapport; sharing tenets of teaching beliefs and values; engaging in apprenticeships among teachers; and communicating upwards and downwards of their enactments. Expertise for the enactment of the new are initially ‘borrowed’ from outside the school, but with an intentional plan to build within school capacity. The initial borrowing of resource expertise is found in the roles performed by: Lead Teachers (LTs) and Master Teachers (MTTs) who apprentice peer teachers in disciplinary enactments. Education Technology Officers from MOE can also aid in communicating upwards and downwards of the system and in design aspects of lessons. Researchers from the National Institute of Education (NIE) provide evidence-based data on learning outcomes; and partners from volunteer welfare organizations who complement in aspects such as the well-being of students could also be involved in the partnership efforts.

To reiterate, the SBLTs and SBPTs perform the functions of constantly calibrating and know where the heart of innovation change lies and intervening where necessary on the principles that: (a) school leaders provide for socio-technical supports; (b) teachers develop design abilities in practice; and students cultivate the agency and competencies for inquiry-based learning. Positioning expertise at the ‘right places’ in the system to enable coherencies and alignments to perform ecological and apprenticing leadership work is necessary, including that of systemic planning and thinking. Table 9.5 elaborates the functions of players in the school-to-school network at the ‘right’ places of the system.

Importantly, the functions of learn-ing, apprentice-ing, ecologic-ing, and systemic-ing (i.e., applying systems thinking) are being played out by respective role performances. Each of these functions are necessary to work itself out by cluster leaders, school leaders, teacher leaders, and teachers themselves. These performances when played with sensitivity and wisdom, managing all the political and change tensions can alignments be achieved both laterally and vertically. Ecological leadership as discussed in our previous studies (Toh et al., 2016) connotes vertical alignments.

In this chapter, we wish to advocate greater lateral alignments between ‘teachers’ across the different tacks—leadership, teaching, and specialist functions. More synergies between teacher leaders, master teachers and lead teachers with school leaders (at both school and cluster levels) are necessary. Our study suggests that the work of teachers and that of school leaders cannot be distinctively separated. Due to power distance cultures, intentional brokering is needed for trust building laterally. This important stance can cultivate more social and positional capital to achieve traction between school leaders and teachers toward the same agenda operational-wise and between teacher/school leaders with policy makers. These lateral alignments are also ecological leadership in action. Social capital for network resourcing can be extended to other school clusters not directly related to implementations. The sharing of knowledge and expertise can benefit the system as a whole.

Table 9.5 Levels of the system expanded and framed according to LftM

Levels of system	People (LftM)	Process	Product	Outcomes
Micro	Teacher	*Learn-ing* for the requirements of designing and enacting inquiry-based learning	Lesson plans and other artifacts	Design competencies
	Teacher leader	PLCs—*apprentice-ing*	Reflections and other mentee feedback	Role modeling and other apprentice-ing leadership skills
	HoD	*Ecologic-ing* between teachers and principals	Communication details and outcomes	Alignments achieved or otherwise
Macro	School leader	Networking of schools with cluster for change management (*ecologic-ing* between schools and clusters and MOE) *Systemic-ing* for change management	Change management and partnerships	Change in school socio-technical infrastructure
	Cluster sup	Networking with MOE, zones (*ecologic-ing*)	Change management and partnerships	School-to-school networks
Meso	Lead teacher/master teacher	NLCs—*apprentice-ing* and *ecologic-ing* between teachers and exo parties	Learning models and frameworks that can facilitate change	Supply of teachers with design competencies
	Education Technology Officers (MOE)	NLCs—*apprentice-ing* and *ecologic-ing*	Pedagogical innovations, e.g., Java Sim	Curation of innovations as system resources
	NIE Researcher	NLCs and PLCs—*apprentice-ing* and *ecologic-ing* with evidence base data	Pedagogical innovations, e.g., WiRead, Mycloud, PF, etc.	Systematic evidence base

Teacher leaders, when expertise and experience is gained, can then support other teachers to move within networks of schools to distribute expertise, role model and advice on evidence-based student outcomes, and influence school leaders and garner support for change and sustainability. As discussed in our findings, these are apprentice-ing functions that teacher leaders do, whether they are positioned within classrooms or at other role-positions in the system.

The teacher leaders from the middle of the system, and at every middle of the larger education system, can be positioned to influence and to build design capacity among teachers so that the desired outcomes of education can be afforded, and greater parity of learning outcomes for all students, especially those from disadvantaged families can be adequately met. School leaders and cluster superintendents increasingly need to engage in ecologic-ing with partners outside the traditional realms of education to cater for diverse needs of students.

Another important dimension of teacher leadership is systemic-ing. As aforementioned, applying systemic thinking is increasingly important. Planning ahead, and knowing how systems work, even systems at classroom levels, would aid teachers in understanding the principles of enactment at higher levels of analysis. When teachers are exposed to issues at different levels of a system would, they begin to appreciate complexities and hence better draw implications to their own work and practice. This also leads to a better appreciation of policies and how they translate and impact on classroom practices. Such understandings broaden the professionalism of teachers.

While in Table 9.5, we connote learning as the function of learner-teachers in the designing and enacting of inquiry-based learning, we wish to add that all teacher leaders are learning to play their functions of apprentice-ing, ecologic-ing, and systemic-ing throughout their job positioning functions as life-long learners in their professional life.

Another important point which might be worth mentioning is that the MOE deploys officers, referred to as Education Technology Officers (ETOs) to the schools where technology-based interventions occur and they serve in pedagogical advisors similar to Lead and Master Teachers, but at the same time, they aid to communicate upwards to MOE. They also curate the innovations and artifacts, and these serve as MOE resources that can be shared to all other schools.

Finally, we have intentionally adopted the term 'teacher leadership' broadly and have positioned them at every middle of the system (see Fig. 9.1). Whether these teacher leaders are functioning in classrooms or at the school level, or cluster, or even at the system, we stress that leadership is crucial for innovation change and sustainability. If we desire for a system that is progressive, we need teacher leaders to function with understanding, courage, and sensitivity to the cultural nuances of any system and learn new skills in situated contexts. Policy–practice translations are complex, and it is leaders that are constantly standing in the gap that enables change and transformations to occur.

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Chapter 10
Addressing the Skills Gap: What Schools Can Do to Cultivate Innovation and Problem Solving

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Abstract Singapore students have consistently demonstrated outstanding levels of performance in mathematics and problem solving captured in international assessments. However, these stellar results stand in contrast to Singapore's real-world problem-solving capacities, evidenced by her diffident innovation levels and a limited talent pool with problem-solving skills that are high in the value chain. This chapter seeks to address this "skills gap" between what schools develop in students and the high-value workforce skills needed for innovation and enterprise. Focusing on mathematics problem solving, we first examined the historical and socio-cultural development of Singapore mathematics education to identify the system's affordances in cultivating the performance in international assessments, and its trade-offs in developing students' skills in dealing with authentic, non-routine and complex real-world problems. We then examined the trajectories and the impact of pedagogical innovations that were designed for the Singapore mathematics classrooms and that sought to address the trade-offs. From a postulation of factors behind the challenges of implementing and sustaining these innovations in the classrooms, 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.

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10.1 Introduction

10.1.1 Singapore's Mathematics Performance in International Assessments: Status and Significance

Singapore students have consistently achieved high levels of performance in mathematics international assessments, securing top positions in the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). Considering that such assessments provide evidence about the comparative success of the Singapore education system in the teaching and learning of mathematics (Mullis et al., 2016) and in equipping her future workforce with the necessary competencies to deal with the authentic contexts deemed essential for life and work in the twenty-first century, this naturally begs the following questions: What factors could be behind Singapore mathematics education's success in driving the stellar performances in these international assessments? Through an insight into these factors, what steps can Singapore's mathematics education embark on next to ensure that the country stays ahead of the curve in terms of ensuring a high-quality workforce equipped with the necessary mathematical skills and problem-solving competencies? To answer these questions, we pursued a systemic perspective to identify the current affordances and trade-offs in the current Singapore education system, which would in turn allow us to examine the possible actions that the Singapore mathematics education can adopt to move forward.

An overview of the Singapore education system could be obtained from the surveys conducted by the TIMSS and PISA (Mullis et al., 2016; Organisation for Economic Co-operation and Development [OECD], 2013a, 2013b, 2013c, 2014) and other related secondary analyses that followed (e.g., Yi & Lee, 2017; Zhu, 2017). With regard to mathematics education, the surveys and the analyses revealed the following findings of the key players of the system. Singapore *students* were showed to be highly intrinsically and instrumentally motivated towards mathematics, were generally confident in the subject, but also had higher than average levels of anxiety towards the subject. Singapore mathematics *teachers* were also generally more qualified than their international counterparts in terms of educational certifications and trainings, and had greater opportunities in receiving professional development programmes that focus on mathematics. Mathematics lessons provided students with adequate exposure to the necessary pure and applied mathematical knowledge and were above international average in terms of their levels of support, classroom management, disciplinary climate, cognitive activation, exposure to pedagogical practices that are both student-oriented and teacher-directed and avenues for formative assessments. In terms of *school governance*, while principals have lower than average levels of autonomy for resource allocation and curriculum and assessment, they practised high levels of strong instructional leadership, and assessments and examinations were highly employed for purposes such as school effectiveness and progress, teacher effectiveness, and the design of instruction. Finally, the *school and external environment* were supportive of students' academic development in mathematics: students perceived schools as adequately resourced and safe, and their home environments provided them access to resources for learning. Students also engaged in mathematics homework and activities in informal, out of school hours. Collectively, these factors illustrated the amount of resources Singapore has invested in her students' mathematics education, which has a central focus in problem solving.

While Singapore's outstanding performance in TIMSS and PISA, as well as its emphasis on mathematics education and problem solving, may imply that Singaporeans are well prepared for problem-solving situations in real life, the validity of this inference is, however, questionable on two fronts. First, real-life problems are often complex, non-routine, ill-structured, admit multiple solutions, and require not only cognitive skills, but also a range of other competencies such as creativity, and social and emotional skills. This contrasts the pre-determined and well-articulated problems that are found in standardized assessments (e.g., Deng & Gopinathan, 2016). Second, Singapore's laudable performance in cognitive-based problem-solving assessments, stands in contrast to her diffident performance in other global indicators of real-world problem solving (e.g., innovation, entrepreneurship). For instance, she was lowly ranked in its "innovation efficiency ratio" (63rd place) in Global Innovation Index 2017 (Cornell University, INSEAD, & WIPO, 2017). Similarly, a recent report published jointly by Telstra and The Economist Intelligence Unit (2017) ranked Singapore 21st (out of 45 countries) for industries' confidence in "innovation and entrepreneurship". These indicators suggest that Singaporeans' exceptional lead in problem solving in international assessments bears little relation to the emergence of a critical pool of value-creators and high-value-chain skilled problem-solvers that can help propel the Singapore economy to greater heights. We refer to "skills gap" as the gap between what schools develop in students and the high-value workforce skills needed for innovation and enterprise. In the context of this chapter, the gap is confined to mathematics problem solving. We postulate that problem solving is one of the key enablers for filling this gap.

Given this paradox, it therefore warrants an examination on the underlying factors accounting for the misalignment between Singapore's demonstrated high levels of mathematics and problem-solving capacities captured in international assessments, and the actual demonstrated real-world problem-solving capacities that are measured by the innovation, entrepreneurship, and other drivers of economic growth. Clearly, the various findings about the current Singapore education system from the TIMSS and PISA cannot address the paradox; we will need to understand how it has evolved to its present state. An appreciation of the historical development of the mathematics education in Singapore could provide us with an insight into why certain strategies were pursued to upskill the numeracy and problem-solving competencies of her population. The affordances and trade-offs of these strategies would also foreground the challenges that Singapore faces in developing a sizeable indigenous talent pool with problem-solving skills that could stay high in the value chain, and maintain her competitiveness in the knowledge age.

Hence, in this chapter, we will first outline the historical and socio-cultural development of Singapore mathematics education, and from this analysis, identify the factors that the system has afforded in the high performance in mathematics international assessments, and the trade-offs that may impede the development of students' skills in dealing with the non-routine and complex real-world problems. We then examined the pedagogical innovations that were designed for the Singapore mathematics classrooms that sought to address the trade-offs. From a detailed understanding of the innovations trajectories and their impact in the local classrooms, we then reflect on and postulate the factors behind the challenges of implementing and sustaining these innovations in the classrooms. Implications for policy, practice, and research are put forth to propose how the Singapore mathematics education can be further enhanced to mould the high value-skilled, value–creating talent that Singapore needs to stay competitive in future.

10.1.2 Going to the Genesis of the Singapore's Mathematics Education: Explaining Singapore's Success in International Assessments and Its Trade-Offs

Prior to her independence under the British colonial rule, Singapore was a small, free entrepôt port and a flourishing hub for trade and commerce (Lee, 2008). In her post-independence years, Singapore's founding leaders leveraged education as an important driver to maximize the potential of Singapore's only resource—her people—in a land-scarce island and used education as a vehicle to level up her pluralistic, multi-ethnic populace that was largely illiterate and unskilled, and to restructure her economy. As Singapore constantly seeks to develop herself to become a major location for research, financial services, and high-end manufacturing (Tan & Bhaskaran, 2015), mathematics has been perceived and employed as a key subject of modernization necessary for economic growth. The mathematics education shifted in tandem with the nation's response to a global environment that is highly susceptible to change and nation building efforts (Lee, 2008). Guided by the principle of meritocracy, pragmatism, and accountability, the mathematics curriculum matured over the years, as it progressed through three major phases of Singapore's education history.

In the ***survival*** phase (1959–1978), which spans both the post-colonial and post-independence periods in Singapore's history, there was a need for the government to develop a common mathematics syllabus for her multi-ethnic citizens, given the vernacular nature of education offered then. Mathematics was to be instructed in English, the language of commerce, and had pedagogical recommendations that was progressive. Problem solving was included as one of the learning objectives in the 1970s. Despite the constant revisions of the syllabus during this period, the strategy did not level up the low numeracy rates of the population. Identifying teacher quality, misalignment between curriculum and assessments, and the perceived lack of coherence of what was learnt in school to what was required in the workforce (Lee, 2017) as possible contributory factors, this led to the next phase of the development in the Singapore education system. Dubbed as the ***efficiency*** phase (1979–1996), this phase aimed to address the high education wastage and the low literacy rates identified in the late 1970s, as well as the need for Singapore to evolve to a higher-skilled economy. The strategy was the employment of an ability-based streaming system at both primary and secondary levels of education that takes into consideration variations in learning capacities of children (Kaur, 2014). In tandem with the streaming initiative, assessments like Primary School Leaving Examinations (PSLE) and Singapore-Cambridge Ordinary and Advanced (O- and A-) levels examinations played major roles in providing information to the placement, selection, and certification of pupils at the key stages of education (Lim & Tan, 1999), and became more high stakes. The Curriculum Development Institute of Singapore (CDIS) was established to design a highly prescriptive mathematics curriculum (e.g., syllabus, textbooks, teacher guides) to allow for differentiated instruction and could be employed by less experienced and skilled teachers. More important, a pentagonal framework for the mathematics curriculum that has a centrally focused on problem solving was developed. Concerted efforts were made to develop and support students' mathematical problem-solving abilities; heuristics, like the model method, (Kho, 1987) were introduced. The policies and strategies pursued during this period resulted in a dramatic decline in dropout rates and an impressive rise in literacy and numeracy rates (OECD, 2011; Mourshed et al., 2010). By 1984, the performance for O-level English was a 90% pass rate, and in 1995, Singapore led the world in mathematics in TIMSS (OECD, 2011).

With the Asian financial crisis in 1997, there was a need to prepare students to be lifelong learners for them to survive the challenges that were brought about by the rapid economic, technological, and cultural changes. This was also necessary to cultivate an environment that breeds innovation, which has become the key driver of growth for advanced economies. These developments brought about the current ***ability*** (1997–2011) and ***student-centric, value-driven*** phases (2012 onwards) of the Singapore education system. A new educational vision, "Thinking Schools, Learning Nation", was mooted, with aspirations for the Singapore schools to develop creative thinking skills, the passion for lifelong learning, and nationalistic commitment in the young. There was a shift in focus to enabling students to reach the fullest of his or her potential, to encouraging student-centred learning, and to the development of ethics, character, and dispositions. The previous streaming system evolved into one where students could now cross over from one stream to another, with multiple bridges and ladders to move from one trajectory to another (Lee et al., 2016). Several support programmes, such as the Learning Support Programme for Mathematics (LSM) and the ICAN project (Improving Confidence and Achievement in Numeracy), are offered for the mathematically less endowed. For the mathematically more capable students, there are gifted education programmes, advanced mathematics options within the syllabus, and also specialist institutions, such as the National University of Singapore (NUS) High School of Mathematics and Science, devoted to the nurturing of mathematical and science talent. With the education policy's focus on developing students' potential, recommendations are made to ensure more "quality" (e.g., related to classroom interaction, opportunities for expression, and innovative and effective teaching approaches and strategies), rather than "quantity" (e.g., in terms of rote-learning, repetitive tests, and following prescribed answers) for instruction (Kaur, 2014). There was also explicit recommendations on teacher practices that would enhance students' process skills, with the curricular document detailing the kind of learning experiences that students should have in their mathematics lessons (MOE, 2012).

Corresponding to the policy changes, there was a reduction and re-organization in the mathematics syllabus content to facilitate innovation development (Kaur, 2014). Aspects of the pentagon framework were also appraised to reflect an increased emphasis on the thinking skills and processes that are necessary for effective mathematical problem solving. Recognizing that processes like creativity and critical thinking, and soft twenty-first century competencies like collaborating with others, perseverance, and initiation could not be driven solely from the top, the Ministry of Education (MOE) allowed for more decentralization, where schools were given much greater flexibility and responsibility for how they should teach and manage their students (Kaur, 2014). For example, funding was provided for ground up initiatives like the *Ignite! Programme*, which was introduced to help fund schools to engage in innovative practices that may help transform learning (see Lee, 2014).

Nonetheless, as much as there was increasing autonomy, there was also increased accountability for results. Decentralization reforms are initiated by the MOE, and while schools have the autonomy to decide on administrative procedures and tasks, such as setting up their own directions, vision and mission, and deciding the percentage of students via school based merit criteria, and the choice of pedagogy to deliver the national curriculum, all schools must conform to the rationale and intents of national policies to the MOE (Toh et al., 2016), and remain rooted to the system of central coordination to ensure that education ends are met (Ng, 2010). As such, despite the increased autonomy for instructional changes in mathematics classroom, the increased accountability for academic results that is part of centralized–decentralization system has led mathematics instruction to continue to be transmissionist, teacher-directed, and dominated by teaching *for* problem solving, so as to ensure that students achieve content mastery for high-stake examinations.

10.1.3 Observations from the Evolution of Singapore Mathematics Education that Explain Her Performance in Assessments Internationally

From the development of mathematics education in Singapore, which is guided by the principle of meritocracy, pragmatism, and accountability, the following four factors could have arisen to explain her stellar mathematics performance. First, in terms of the ***historical and cultural development***, Singapore's historical beginnings as a port for trade and commerce and her post-independence economic strategy to develop herself as a major location for high-end manufacturing pre-disposed the development of the necessary numeracy and problem-solving competencies required to develop the trading psyche, and the need to have good mathematics education. Coupled with a societal culture that upholds Confucian teachings that emphasize the respecting of authority and order and the importance of education in upgrading oneself, Singapore students are compliant to work hard for their studies. This gave rise to the competitive, high-performing, and high-stressed system that possibly propelled high performance in international assessments.

Second, there was a ***strong alignment of intended curriculum, assessment, and pedagogy***. As the Singapore mathematics education evolved over time, and with MOE maintaining a strong control on curriculum and assessment matters in the centralized–decentralized system, the intended curriculum, assessment, and pedagogical support to meet the educational needs of the population gets more and more aligned. The mathematics curriculum, which consults the curriculum and teaching approaches from both Eastern and Western countries, lays out a balanced asset of mathematical priorities centred for problem solving and build deep understanding of mathematical concepts (Ginsburg et al., 2005). Heuristics and the teaching for problem-solving approaches in the classrooms that geared towards the mastery of mathematics helped students rise to the demands of high-stakes assessments, which were described as of high standard and challenging (Ginsburg et al., 2005).

Third, Singapore's stellar mathematics could be attributed to its ***quality teachers***. Singapore mathematics teachers are generally more qualified than their international counterparts in terms of certifications and training, and were selected based on a stringent criteria prior to joining the service. They are well-compensated and have access to more opportunities of professional development (PD) in mathematics. Kaur (2009) also noted that mathematics teachers in Singapore have high standards of professionalism and work ethos.

Finally, the Singapore education system allows ***opportunities for levelling up***, and for crossing of pathways. For students who are ready to move to a more advanced level of learning, they can move from their current stream, and thereby allowing for levelling up. There are also availability of support programmes (e.g., LSM and ICAN) and setting of institutions (e.g., NUS High Schools) to cater to students of diverse mathematically skills and talents.

The Singapore mathematics education system, with its high standard of curriculum and assessments, quality teachers, and differentiated support for students, has undoubtedly aided students to excel in problem solving within test-taking situations. However, to prepare students to problem solve beyond the school context, Gravemeijer et al. (2017) argued that there is a need for mathematics taught in the classroom to not only be responsive to the increased digitalization and automatization of work processes, but also to be aligned to the characteristics of mathematics in the workplace. Specifically, mathematics education should develop students' ability to (i) *recognize where mathematics is applicable;* (ii) *translate practical problems into mathematical problems;* (iii) *solve the mathematical problem; and* (iv) *interpret and evaluate the outcomes.* Like most mathematical education systems around the world, the current Singapore mathematics education focused largely on the third area of solving mathematical problem solving, which Gravemeijer and colleagues (2017) noted are increasingly carried out by computers. This narrow focus on problem solving is also evident from the mainly teaching *for* problem-solving approaches adopted in the Singapore mathematics classrooms (Fan & Zhu, 2007; Hogan et al., 2013; Kaur, 2017). This teaching approach is reinforced by the centralized–decentralized system, where tight control is exerted on curriculum and assessment, assessments are high-stakes, and students' achievements are part of teachers' performative indicators. Although teaching *for* problem solving has been effective in helping students develop mastery of skills and content, and in preparing them to achieve in standardized examinations, it is at the expense of the less measurable but equally important development of soft competencies. To promote these mathematical problem-solving processes that would help students to deal with non-routine and complex real-world problems and where skills are increasingly automated by technology and machineries, there is a need to encourage the teaching *about* and via problem-solving strategies (Lester, 2013; Shroeder & Lester, 1989) to engender more meaning in problem solving, allowing for more deeper understanding of mathematics through inquiry-based environments (Lester, 2013; Shroeder & Lester, 1989), and could afford the development of the necessary twenty-first century competencies.

Two pedagogical innovations—the *Mathematical Problem Solving for Everyone* (*M-ProSE;* Toh et al., 2011) and the use of constructivist learning designs (e.g., *Productive Failure* [*PF*]; Kapur, 2008, 2010)—were introduced for this purpose. Against the backdrop of the current system, we describe the ways each innovation diffused into a centralized–decentralized system in their bids to help transform practice in the Singapore mathematics classroom.

10.2 Transforming Mathematical Practice to Get Singapore to Stay Ahead of the Curve: Pedagogical Innovations and Their Trajectories

M-ProSE relates to the teaching *about* mathematical problem solving, as it involves a 10-lesson problem-solving module that explicates the teaching of Pólya's four-stage problem-solving strategy through the use of appropriate non-routine problems, teacher instruction, and teacher modelling.

(i) ***How did the innovation travel?*** To help teachers understand how to implement teaching *about* problem solving, the researchers designed a prototype model with one school first, and in the process developed the module and built teacher capacity. Participating teachers were also provided with a comprehensive three-stage PD training (Leong et al., 2011). The "success story" in the high ability school paved the way to diffusing the innovation to four more secondary schools that were representative of the spectrum of schools in the Singapore education landscape (Toh et al., 2017).

(ii) ***How did the research practice nexus pan out?*** The research team operationalized Pólya (1954)'s and Schoenfeld (1985)'s problem-solving model into a lesson plan that encouraged the use of explicit instruction, scaffolding, and non-routine problem practices to help students understand the nature of a Math problem, Pólya's Four-Step Problem-Solving Process, the selection and functions of heuristics, and Schoenfeld's (1985) notion of control. Practical worksheets that explicate students' thinking processes were also constructed. During the implementation, researchers worked closely with teachers to find out teachers' concerns (e.g., task difficulty) to further refine the innovation.

(iii) ***How systematic was the research done?*** To demonstrate the tractability of M-ProSE, research on the project proceeded in three identifiable phases: (a) *exploration and pilot phase*, where the research team laid the groundwork for the problem-solving curriculum; (b) *development and implementation phase*, where M-ProSE team used a "design experiment" method to develop and implement the innovation in a high ability school; and (c) *infusion and diffusion* phase, where M-ProSE was diffused to four more secondary schools (Toh et al., 2017), and further infused in the original M-ProSE school's curriculum.

PF (Kapur, 2008), a constructivist learning design, promotes the teaching of mathematical concepts via problem solving. It includes a two-phase learning design: (a) *generation phase*, where students generate and explore solutions collaboratively to a novel problem that targets a mathematics concept they have yet to learn; and (b) *consolidation and assembly phase*, where the concept is taught and teachers compare and contrast the canonical solution to what students have produced in their problem-solving efforts.

(i) ***How did the innovation travel?*** Given that constructivist learning designs, such as PF, counter the conventional instruction problem-solving cycle adopted in most mathematics classrooms, a series of quasi-experiments were conducted to first establish a strong proof-of-concept (Kapur, 2008; Kapur et al., 2008), and it was later followed by an expansion of the evidence base for the innovation (Kapur, 2012). Following which, there was a PD research programme that helped to build teachers' design, content, and pedagogical knowledge in designing PF units. The empirical studies and teacher capacity building effort also enabled a collaboration between MOE and the research team to translate and scale the PF learning design across key concepts in the A-level statistics curriculum in 2014.

(ii) ***How did the research practice nexus pan out?*** The crux of PF research lay in the re-examination of the roles of structure and failure in problem solving. The PF learning design embodies four core interdependent mechanisms: (i) activation and differentiation of prior knowledge in relation to the targeted concepts, (ii) attention to critical conceptual features of the targeted concepts, (iii) explanation and elaboration of these features, and the (iv) organization and assembly of the critical conceptual features into the targeted concepts (Kapur & Bielaczyc, 2012). PF, however, would require support for the teachers in developing the necessary knowledge to design for, and enact the learning design, and also a change in classroom culture. Hence, from the comprehensive PD and in-situ support, the research team worked with the teachers to effect the paradigm shift in employing the teaching of concepts via problem solving and help them see the relevance and meaning of employing the pedagogy in the deep learning of mathematics.

(iii) ***How systematic was the research done?*** The PF research proceeded through four identifiable phases: (a) *proof-of-concept,* which sought to demonstrate the efficacy of PF as compared to DI; (b) the *expansion of evidence base,* which sought to examine the effectiveness of PF across curricular units, grade levels, and schools; (c) *building teacher capacity*, which sought to develop teachers' design, content, and pedagogical knowledge; and (d) *translation and scale*, which sought to translate and scale PF across key concepts in the A-level statistics curriculum. In its progress from its proof-of-concept to the translation phases over the years, the PF research conducted design experiments in establishing the pedagogical tractability of the design for learning, and the progression of the research; the evidence collected allowed the research to convince stakeholders to engender this diffusion into the system. Three important findings have emerged: (1) despite failing to discover the canonical solution in their problem-solving efforts, PF students significantly outperformed their counterparts in the traditional Direct Instruction (DI) classrooms in conceptual understanding and transfer problems without compromising procedural fluency, and this trend was consistent in schools with different academic profiles; (2) students with significantly different mathematical abilities were not as different in terms of their ability to generate multiple representations and solution methods to the complex problems; and (3) students' capacity to generate solution methods positively predicts how much they learnt from PF. Taken together, these findings suggest that the PF design not only combines the benefits of exploratory problem-solving and instruction, but is also a promising way of maximizing the learning potential in Singapore mathematics classrooms. The research also shed light on the importance of the role of the teacher in building upon students' ideas when instructing the canonical concept.

To date, all five schools in the M-ProSE research continue to implement the 10-lesson module. As for PF, the innovation impacted mathematics classrooms from 23 schools, 240 teachers and more than 8700 students. The translation project has impacted 16 out of the 20 JCs (80%) in Singapore, 8 of which expressed interest in the continuation of PF in the instruction of statistics in their school. A ground-up initiative of a Networked Learning Committee (NLC) comprising eight junior college teachers also emerged to advance the use of constructivist learning design like PF, in the design of mathematics instructional units.

10.3 Discussion and Conclusion

In the course of unpacking the paradox behind Singapore's stellar performance in mathematics international assessments and the under-developed pool of value-creating talent, we postulate that this could be due to the current mathematics classroom practices being predominantly transmissionist, and centres on teaching *for* problem solving. Although innovations like M-ProSE and PF were introduced to address this issue, their uptake remained with a selected few schools. Reflecting on the education eco-system, we postulate the following factors that may explain the general inertia in Singapore mathematics practice in embracing innovations:

(i) ***Teacher level***. Teacher capacity and practice may be impeding factors. This is related to (a) the nature of teachers' practice, which is time pressured to fulfil multiple instructional goals within an allocated time, resulting in further decreased sense of competencies in adopting a new instructional approach (Leong & Chick, 2011); (b) the innovations' demands on teachers' design (DK), content (CK), and pedagogical content knowledge (PCK); and (c) teachers' beliefs that acquiring knowledge is more important than how it is acquired, that certain conceptual strategies are more suited for their high achieving students than for the low-achieving ones, and that pedagogical innovations are less efficient than their usual practice.

(ii) ***Institutional level***. Teachers' lack of efficacy and unwillingness to implement constructivist learning designs in the classroom are also influenced by the type of trainings that they were exposed to prior to their incumbency. While most mathematics teachers are graduates, not all possessed the requisite mathematical disciplinary knowledge, given that most of them are non-mathematics majors or underwent training in more applied mathematics disciplines, such as engineering and business. While the National Institute of Education (NIE) provides comprehensive training in the mastery of mathematics content and does expose teachers to constructivist learning designs, the short duration of the pre-service training and the demands of implementing such designs possibly explain the low take up of pedagogical innovations. In addition, for in-service teachers, the general training for the use of constructivist training methods in practice is not extensive.

(iii) ***Policy level***. While there is a push at the policy to effect more constructivist ways of instruction in the classroom, the high-stake assessments system may be a disincentive for teachers to take up instructional methods that are less efficient in getting students to master the necessary content knowledge to tackle the assessments, or methods that allow exploration and failure.

(iv) ***Cultural level***. At the macro-level, two cultural forces that are inherent in the Singapore culture may affect teachers' and students' actions and motivations, which in turn impede the adoption of pedagogical innovations: (a) *fear of failure*, which inhibits students' creative problem-solving capacity and teachers' openness to instructional methods that take up more time, rely on failure mechanisms, and possibly might not have any comparative advantage to the tried and tested DI; and (b) high *power distance* (Hofstede, 1991), which is reinforced in mathematics classrooms where teachers play an authoritative role concerning knowledge, and where students are comfortable not be invited to voice themselves and participating in the knowledge construction process. Such forms of instruction will propagate an absolute form of epistemology about knowledge, i.e., knowledge provided by teacher or an authority is absolute and final.

Taken together, given the centralized system which demands that teachers meet standards, and the demands that new innovations place on teachers' capacity, and their beliefs and attitudes, it will take a leap of faith and lots of courage for teachers to make space to implement pedagogical innovations independently. However, the focus on just content and procedures will be ineffective in the long run, given the gradual obliteration of such technical knowledge with the increased automatization of the world. Hence, despite MOE's attempts to encourage teachers to complement their current strategies with pedagogies that are more student-centred and encourage higher-order thinking, the lack of a wider uptake of these pedagogical innovations in Singapore mathematics classrooms reflects a policy practice translation gap.

To address this gap, there is a need to enhance Singapore mathematics education, taking into account its position in a centralized education system, its current heavy emphasis on the mastery of content knowledge for the preparation of high-stake examinations, and the general culture of conformity and risk-aversion. We need a more concerted movement to develop and incentivize teachers to consider the *process* of learning mathematics, in order to ensure the kind of depth in learning and development of competencies that are necessary for the development of value-creating talent for the future. Constructivist pedagogies, especially those that afford students to tinker and explore ideas, elicit their intuitive conceptions prior to the formal instruction of targeted concepts, and persist in their failed problem-solving efforts, could be ways to engage students both in the deep learning of concepts, and creative problem solving. Considering that mathematics practice is couched in the unique Singapore education ecology system, implications of how this can be achieved are detailed below:

(i) ***Implications on taxonomy, mathematics curriculum, and assessments***. There is a clear emphasis from MOE for teachers to focus on how mathematics should be taught to allow students to experience the discipline of mathematics deeply. However, given the general pedagogical practices in the current mathematics classrooms, this possibly requires a stronger push from policy to transform the socio-mathematical culture in Singapore classrooms through (a) stipulating the use of such innovations nationwide; (b) developing a taxonomy that defines and operationalises features of effective mathematics lessons in which mathematics teachers could leverage; (c) providing directives on the use of the various assessment methods to assess mathematical competencies at the national level; and (d) freeing up more time for teachers to implement these new pedagogies in the classroom.

(ii) ***Implications on Practice***. The implementation of pedagogies for the teaching about and via problem solving demands teachers' CK, PCK, and DK. Considering the background of the majority of mathematics teachers, where most come from non-mathematics major background, there is a need for training institutions (i.e. NIE, Academy of Singapore Teachers, AST) to not only continue the development of CK and PCK, but also in specialized content knowledge (SCK), which is the mathematical knowledge and skills unique to the teaching (Ball et al., 2008). Master Teachers from AST could also help to form the necessary Professional Learning Communities (PLCs) and Networked Learning Communities (NLCs) to help support teachers, whereas NIE research teams could provide teachers with in-situ support of the pedagogy during implementation, and follow up with the teachers to identify sustainability issues. The other source of scaffolding for teachers could come from the teachers' immediate work environment, i.e., the school culture. With the push to ease the cultures of fear of failure and power distance, existing leadership in schools will need to find ways to lead the micro-cultures within each school in the realization of the change of culture in the classrooms. The collective efforts from NIE, AST, and schools will be instrumental in the development of teachers in leading the innovations in the mathematics and effecting ecological leadership (e.g., Toh et al., 2016). These might be help to overcome the cultural barriers such as power distance. Finally, formal learning environments would need to be redesigned to include pedagogies that support the teaching about and via problem solving, and schools could also collaborate with external agencies to enable students to participate in informal learning environments (e.g., learning of coding) for authentic learning.

(iii) ***Implications on Research***. With the slow uptake of pedagogical innovations in the classroom, as well as the lack of adequate expertise in NIE to support the development and training of all mathematics teachers in terms of implementing and designing resources to realize constructivist learning in the classrooms, there is a need for NIE research fraternity to (a) work with MOE and AST to develop the necessary resources in advancing these pedagogies; (b) develop effective PD models that could equip Singapore teachers with the necessary capacities; (c) play the role of the broker, understand the needs of the ground, and suggest the necessary ideas and avenues to get teachers to be the implementers of these strategies; (d) to embrace the essence of action research and teacher inquiry as measures of success of adaptation on the ground, and; (e) continue their roles in helping MOE and schools improve deep levels of mathematical learning in schools.

For the past 20 years, Singapore students have demonstrated high levels of mathematical competencies and problem-solving capabilities in TIMSS and PISA. However, Singapore's innovation levels, which are demonstrations of a country's comparative advantage in problem solving in a competitive, globalized world, have a weak correspondence with the results of these international assessments. To address this skills gap, we need to cultivate Singaporeans to achieve skills that are at the highest end of the value chain. To do so, we argue that mathematics instruction should emphasize more on the *processes* of problem solving and argue for the teaching *about* and via problem solving as the necessary approaches to afford deep and meaningful learning and the development mathematical habits and dispositions in students. We postulate that cultural factors and teacher capacity are the reasons behind the slow development of these practices and that these factors can be addressed through the collective efforts of MOE, NIE, AST, and schools, in investing in teacher development, and in pushing for a change in school and classroom culture (e.g., reducing power distance). We believe that a concerted effort for change from policy, research, and practice could slowly help to close this skills gap.

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Chapter 11
Leadership Supporting Innovation in Curriculum: Essential Lessons

Hairon Salleh

Abstract The task of school leadership has never been less challenging than before especially taking into consideration current education reforms that demand extensive, comprehensive and in-depth changes. At the ground level, schools as organizations are now engulfed in this 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 upshot of which is school leaders' responsibility and prerogative to provide diverse curricula that satisfy diverse needs of stakeholders. This chapter 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 brings to the fore the indispensable role of leadership across all levels of the organization encompassing a diverse set of leadership models to support curriculum development and innovation.

Keywords School leadership · Curriculum innovation · School-based curriculum development

11.1 Introduction

The inception of the 'Thinking Schools, Learning Nation' (TSLN) policy initiative in 1997 was a precursor to a myriad of rapid, wide-ranging, deep-changing education reforms in Singapore. This was predominantly motivated by globalization forces in economic and social facets. This policy initiative received a further boost with the introduction of another major policy initiative coined as 'Teach Less,

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Learn More' (TSLM) in 2005, which saw further comprehensive reforms in education. By 2013, the education ministry further casts their attention to values education. The policy reforms that took place since 1997 essentially require key education stakeholders to consider school outcomes beyond academic achievements (e.g., twenty-first century competencies) due to the changing economic, social and political contexts surrounding education. The apparent upshot to these reforms is the increase and complexity of demands placed on schooling. Educational contexts are increasingly getting complex insofar as the changes accompanying educational reforms are characterized by intensity, rapidity, fluidity, uncertainty and complexity.

Schools are therefore expected to satisfy needs of multiple stakeholders, namely policymakers, parents and community members—needs that are increasingly getting more demanding and complex. Also, school leaders and teachers are to provide appropriate educational curricula that satisfy these needs. However, the real challenge is on school leaders to mobilize and optimize physical and human resources toward shared organizational goals in increasingly complex educational contexts. One reason for this rising complexity is due to the general weakening of classifications in social relationships and boundaries and a moving away from organized social structure to network culture (Hartley, 2007). A former example is the general rise in parental expectation and intrusion into teachers' professional practice. A latter example is the general rise in partnerships between schools and external organizations. Furthermore, contemporary reforms in the public service have been observed to demand greater 'joined-up' or 'network' regime of governance—a societal culture wherein (i) all categories and classifications are weakened and rendered increasingly permeable (a flexible 'liquid modern' view of space and time) and (ii) the new work order consistent with the knowledge economy (where individuals work and learn beyond bureaucratic enclosures using their loose spatial and temporal codes) (Hartley, 2007).

It is therefore understandable that contemporary school leaders have to use more time and energy in managing these increasingly fluid and cross-boundary relationships. It is also not surprising that school leaders resort to distributed leadership, where decisions are delegated and shared to other staff members beyond the purview of school principals. In the Singapore context, delegation or sharing of leadership decisions to middle managers such as department heads (HODs) or subject heads (SHs) has been a common place for at least more than two decades, especially that pertaining to instruction. In this sense, distributed leadership is closely tied to instructional leadership insofar as the former allows instructional leadership practices to be delegated or shared to other staff members beyond school principals or vice-principals. Unsurprisingly, the link between instructional leadership and distributed leadership has been observed before (Lieberman & Miller, 2011; Spillane & Louis, 2002; Timperley, 2005). In this respect, instructional leadership practices have become more dispersed across the school organization, making it more effective to bring about enhancements in teaching and learning.

However, over the last decade, leadership decisions pertaining to instruction have been delegated and shared to teachers who are considered informal leaders, or teacher leaders, in response to growing intensity, rapidity, fluidity and uncertainty in education reforms. This is a result of the growing demands placed on schools so much so that administrative decisions have to be passed on from senior to middle leaders, which result to middle leaders delegating or sharing their decisions on instructional matters to teacher leaders. These teacher leaders include Senior or Lead Teachers (STs and LTs), Subject and Level Reps and Professional Learning Community Team Leaders—all of which are involved in making leadership decisions on instruction. The effectiveness of distributed leadership to enhance instruction is therefore dependent on how well instructional leadership is distributed to teacher leadership, and thus how well both distributed leadership and teacher leadership competencies are developed. However, while delegating or sharing decisions on instruction from senior to middle leaders has been formally established for some time, the distribution of instructional leadership from middle leaders to teacher leaders is not. Furthermore, distributed leadership is not merely to do with delegating, relinquishing or sharing decisions on instruction from senior to middle leaders or from senior and middle leaders to teacher leaders. It involves empowering staff in decision making, developing leadership, encouraging shared decisions and providing collective engagement (Hairon & Goh, 2015).

Although the problems raised above describe realities at the ground level and pose tremendous challenges to school leaders, what is most pressing and demanding is school leaders' task in leading curriculum development and supporting curriculum innovations in present-day education contexts. How do school leaders lead organizations to initiate, develop and sustain curriculum innovations? What strategies do they use to develop appropriate school curricula? What leadership practices support curriculum development and innovation? How are leadership practices distributed across the organization, and to what effect? Who are the instructional leaders within school organizations? This chapter describes research 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 purpose of the study was to investigate how school leadership supports curriculum development for curricular innovation involving ICT.

11.2 School Leadership Matters for Curriculum Innovation

The question whether leadership makes a difference to the success of schools, or any organization or institution outside education, is not of contention in contemporary thought. For centuries—as demonstrated in the writings of Plato, Caesar and Plutarch (Bass, 1981), it has been assumed that leadership is critical to the success of any human endeavor (Marzano et al., 2005). Nevertheless, what is of interest now is primarily to do with—(1) the extent of effect leadership has on school improvement processes and outcomes, (2) how leadership affect school improvement processes and outcomes, (3) how contextual factors within and outside schools affect the extent and ways in which leadership has on school improvement processes and outcomes, (4) how leaders' individual differences affect the extent and ways in which leadership has on school improvement processes and outcomes and (5) the ways in which leadership are developed to optimize the ways in which school leadership affects school improvement processes and outcomes.

Although interest in leadership started as early as the first half of the 1900s—specifically trait theories in the 1930s, interest in leadership in schools only had its strong impetus in the 1980s along with the burgeoning of the school effectiveness movement. And although leadership is centrally to do with influence—defined as 'a social influence process whereby intentional influence is exerted by one person [or group] over other people [or groups] to structure the activities and relationships in a group' (Yukl, 1994, p. 3) or simply a process of influence in achieving shared goals (Bush & Glover, 2003), the study of leadership in education has shifted its focus on leadership practices. This is in part because influence as a construct for investigation is both methodologically difficult and too simplistic to investigate. The focus on practices is also contemporaneous with the shift from trait theory of leadership to situational and behavioral theories of leadership especially with Stogdill's (1948) findings which severely challenged the utility of trait theories on leadership. In many ways, the focus on leadership practices, or behaviors, in education mirrors or follows that in the field of organizational study. Since its great impetus in the 1980s, the concept on educational leadership has grown in complexity. In their review on educational leadership from 1988 to 1995, Leithwood and Duke (1999) found 121 out of 716 articles that pertain to leadership. In their review of leadership research over ten years, Heck and Hallinger (1999) observed a clear trend toward the accumulation of knowledge on school leadership and postulated the continual expansion of interest in leadership research along with its eclectic diversity—philosophically and methodologically speaking, in view of leading and managing effective schools in an era of educational reforms.

By early twenty-first century, knowledge on school leadership has reached a point where there is a general consensus that not only school matters, but also how school leadership matters. In this regard, Leithwood et al. (2006) outlined seven 'strong claims' about successful school leadership:

1. School leadership is second only to classroom teaching as an influence on pupil learning.
2. Almost all successful leaders draw on the same repertoire of basic leadership practices.
3. The ways in which leaders apply these basic leadership practices—not the practices themselves—demonstrate responsiveness to, rather than dictation by, the contexts in which they work.
4. School leaders improve teaching and learning indirectly and most powerfully through their influence on staff motivation, commitment and working conditions.
5. School leadership has a greater influence on schools and students when it is widely distributed.
6. Some patterns of distribution are more effective than others.
7. A small handful of personal traits explains a high proportion of the variation in leadership effectiveness.

Table 11.1 School leadership models

Type of leadership	Orientation
Instructional leadership	Curriculum and instruction
Extended instructional leadership	School mission
	Managing the curriculum
	Providing learning climate
Transformational leadership	Models organizational values
	Develops shared mission
	Provides intellectual stimulation
	Builds consensus
	Redesigns organizational structure
Integrated leadership	Conditions supporting school improvement
	Instructional leadership; broader perspectives on organizational effectiveness, leadership roles 'delegated' to people and structural coordination mechanism

Although knowledge on school leadership has indeed become more diverse and eclectic over more than two decades, it has also become more integrated (Hendricks & Scheerens, 2013) insofar as we are now able to identify specific practices that are considered effective in school leadership drawn from the wide array of leadership models, especially instructional or curricular, transformational and distributed leadership. As an illustration, Hendricks and Scheerens (2013) provided a schematic view of the development in the concept formation on school leadership in Table 11.1.

Leithwood et al. (2006) had also proposed a form of integration by proposing four categories of practices that are considered successful leadership practices: building vision and setting direction, understanding and developing people, redesigning the organization and managing the teaching and learning programme. Notwithstanding the value in understanding school leadership in an integrated manner drawn from broader perspectives, three school leadership models seem to stand out. These are: (1) transformational leadership, (2) instructional leadership, and (3) distributed leadership.

11.2.1 Transformational Leadership

Transformational leadership in education has been researched over the last two decades. Drawing from Burns' (1978) conceptions of transformational leadership, Leithwood and his colleagues (Leithwood, 1994; Leithwood et al., 1999) established eight dimensions of transformational leadership consisting of (1) identifying and articulating a vision, (2) fostering the acceptance of group goals, (3) providing individualized support, (4) intellectual stimulation, (5) providing an appropriate model,

(6) high-performance expectations, (7) strengthens school culture, and (8) builds collaborative relationships. 'Identifying and articulating a vision' involves leaders' behaviors aimed at identifying new opportunities for their school and developing, articulating and inspiring others with a vision of the future (Jantzi & Leithwood, 1995, p. 515). 'Fostering the acceptance of group goals' involves leaders' behaviors aimed at promoting cooperation among staff and assisting them to work together toward common goals (Jantzi & Leithwood, 1995, p. 515). 'Providing individualized support' involves leaders' behaviors that indicate respect for individual members of staff and concern about their personal feelings and needs (Jantzi & Leithwood, 1995, p. 515). 'Intellectual stimulation' involves leaders' behaviors that challenge the staff to reexamine some of the assumptions about their work and to rethink how it can be performed (Jantzi & Leithwood, 1995, p. 515). 'Providing an appropriate model' involves leaders' behaviors that sets an example for staff members to follow consistent with the values the leader espouses (Jantzi & Leithwood, 1995, p. 515). 'High-performance expectations' involve leaders' behaviors that demonstrate the leader's expectations for excellence, quality, and high performance on the part of staff (Jantzi & Leithwood, 1995, p. 515). 'Strengthens school culture' involves leaders' behaviors that demonstrate the leaders' expectations for staff participation, the sharing of power and responsibility of others, promotes an atmosphere of caring and trust among staff, frequent and direct communication, clarification for school's vision and norms of excellence (Leithwood, 1994). 'Builds collaborative structures' involves leaders' behaviors that demonstrate the willingness of the leader to share in responsibility, power, and decision making, which includes staff's opinions when making decisions and that ensure effective group problem-solving, provides autonomy for teachers in their decisions and alters working conditions to ensure that staff have collaborative planning times (Leithwood, 1994).

11.2.2 Instructional Leadership

Instructional leadership in education has been researched upon since 1980. Hallinger (2005) claimed that instructional leadership is 'still alive in the domains of policy, research, and practice in school leadership and management' (p. 221) attributing this to the rise in global emphasis on school accountability. Hallinger's conceived instructional leadership as a role carried out by school principals (Hallinger & Murphy, 1985). Instructional leaders are viewed as strong, directive leaders; culture builders; goal-oriented in terms of student academic outcomes; focusing both leading and managing; hip-deep in curriculum and instruction; and working directly with teachers to improve teaching and learning (Hallinger, 2005). Further, instructional leadership has three core dimensions: (1) Defining the schools' mission, (2) Managing the instructional program and (3) Promoting a positive school learning culture, which are further delineated into ten instructional leadership functions (Hallinger, 2005). They include the following:

(I) Defining the schools' mission

i. Framing the school's goals
ii. Communicating the school's goals

(II) Managing the instructional program

iii. Supervising and evaluating instruction
iv. Coordinating the curriculum
v. Monitoring student progress

(III) Promoting a positive school learning culture

vi. Protecting instructional time
vii. Promoting professional development
viii. Maintaining high visibility
ix. Providing incentives for teachers
x. Providing incentives for learning.

However, in his re-conceptualization of the instructional leadership construct, Hallinger (2005, p. 233) proposes seven aspects of focus for school leaders. They are as follows:

1. Creating a shared sense of purpose in the school, including clear goals
2. Focused on student learning
3. Fostering the continuous improvement of the school through cyclical school development planning that involves a wide range of stakeholders
4. Developing a climate of high expectations and a school culture aimed at innovation and improvement of teaching and learning
5. Coordinating the curriculum and monitoring student learning outcomes
6. Shaping the reward structure of the school to reflect the school's mission
7. Organizing and monitoring a wide range of activities aimed at the continuous development of staff; and being a visible presence in the school, modeling the desired values of the school's culture.

11.2.3 Distributed Leadership

Unlike transformational and instructional leadership, interest and research in distributed leadership in education has been more recent even though the concept has been in the management literature for some time (Gronn, 2000; Harris, 2004; Harris & Spillane, 2008). Hartley (2007, 2009) observed that the rise to prominence in distributed leadership can be attributed to contemporary reforms in the public service that demands greater 'joined-up' or 'network' regime of governance—a societal culture wherein (i) all categories and classifications are weakened and rendered increasingly permeable (a flexible 'liquid modern' view of space and time) and

(ii) the new work order consistent with the knowledge economy (where individuals work and learn beyond bureaucratic enclosures using their loose spatial and temporal codes). These changing work contexts are consistent with the three kinds of roles emerging within changing policy environment, that is—enhanced line roles, project roles and networking roles (Simkins, 2005). Specifically, the attraction of distributed leadership in education lies in its potential to bring about school improvement (Harris, 2007, 2011, 2012; Spillane & Healey, 2010). Claims have also been made on distributed leadership's potential impact on instructional aspects of leadership (Elmore, 2000; Lieberman & Miller, 2011; Smylie et al., 2002; Spillane & Louis, 2002) and leveraging on instructional improvement (McBeth, 2008; Murphy & Datnow, 2003; Timperley, 2005). Distributed leadership, along with transformational leadership, has also been claimed to supersede transactional leadership in influencing school climate and environment and enhancing the instructional capacities of teachers (Jones et al., 2012; Spillane et al., 2001). Although the literature remains agnostic about its impact on student achievement because of insufficient empirical data (Bennett et al., 2003), its potential to do so remains intuitively attractive, compelling and positive (Gronn, 2008; Leithwood et al., 2006). As such it is not surprising that distributed leadership is endorsed by many as good practice (Hopkins, 2001).

11.2.4 School-Based Curriculum Development (SBCD)

Notwithstanding the prominence of transformational, instructional and distributed leadership models for effective schools, the question that needs answering is whether and how the manifestations of such leadership practices are critical in supporting schools seeking to initiate, develop and sustain school-based curriculum development for curriculum innovation. First and foremost, it is instructive to take note that school-based curriculum development (SBCD) has been around since the 1970s and 1980s prior to the onset of centralized curriculum and national standards in predominantly western countries such as Canada, USA, UK and Australia. On the flipside, its importance in non-western education systems has grown only in the last decade or so (Kennedy, 2010). SBCD has been defined in different ways. It has been defined as the 'planning, design, implementation and evaluation of a programme of students' learning by the educational institution of which those students are members' (Skilbeck, 1984, cited in Marsh et al., 1990, p. 48). It has also defined as

> a process in which some or all of the members of a school community plan, implement and/or evaluate an aspect or aspects of the curriculum offering of the school. This may involve adapting an existing curriculum, adopting it unchanged, or creating a new curriculum. SBCD is a collaborative effort which should not be confused with the individual efforts of teachers or administrators operating outside the boundaries of a collaboratively accepted framework. Bezzina's (1991, p. 40)

Further, the OECD defined SBCD as

> any process which – on the basis of school-initiated activity or school demands regarding curricula – brings about a redistribution of power, responsibilities and control between central and local educational authorities, with schools acquiring the legal and administrative autonomy and the professional authority enabling them to manage their own process of development. (OECD, 1979, p. 4)

The combination of the definitions provided by Skilbeck (1984), Bezzina (1991) and the OECD (1979) seems to imply that curriculum development processes can involve members within (e.g., local—school teachers and leaders) and outside school contexts (e.g., central—district superintendents, officials at headquarters). What is at the core of SBCD is that curricular decisions must involve members within schools, which could involve teachers, leaders, students and parents. On the flipside, however, curricular decisions do not rest entirely within schools. This balanced or middle perspective on SBCD has been highlighted by Marsh et al. (1990). Notwithstanding the distinction between school's autonomy versus central education's authority in matters of curricular decisions (Bolstad, 2004), SBCD is said to be an appropriate response to centralized curriculum which tends to neglect the diverse needs of teachers and students in their respective school contexts (Marsh, 1992).

Granted that research on SBCD has been more pronounced in Western education contexts, it would be interesting to investigate how schools in Asian education contexts with centralized education systems enact SBCD. In Singapore, where the education ministry has been encouraging greater school autonomy on school-based curricular decisions over the last decade or so—especially since the introduction of the 'Teach Less, Learn More' (TLLM) policy initiative, SBCD has taken a unique form. This is a result of policy initiatives which started since the mid-1990s (Gopinathan & Deng, 2006)—specifically, in the era of 'Thinking School, Learning Nation' (TSLN) starting in 1997. In their analysis of SBCD in Singapore, Gopinathan and Deng (2006) understood SBCD more as '*school-based curriculum enactment*' whereby school leaders and teachers adapt, modify and translate the externally developed curriculum materials (e.g., syllabi, textbooks and resources) from the education ministry, and in doing so, participate in the 'creation' of a new curriculum product. This will then result in the production of 'educative' curriculum materials which have the potential to support teacher as well student learning. In acknowledging this potential, Gopinathan and Deng (2006) suggested drawing inspiration from the use of nine heuristics by Davis and Krajcik (2005), albeit within science teaching. They are as follows.

1. Support teachers in engaging students with topic-specific scientific phenomena.
2. Support teachers in using scientific instructional representations.
3. Support teachers in anticipating, understanding and dealing with students' ideas about science.
4. Support teachers in engaging students in questions.
5. Support teachers in engaging students with collecting and analyzing data.
6. Support teachers in engaging students in designing investigation.
7. Support teachers in engaging students in making explanations based on evidence.

8. Support teachers in promoting scientific communication.
9. Support teachers in the development of subject matter knowledge.

The key idea or purpose behind 'educative' curriculum materials is to design curriculum materials that enhance teachers' understanding of students and content, increase curricular and pedagogical resources, help teachers find productive ways of adapting materials in classroom contexts, enhance teachers' abilities to respond to particular needs of students and strengthen the role of teachers as curriculum developers to enhance meaningful curriculum experiences (Gopinathan & Deng, 2006). In addition to promoting 'educative' curriculum materials, investing in teacher professional development has also been suggested.

The question that needs answering is 'Does school leadership matters in SBCD'? While the discussion on school leadership above seems to support that school leaders and school leadership do indeed play a significant role in supporting SBCD, how they do so in educational reform contexts that are increasingly characterized by intensity, rapidity, fluidity, uncertainty and complexity is yet to be understood fully at the ground level. This study therefore sought to give greater in-depth understanding of the complexities involved in SBCD within an education system that seeks to find the right balance within the centralized–decentralized continuum. The study centrally asks, '*What are school leadership practices that support school-based curriculum development processes?*'.

11.3 Method

The study made use of qualitative focused-group interviews (FGIs) to collect data from participants belonging to one public primary school—Technology Primary School (*fictitious name*). There were altogether five FGIs: one for the principal and vice-principal, two for the middle managers, and two for the teachers. In total, 23 participants took part in the FGIs—two school leaders, ten middle leaders and 11 teachers. The teachers who participated in the FGIs were chosen by the school leaders based on the specific curricular innovations that they were exposed to. The school was among other schools in Singapore that were involved in a nation-wide curriculum innovation programme using information communication technology (ICT). The purpose of using FGIs was to gather and generate in-depth information on the processes of curriculum development through conversations among school participants with similar experiences. The conversations that took place for each FGI were guided by a set of semi-structured questions. Each FGI was audio-taped and transcribed. The transcripts from the FGIs were chronologically coded to arrive at themes and categories. These themes and categories were developed taking into consideration coherence to generate findings focusing primarily on how school leadership support curriculum development processes.

Technology Primary School was established in 2000 and is located in one of the residential estates in the north region of Singapore. The school is considered a 'mainstream school'—that is, with the following characteristics: (1) located within a public housing estate, (2) not affiliated to any religious or ethnic group and (3) does not have special status identifiers such as the Special Assistance Programme (SAP). It was headed by a principal who was assisted by three vice-principals (one VP academic and two VP administration). The school had about 101 teaching staff and about 1800 student population. In 2007, the school was selected to participate in a nation-wide ICT programme to lead the way in harnessing technology so as to enhance student learning. Prior to this, the school was progressively recognized for their exploration and experimentation in ICT for teaching and learning. Besides using technology as a medium for teaching and learning, the school had also used technology to support the school-wide approach in curriculum integration which cut across grade levels (e.g., Primary 3 and 4), content subjects (English and Social Studies) and school programmes. The school aimed to develop (1) students' learning strategies in questioning and inquiry skills, (2) students' media literacy, global and cultural awareness, communication skills and active citizenry and (3) students' self-responsibility and self-management of students' holistic health. The school had also worked with industrial partners to develop a range of ICT applications—specifically, 4Di/3Dhive, Imprints and Learning Objects.

11.4 Findings and Discussion

The findings from the study showed that a myriad of school leadership practices had played a significant role in supporting SBCD. These leadership practices encompass strategic leadership, instructional leadership, distributed leadership, teacher leadership and network leadership. The findings were also consistent with the assertion by Hendricks and Scheerens (2013) that school leadership has become more diverse, eclectic and integrated.

11.4.1 Strategic Leadership Supporting SBCD

The findings highlighted the importance of strategic leadership in supporting SBCD. It showed the importance of the school principal, along with the support of his vice-principals, in developing a coherent long-term vision on teaching and learning using technology based on the previous school principal's initial work which started in 2007. The main challenge that the principal faced when he took over in 2009 was to develop the curricular work which he did not initiate. Although he needed to make necessary changes as he deemed fit, he would need to take into consideration the contexts in which the previous principal had established to maintain stability in the change process. The ability to see the importance of continuity in order to sustain curricular changes is akin to having long-term future, seeing the bigger picture and understanding the current contextual setting of the organization, and is a key characteristic of strategic leadership (Brent & Davies, 2004). In understanding the current contextual setting of the organization, the principal saw the importance of enacting real change as opposed to superficial change. This was in specific regard to changes that are considered meaningful to his teachers. The following comments made by the principal illustrate this finding.

> For the two years, I observed how curriculum integration is done in this school. It's something really not out of the intent just to showcase but the intent is to practice. I think this is the difference because when you practice, teachers believe, and because teachers believe in curriculum integration, the integration of ICT becomes more meaningful. Otherwise, the ICT will be seen as an intruding factor. (Principal)

The second aspect of strategic leadership that was salient in the findings was the principal's ability to determine effective strategic intervention points. The first strategic intervention point was the "Team 1, Team 2" strategy. When the principal took over the school, he saw the strategic need to renew existing teams (Team 1) working on their ICT applications by injecting new team members (Team 2) to Team 1. Team 2 members were tasked to support, continue and succeed the work of Team 1 members. This strategy serves to heighten accountability among team members and increase the competency of team members in developing ICT applications through role modeling by Team 2 teachers. The sole purpose of using the 'Team 1, Team 2' strategy is essentially to make sure that the development of ICT applications was completed.

> I will have a Team 2 effect whereby Team 1 is the one that is developing the first generation, for example 4Di … I have a Team 2, another two more members to learn from the first team. But they are not just following. They're developing new themes … So when I meet Team 1 and Team 2 I see their methodology is quite different. (Principal)

The second strategic intervention point was the 'Roll-out' strategy, which capitalized on the idea of continual and progressive development of ICT applications. In this regard, the development of ICT applications could start at Term 1 school calendar year, then to be further developed in Term 2 school calendar year and then the second semester of the school calendar year. Another way of 'rolling-out' is to start the development of ICT applications at one grade level and then to be tried out at another grade level. A key advantage to this strategy is that the planning, designing, implementing and reviewing of the curriculum can be done on the go in gradual progressions and in small doses, as opposed to one-time massive comprehensive change.

The fourth strategic intervention point was the 'Staged' strategy, whereby the development work of ICT applications was checked for quality in stages. Teachers in their respective teams developed their ICT applications with direction from team leaders, ICT champs (team members who were more knowledgeable in certain technologies, and championed the use of ICT) and HODs, with the support from vendors. The completed development work was then submitted to the respective HODs to value-add the work, which will then be endorsed by the vice-principal and principal—the former for quality in curriculum integration, and the latter for ICT applications.

The fifth strategic intervention point was the ‘faculty-based’ curriculum development strategy, whereby teams develop ICT applications with sensitivity to different faculties—grade level 1 and 2, 3 and 4 and 5 and 6.

The determination of the five strategic intervention points also showed the ability of the principal to translate strategies into action and aligning individual members in the organization to the future organizational state or position (Brent & Davies, 2004)—in this regard, the school’s vision of curriculum integration using technology. The findings had not only highlighted the importance of strategic leadership in supporting SBCD, but also give further emphasis on the importance of strategic leadership—a leadership model which seemingly has not received much attention in recent times.

11.4.2 Instructional Leadership Supporting SBCD

The findings from the study showed that the school principal had supported SBCD through the enactment of instructional leadership practices. First and foremost, the findings pertaining to strategic leadership practices described above overlap with the findings on instructional leadership practices insofar there was clarity in defining the school vision and goals (Hallinger, 2005)—that is, curriculum integration using technology. Furthermore, the principal, along with his vice-principals, was cognizant of the importance of not only framing the school goals on curriculum integration using technology, but also communicating these school goals—as illustrated in the comments below.

> I think we also aim for clarity in terms of direction that we are taking. Why are we doing this? I think that this clarity is actually being passed down to the next in line, be it the KP (Key Personnel) or the teachers … Basically I want teachers to be very clear … They must be able to justify and the justification is very simple. If anything we do is for the sake of learning for our students, you are absolutely right and go ahead … Every day we meet – long or short, and when we meet, it’s not about – I give instructions. It’s about they telling me what to do (with regard to the development of ICT applications). (Principal)

The determination of strategic intervention points described above is also evidence of the dimension of instructional leadership on ‘managing the instructional programme’ (Hallinger, 2005) comprising (a) supervising and evaluating instruction and (b) coordinating the curriculum.

In addition to the instructional leadership practices that overlapped with strategic leadership practices, the principal also provided ongoing support in the development of ICT applications such as finance, expertise and networking. The ongoing nature of the support reflected not only the evolving nature of the development of ICT applications, but also with the primary purpose of supporting teaching and learning. The dialogue below highlights the support given by the school leaders.

> HOD A: They (principal and vice-principals) were not ‘the boss’ (directive), but they were very supportive of our ideas, yes. Very, very supportive.

HOD B: They (principal and vice-principals) gave us their full support. So whenever we need extra help, or whatever we can explore our ideas, ya, we can go to them.

HOD A: They were the ones who will get the MOE (Ministry of Education) and the ETD (Educational Technology Division) people to come down, and give guidance.

HOD A: Yhey were ready to support us – if it makes sense.

HOD B: Correct.

HOD A: Like HOD B says. It (curriculum development of ICT applications) has to be progressive. You just don't do something in isolation and then dump in. So as long as it helps our pupils – it makes a lot of sense – facilitate learning and teaching, of course the greater support it is.

Besides leadership support for teaching and learning, the school principal also provided guidance to the development of the ICT applications to be used for teaching and learning. The school principal, along with the vice-principals, played the primary role of 'advisors' which included strategic direction, giving guidance, consolidation of thought processes (e.g., resolving issues, clarifying ideas, reviewing outcomes)—as highlighted by a key personnel member.

But they (KPs) are also the ones that seek advice from the school leaders. The school leaders would say that, 'Okay, roughly these are the things that you can do.'

11.4.3 Distributed Leadership Supporting SBCD

Besides strategic and instructional leadership practices, the findings from the study also showed that the school principal had supported SBCD through the enactment of distributed leadership practices—specifically, in terms of empowerment of staff members, collective engagement and shared decision. With regard to empowerment, the principal distributed decision-making power on the development of ICT applications to various staff members in the school. One vice-principal academic was given the responsibility to coordinate the school-wide curriculum integration endeavor of the school taking into consideration the use of ICT applications, while the principal looked into overseeing the coordination of the development of ICT applications. In addition to this, the HODs had been given the responsibility to check the quality of the ICT applications created by teacher groups in context of the curriculum under their content subject jurisdiction. The role of HODs in this matter was considered a new introduction to the previous mode of curriculum development—as indicated in the following comments.

Okay. In the past, the model of decision making is one of the teachers are encouraged to initiate, then they have to collaborate and make collective decision. However, now the decision has been upscale. It's not just among teachers now but really with the HODs. This is the current model of change. (A key personnel member)

Among the teacher groups, team leaders played the role of leading fellow teachers in developing ICT applications allocated to them. This constitutes the second and third aspect of distributed leadership—that is, collective engagement and shared decision. Teachers working in their respective ICT application teams collectively work together to reach shared decisions on the merge between technologies and pedagogies.

The findings of the study on distributed leadership are interestingly consistent with claims made by educational leadership theorists that there is a close connection between instructional and distributed leadership (Lieberman & Miller, 2011; Spillane & Louis, 2002; Timperley, 2005)—albeit more indirect than direct. In this study, different staff members enacted different emphases on instructional leadership. The principal played a more indirect role in impacting the teaching and learning through direction setting, guidance, support and monitoring in the development of ICT applications. The vice-principal played an indirect role in impacting teaching and learning through guidance and monitoring in the development of ICT applications. The HODs played the role of ensuring that ICT applications were developed within the context of the content subject curriculum. The team leaders played the role of leading the direct development of ICT applications for teaching and learning. This synergistic operation is consistent with Gronn's notion of 'concertive action' (or holistic)—and what Spillane terms 'person plus' synergistic relationship (Spillane, 2006), as opposed to 'additive action'. While the latter is the aggregated effect of a number of individuals contributing their initiative and expertise in different ways to a group of organization, the former is about the additional dynamic which is the product of conjoint activity and where the outcome is greater than the sum of individual actions (Bennett et al., 2003; Gronn, 2002). Decisions made by empowered subordinates across all levels in the school organization were coordinated in ways that achieve alignment with the school goals.

Besides distributed leadership being related to instructional leadership, the findings of the study also raised the importance of teacher leadership in the development of ICT applications. Teacher leadership can be defined as 'the process by which teachers, individually or collectively, influence their colleagues, principals and other members of school communities to improve teaching and learning practices with the aim of increased student learning and achievement' (York-Barr & Duke, 2004, pp. 287–288). With regard to construct dimensionality, three dimensions for teacher leadership had been identified (Hairon, 2014; Hairon et al., 2015)—(1) building collegial and collaborative relationship, (2) promoting teacher learning and development and (3) enabling change in teachers' teaching practices. However, the findings from the study did not surface these three aspects of teacher leadership in its richness and depth. This could suggest the lack of investment in developing leadership in staff members for the development of ICT applications vis-à-vis the second dimension of distributed leadership (Hairon & Goh, 2015).

11.5 Conclusion

This study has shown that school leadership has played a significant role in supporting SBCD through the enactment of several leadership types or models—specifically, strategic leadership, instructional leadership, distributed leadership and teacher leadership. The study has also shown that the enactment of these leadership practices works in a collective sense to support SBCD. The configuration on the enactment of these leadership practices also indicates the Singapore context of SBCD, which privileges pragmatism and efficiency. The emphasis on strategic leadership practices depicts the need for efficient use of school resources to achieve the desired organizational goals. The emphasis on instructional leadership depicts the focus on improvements on nothing less than teaching and learning. The emphasis on distributed leadership further depicts the importance placed on role specializations to secure the development of ICT applications—the production of 'educative curriculum' to support the 'school-based curriculum enactment' which Gopinathan and Deng (2006) had argued for. The form of empowerment is also 'bounded' (Hairon & Goh, 2015) in the sense that all decisions pertaining to teaching and learning must be within the scope of acceptability insofar as they fit within the departments' and overall school's curricular goals. The study had also surfaced the importance of building leadership capacity to sustain SBCD, especially that of teacher leadership. Finally, underlying the enactment of leadership practices is the philosophy—or set of beliefs, that school leaders cherish, in their day-to-day practices. The principal in this study held a strong belief on making the curriculum meaningful and enjoyable for students—which essentially constitute his vision and inner drive for school-based curriculum development.

> And the day that they (students) are introduced to games (in school) is how they will sink into it. Or those that are now already playing games. There're some very good gamers. The good gamers when they are into it (games) they will forget the rest of the world. They come in to school – is like a CCA (Co-Curricular Activity). Their main core learning is at home playing games. Some are very balanced. They come to school, they play games. It's like a social thing but they also study very hard. Ah, this student, we must see how they can help each other. (Principal's view on games for learning in school)

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Chapter 12
Teacher Learning Communities as Catalytic Levers for Educational Innovations in Singapore Schools

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Abstract Grounded in our work on analysing teacher learning communities as they evolve from traditional learning epistemologies towards constructivist orientations and progressive, inquiry-driven pedagogies (Hung et al., J Interactive Learn Res 17:37–55, 2006; Hung et al., Educ Technol 55:20–26, 2015; Shaari et al., in press; Wu and Hung, Transforming learning, empowering learners: The international conference of the learning sciences (ICLS). International Society of the Learning Sciences, Singapore, vol 1, pp 474–481, 2016), this paper articulates teacher learning communities as catalytic levers for educational innovation in Singapore schools. We begin with an articulation of the characterizations of teacher learning communities within the Singapore education system—from those that organically emerge at the grassroots (teacher) level to those that were intentionally designed at the systems (ministry) level. While there has been growing recognition for networked learning of school faculties that engender results, which are meaningful and impactful at both the teacher and student level, the purported stance is that change towards innovation and progressive, inquiry-driven learning practices is not just a change in instructional strategies but also a fundamental change in teachers' epistemologies. Through case examples of the developmental processes of a networked learning community within the system, we posit that *apprenticeship-learning* affordances of networked learning communities underpin teachers' shifts in epistemology and function as proximal vehicles for catalyzing innovations through progressive, inquiry-driven pedagogies. These shifts are engendered through tenets of (i) growth intentionality, (ii) dialectics of structure-agency, design-emergence, periphery-centrality, and commonality-diversity, (iii) socio-technological leverages, and (iv) ecological coherence and alignments. Expanding our analysis both vertically (macro systems level to micro personal

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level) and horizontally (abstract cross-disciplines to concrete subject-specific affinities), we ground these theoretical ideas to a nuanced understanding of *scalable epistemic learning*, in the context of educational innovation and diffusion.

Keywords Inquiry based learning · Teacher learning communities · Teacher epistemology · Apprenticeship learning · Scalable epistemic learning · Innovation change · Networked learning communities

12.1 Introduction

Global challenges of accelerated human mobility, urban density, healthcare, and economic and environmental sustainability (IDA, 2015) have underscored how the old ways of twentieth-century education standardizations are ill suited to the fast, flexible, and vulnerable landscapes of the twenty-first century. Traditional models of education, rooted within assumptions of knowledge transfer from external sources—such as teachers, books, and schools—to students, categorized by age, progress, and amount of time spent in class, are struggling to engage a new generation of learners for whom learning is happening all the time—in formal and informal spaces, in classrooms and out of classrooms, and in online and offline environments. It is now more pertinent than ever to invest in the appropriate training and skills that will shape our learners' future, to attend to educational elements that seed deeper transformations in the quality of teaching and learning while fostering critical process skills embedded within inquiry-based practices. Such process skills, embedded within the twenty-first-century competencies framework (Fig. 12.1), include appropriate dispositions of questioning, knowledge building, problem solving, critical thinking, creativity and imagination, and aesthetics and design thinking, that are socially embedded, interest-driven and oriented towards development of personal integrity, social democracy, and the advancement of quality human living amidst networks of interactions.

Within the context of Singapore classrooms, there have been ongoing efforts towards reforming conventional didactic practices through innovative intervention projects spearheaded by the Office of Education Research (OER) at the National Institute of Education (NIE) (e.g. Social Studies inquiry (Critical Web Reader), knowledge building, seamless learning, productive failure, mathematics problem solving, game-based learning, six learning), albeit not without resonant tensions of education change in terms of resistance on the ground, innovation *wither* phenomena, and lack of sustained innovation cultivations (Hargreaves & Shirley, 2012). Within this vein, undergoing a basic change in pedagogical practices may be comparatively analogous to breaking down the 'Berlin Wall' of conventional didactic practices. From a macro-systemic perspective, if such a change can be optimally achieved, it is posited that it ought to be at *scale*. In other words when a change phenomenon begins to succeed, policy makers will begin to ask how the gains and benefits observed in a particular context can begin to spread. Specifically, it impels the question of how the spread can bear benefits across the system—not stratified to benefit only specific group (e.g. low, middle, high) of achievers or prejudiced on the part of students in faster-paced streams (Tan, 2013) and teachers towards students in slower-paced streams

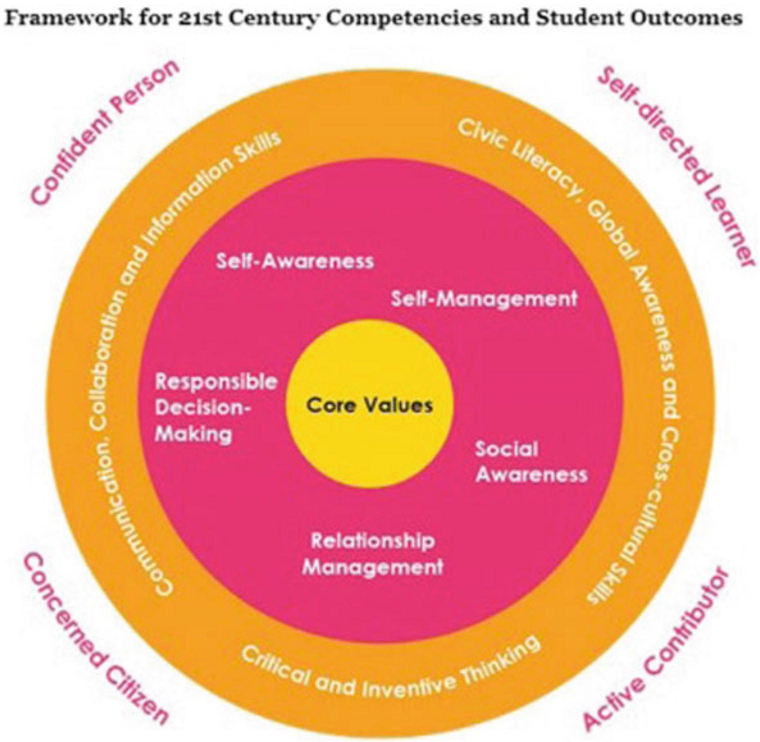

Fig. 12.1 Framework for twenty-first-century competencies (21st CC) by Ministry of Education, Singapore (MOE, 2017)

(see for e.g. Tan & Ho, 2001; Kang, 2004)—but instead how education change, that is systematically extensive across all levels and layers of learners, can achieve the critical mass to be sustainably engendered.

Our purported stance is that the shift from traditional knowledge transfer models towards innovation and progressive learning models is not just a change in instructional strategies, but a fundamental change in teachers' *epistemology*. This entails shifts in the way teachers' construe the process of learning and how knowledge is being constructed. While knowledge within a 'twentieth-century' paradigmatic thinking is described as fixed, stable and something that exists 'out there' waiting to be discovered, a progressive twenty-first-century lens views knowledge as fluid, complex, and uncertain and constructed in social contexts as people seek to make sense of their world. Teaching and learning in this paradigm are dominated by processes where knowledge is viewed as relational, a network or flow, and the aim is to use knowledge to make things happen (Gilbert, 2009). Sterling (2010) interprets a 'learning level, which may be said to be epistemic learning; that is, it involves a shift of epistemology or operative way of knowing and thinking that frames people's perception of, and interaction with, the world' (p. 23). This is consistent to Bateson's

(1972) view of 'seeing our worldview rather than seeing with our worldview so that we can be more open to and draw upon other views and possibilities' (p. 23). Within this vein, teachers need to change the way they view classroom learning from a dominantly teacher centric one to one which is student-centred. In other words, for education change and innovation towards inquiry-based learning practices to be sustained, it necessitates parallel shifts of teachers' and students' 'worldview' of the classroom and learning in general.

In this paper, we foreground a discussion of how scaling agentic inquiry practices, that underpin educational innovations, may be mediated—and catalyzed—through networked learning communities (nLCs). Specifically, we argue that scaling of innovative inquiry practices is not a mere 'top-down' roll out of resources related to any particular new pedagogy, nor is it adequate to provide only professional development for teachers; rather, it requires conviction on the part of teachers and the resilience for change seeded by the variant degrees of epistemic learning afforded by nLCs within the system, coupled with appropriate leadership and socio-technological infrastructures. 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.

12.2 Literature

12.2.1 Teachers' Epistemic Learning as Underpinning Change Towards Innovation and Inquiry-Driven Learning

Research on epistemic learning has primarily focused on the relation between the knower and the known (Hofer & Pintrich, 1997). Hofer (2004), for instance, posited plausible models of personal epistemology and describes two areas and four dimensions of beliefs about knowledge and knowing. This included two main lines of research on individual's beliefs that are most compatible to philosophical dimensions of epistemology: *nature of knowledge* and *nature of knowing*. Four dimensions were specified further from these two areas which included: certainty of knowledge (ranging from conceptions of knowledge being fixed to being tentative and evolving), relationality of knowledge (ranging from conceptions of knowledge as discrete pieces of information to highly interrelated concepts), source of knowledge (ranging from conceptions of knowledge being derived from external authorities to conceptions of self as knower), and justification for knowing (how knowledge claims are evaluated, including the use of evidence, the use they make of authority and expertise, and their evaluation of experts) (Hofer & Pintrich, 1997, p. 120). Other researchers have extended the area of epistemology into three broad categories of investigation that delved into analysis of epistemic learning (i) from a developmental perspective (e.g. Perry, 1999; Belenky et al., 1986; Baxter Magolda, 1992; King & Kitchener, 1994; Kuhn, 1995), (ii) as a system of beliefs (e.g. Schommer-Aikins, 2002), and (iii) as conceptualizations of personal epistemology (e.g. diSessa et al., 2002; Hofer & Pintrich, 1997).

Specific to teaching and learning, contemporary psychological research on learners' epistemological conceptions may trace its roots back to the work of Perry (1968/1999), who interviewed Harvard students' ideas about knowledge during their four year college. Schommer's (1990) research into teachers' epistemological beliefs, on the other hand, surfaced the importance of relating both teachers' and learners' cognition and performance. Specifically, she developed a multidimensional framework of epistemological beliefs as consisting of knowledge interrelations (ranging from the belief that knowledge is isolated bits to the belief that knowledge is interrelated concepts), knowledge stability (ranging from the belief that knowledge is certain and unchanging to the belief that knowledge is tentative and evolving), knowledge source (ranging from the belief that knowledge comes from authority to the belief that knowledge comes from reason and empirical evidence), learning ability (ranging from the belief that ability to learn is gifted or innate at birth to the view that it can be increased), and learning velocity (ranging from the belief that learning takes place quickly or not at all to the belief that learning is gradual) (Schommer, 1990; Schommer et al., 1992). The theoretical assumption framing the development of the multidimensionality of beliefs was based on the premise that learners' epistemological beliefs range from 'naïve' towards 'sophisticated' beliefs (Schommer, 1998), wherein 'naïve' is used to indicate a person who thinks that knowledge is certain, absolute, and can be transferred by an authority; while sophisticated beliefs refer to knowledge that is more complex, relative, flexible, and can be actively constructed by the individual (Brownlee et al., 2001) (see Fig. 12.2). Howard et al., (2000) approximated such a naive-sophisticated categorization to align to the behaviouristic vis-a-vis constructivistic paradigm of knowledge and knowing. Extending this approximation, we posit that engendering innovative change towards inquiry-based paradigms within the classrooms would thus necessitate socially constructivist epistemic shifts towards more sophisticated cognizance of *knowledge* and *knowing* means, in terms of how both are inextricably intertwined and co-constructed through developmental

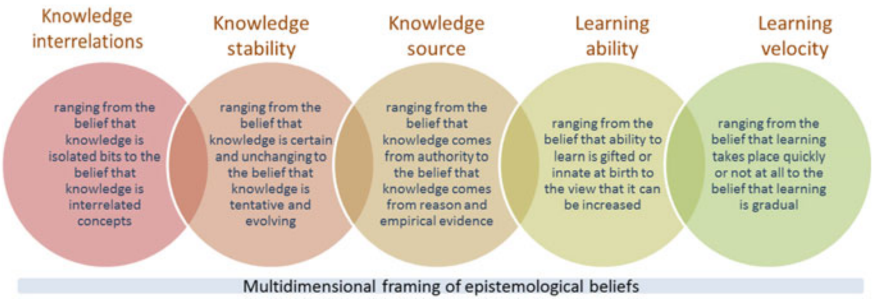

Fig. 12.2 Framework for epistemic learning on a range from *naïve* to *sophisticated*

trajectories of learner-directed inquiry—a process we frame as *epistemic learning* in this paper.

12.2.2 Challenges for Epistemic Learning and Innovation in the Singapore Classroom

Against a backdrop of securing economic competitiveness and social cohesion, while grappling with the challenges posed by globalization, the Singapore education system has evolved over the years through enunciations of the Desired Outcomes of Education (DoE) (MOE, 2015) for supporting clear and defensible learning foci for students, teachers, and leaders. The DoE documents (e.g. see Table 12.1) represented approaches by the Ministry of Education (MoE) to categorize outcomes specific to the various stages of schooling and had twofold functionality—first, as a common blueprint to guide all education policies and programmes, and, second, as a basis for evaluating the success of these policies and programmes (Tan, 2013).

Yet, amidst clear articulations of the DoE and the 21st CC framework (refer to Fig. 12.1), there exist an inherent problematization of the culture of didactic teaching

Table 12.1 Key stage outcomes of education

At the end of Primarv school, students should:	At the end of Secondary school, students should:	At the end of Post- Secondarv education, students should:
be able to distinguish right from wrong	have moral integrity	have moral courage to stand up for what is right
know their strengths and areas for growth	believe in their abilities and be able to adapt to change	be resilient in the face of adversity
be able to cooperate, share and care for others	be able to work in teams and show empathy for others	be able to collaborate across cultures and be socially responsible
have a lively curiosity about things	be creative and have an inquiring mind	be innovative and enterprising
be able to think for and express themselves confidently	be able to appreciate diverse views and communicate effectively	be able to think critically and communicate persuasively
take pride in their work	take responsibility for own learning	be purposeful in pursuit of excellence
have healthy habits and an awareness of the arts	enjoy physical activities and appreciate the arts	pursue a healthy lifestyle and have an appreciation for aesthetics
know and love Singapore	believe in Singapore and understand what matters to Singapore	be proud to be Singaporeans and understand Singapore in relation to the world

Ministry of Education (2015) (Printed with permission from MOE) coupled with rote learning (Koh, 2013) endemic within a system characterized by competitive high-stakes national examinations (Tan, 2013) and a historical ideology of efficiency for the survival of the nation. For example, although students in Singapore have achieved first place in public and international Mathematics and Science Olympiads, such achievements have been attributed to the ‘spoon-feeding’ culture and “well-trained exam-smart” students’ (Koh, 2013, p. 53). Antithesis to the illocutionary intent of the policies implemented to achieve the DoE (e.g. Thinking Schools, Learning Nation; Teach Less, Learn More, Curriculum 2015), anecdotal evidences suggest that teachers, parents, and students remain seemingly embroiled in a feverish quest for examination success. However, in our observations concerning schools, we recognize that the intents of DoE are gradually taking root, albeit rather gradually. Content teaching remains a priority within classrooms, and with a typical class size of 35 students, this makes innovation challenging with teachers having to both manage the classroom and to complete teaching the necessary syllabus in all the subject areas. As a result, frontal teaching is often defaulted, privileging seemingly naïve conceptions of knowledge construction. Yet Singaporean students excel in practically all international benchmark tests, which may suggest that the seemingly frontal pedagogy may have semblances of deep learning.

Reverberating tensions between examination assessments and DoE yield questions as to whether teachers can overcome this need to cover the content syllabus yet at the same time foster innovative learning. The aforementioned ongoing efforts at the OER, NIE has spanned almost a decade of active endeavours into seeding inquiry based approaches in schools through the various intervention projects, and the need is recognized to frame a systematic approach to how innovative, inquiry-based practices may be diffused into classrooms in an accelerated, equitable manner. For instance, there have been attempts to overcome the linearity of syllabus coverage through the introduction of more performative ways, consistent to real world enactments, of learning through game-based learning where content is not ‘transmitted’ through traditional ways, but through students’ appropriating conceptual understanding through the gameplay experience (Chee & Tan, 2012). While such progressive ways of teaching and learning bear its own efficacies, the spread of such practices was impeded by systemic challenges inherent within the Singapore education system, induced by both practical constraints such as time and assessment requirements as well as skills and epistemic limitations. These include challenges such as teachers’ ‘locked’ mindset where they hold steadfast to content transmission and syllabus completion during classroom enactments; constrained time where teachers have limited time for professional development and sharing of good practices and students have no time and space for reflection; and exam-oriented culture where learning is oriented to drill and practices assessment. Importantly, against a backdrop of such scaling and translation challenges, we observed the important role of leadership and socio-technological enablers for inquiry driven learning (Toh et al., 2014). For example, in another intervention project on students’ synchronous questioning (Wu, 2018), the technological platform—SMILE, a low-cost, LAN-based technology—mitigated the problem of asynchronous questioning in traditional classrooms by affording synchronous interactions and questions. Over the course of time, one can begin to see whether other peers 'liked' the questions that their peers ask. This apparently prompted the impetus for more questions posed and seeding the change in classrooms culture—from one of mere 'receiving' to that of active 'questioning'. As students' dispositional shifts in terms of questioning and gainful learning were made visible, teachers become more convinced of the efficacy of the intervention and seeds the changes in thinking and practices in schools.

From a research perspective, orienteering towards the need for intervening and scaling inquiry-based practices thus triggers the following questions—First, what are the key elements in the innovation that enable that change in practice, vis-à-vis the current modes of instruction as practised in schools? Second, what are the affordances in that innovation that facilitates epistemic inquiry; and third, how do we know that we have achieved the desired learning outcomes of education?

12.3 Method

12.3.1 Network Learning Communities as the Contextual Space of Analysis

Against this backdrop, the research reported in this paper arises from our work in analysing how mentoring or apprenticeship forms of learning occur among teachers at the various layers of the ecology, and the observable shifts in teachers' epistemic learning as they engaged within the respective communities. To analyse and interpret our data, a case study approach (Yin, 2002) was used in conjunction with qualitative interview and discourse analytic methods. Given the socially constructivist underpinnings of this study, relevant methods of inquiry within such a paradigm are represented by qualitative methods of 'understanding meanings people have constructed, that is, how they make sense of the world and the experiences they have in the world' (Merriam, 1998, p. 6). This relates closely to our research objectives of understanding how change towards inquiry-based paradigms within the classrooms may be engendered and scaled, afforded through nLCs. A social constructivist-driven epistemology thus necessitates interaction and dialog between researchers and participants, in this case participating teachers of the nLCs, in uncovering a multitude of perspectives and insights into the meaning making processes. Specific to our study, our research methods entail qualitative measures in the form of face-to-face interviews and open-ended dialog, (Trochim, 2001) with a view to articulating teachers' evolving interactions as they make meaning in the context of socially networked communities.

Addressing our first research question, we first sought to characterize the variant types of nLCs within the Singapore education system. Next, through an analytical case example of teacher engagement in a networked learning community—a digital game-based learning community (DGBLC) that focuses on developing teachers' competencies in the context of scaling the pedagogical understandings of digital game-based learning in schools, we illustrate the degree of shifts observed in teachers' epistemic learning. At an overarching level, the networked learning community is oriented towards seeding the aforementioned innovative inquiry practices pertinent in the current context of teaching and learning through *epistemic learning*. For example, the DGBLC's focus is to explore how teachers can harness on collective knowledge and experiences in using digital games for students' learning and for teachers to strategically seed inquiry practices into their lesson design and classroom implementation. Importantly, we posit that fostering a culture of inquiry fundamentally stems from teachers' epistemic learning, and it is when these learning shifts occur that scaling in the context of maximal latitude of education change is achieved.

12.4 Findings and Discussion

12.4.1 Networked Learning Communities (nLCs) for Epistemic Learning

Moving away from non-innovative classroom cultures, where teachers in isolation tend to develop cultures of 'conservatism, individualism, and "presentism"—a fixation on the short term' (Hargreaves & Shirley, 2012, p. 91), there have been systemic efforts within the Singapore educational context to engage teachers in collaborative cultures that both underscores teacher development and student outcomes oriented towards future needed skills. Specifically, such collaborative efforts were strongly focused on (i) the relation between individual: structured mentoring, (ii) professional learning communities in schools, and (iii) networked learning communities and subject chapter communities at the national or cluster school level (Heng, 2014). From an overarching perspective, it is observed that the origin point of the nLCs can be traced to the respective ecological layers of the system through initial structures to bring teachers together and through an emergent recognition of 'need' that revolves around students' learning (Fig. 12.3).

At the micro-level, individual school and teacher-led nLCs are emerged from the 'micro'-realms of classroom teacher and student interactions for operationalization and enactment of classroom-based activities. We observed these include specific on-the-ground needs from teachers such as 'how to differentiate inquiry lessons in the classroom such that all students can be levelled up', 'how to use inquiry for lower ability learners', and 'how do we motivate [students] to pose questions when time is tight and they are more keen to know specific content'. At the meso-level, nLCs function as intermediaries of networking and partnerships between clusters of schools[1] or affinity-led collaborations drawn upon institutional pedagogical

[1] Schools in Singapore are organized into geographical zonal branches based on North, South, East, and West proximal locations. Within each geographical zonal branch, schools were further organized into clusters (approximately 7–8 clusters per zone), with an average of 11–13 schools per cluster (a mix of primary, secondary, and post-secondary institutions). With a view to raising the capacity of the

Fig. 12.3 Characterization of macro-meso-micro-nLCs within the system

orientations or organizing structures to share knowledge and develop cross-school strategies in advancing inquiry-based pedagogies. These include schools within the same cluster coming together to share resources and support each other through, for example, concrete lesson redesign of primary science lessons for inquiry enactments. Teacher expertise is also shared through such meso-level collaborations. At the macro-level, nLCs are 'system-led' designed from divisions within the ministry, such as the Academy of Singapore Teachers (AST) and Educational Technology Divisions (ETD). Aligned to broad policy thrusts, system-led nLCs draw upon global trends and landscape developments, and these include recognizing the need to systematically level up the principles of professionalism in terms of teachers' status and competencies to address students' learning challenges of the twenty-first century. For example, ETD-led communities focus on levelling up teachers' tinkering and experimentative dispositions through spreading practices adapted from innovations seeded in Future Schools.[2] Specifically, premised on the conjecture that inquiry-based practices are 'process inclined' and shifting epistemologies of teachers would enable the diffusion of inquiry-based practices, and we observed that the variant nLCs are existing within dialectics of design and emergence at the macro-meso-micro-layers for the learning and spread of inquiry-based practices. Concomitantly, beyond

leadership teams and the level of performance in each school, a cluster superintendent was attached to every cluster to facilitate networking, sharing and collaboration among the member schools within the cluster (Ministry of Education, 2015). Each school zonal branch further oversees the management of the schools within their purview, in terms of personnel development and facilitating projects and activities oriented towards overarching desired outcomes of education.

[2] Future Schools in Singapore are distinguished by their capacity to leverage infocomm technologies and innovative school designs to enable efficient administrative practices and innovative school-wide educational programmes to bring about engaged learning for students.

functioning as catalytic growth mechanisms for teachers' epistemic learning toward innovative pedagogies, there is a gradated apprenticeship structure afforded by the different nLCs where teachers' change process may be outlined on an acquisition to transformation continuum, as unpacked by the following case illustration.

12.4.2 Case Illustration: Digital-Game-Based Learning Community

An example of a 'macro-level' nLC that focuses on leveraging learning affordances of digital games to meet desired pedagogical outcomes is the digital game-based learning community (DGBLC). Formed at the 'systems' level by the Ministry of Education-Educational Technology Division (MOE-ETD), the DGBLC explored how teachers can harness on collective knowledge and experiences in using digital games for students' learning and for teachers to strategically implement these understandings into their lesson design and classroom implementation. Facilitated by ETD officers, the DGBLC function to provide concrete participatory contexts for teachers to not only appropriate understandings about digital games in relation to pedagogy but also to (i) gain embodied experiences of designing their own games through game design workshops (e.g. Scratch), (ii) peer-evaluate community members' created games, (iii) have shared access to a common repository of member created games, (iv) garner access to networking opportunities with game enthusiasts, and (v) leverage on support by the DGBL community.

Importantly, at an overarching level, the DGBLC provides opportunities for teachers' professional growth and epistemic learning (within the domain of DGBL) through the explicit identification of DGBL 'teacher champions', who are meant to take on the role of facilitators as ETD officers move on to a 'sponsor' level of participation, and seeds continual interaction between community members, mediated through both synchronous, mediated by an online Coursemology platform, and asynchronous (e.g. thematically designed face to face workshops) means. Figure 12.4 provides an illustrative description of the annual growth trajectory of the DGBLC (across four school terms).

12.5 DGBLC as a 'Vehicle' for Innovation Diffusion

A key thrust for seeding learning communities such as the DGBLC was premised on an orientation towards the diffusion of innovations as arising from MOE-ETD

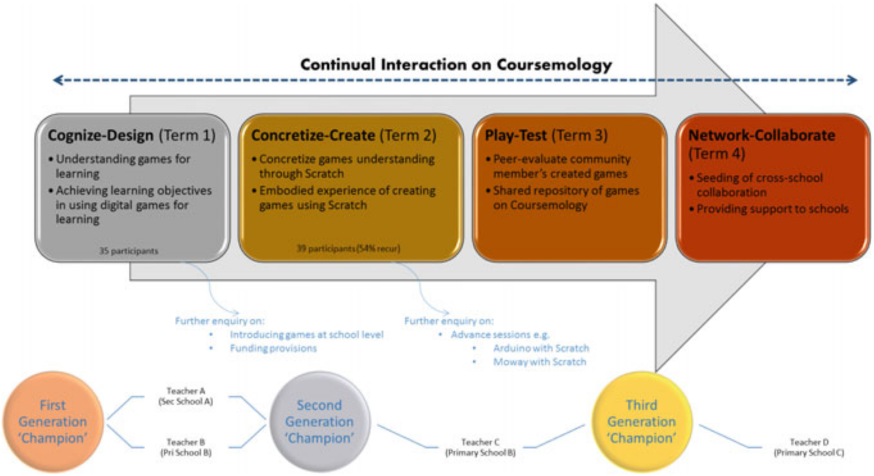

Fig. 12.4 Growth trajectory of the DGBLC is oriented towards teachers' professional growth and the seeding of teacher champions

projects such as the Future Schools(FS)[3] or eduLab[4] projects. An initial FS innovation highlighted at the DGBLC was the canberraLive and 3DHive, developed by an FS primary school in Singapore, underpinned by play as pedagogy. Arising from the concrete 'need' of a macro-landscape shift towards exponential growth of digital game-based tools, the DGBLC similarly evolved to foreground it's focus on emphasizing pedagogical approaches and ICT-enabled practices, rather than specific technological tools. For example, while participating teachers within the DGBLC were taken through a hands-on experience in creating games using Scratch, it is only but one of many other game creation platforms that teachers could potentially try their hands on Similarly, 'gaming interests' among the participating teachers vary. For example, there was participation variance in terms of a group of teachers who prefer to conduct paper prototypes through adaptation of existing off-the-shelf games, a group who prefers freemium Web-based/mobile application games, and a group who prefer to design their own simple games through visual programming languages such as Scratch, Kodu, Alice, or Tynker. As shared by a teacher on her participation within the DGBLC,

> …in my classrooms, I've been using some games for the students…those games that are available on the Marshall Cavendish portal….and I can see that in terms of engagement,

[3] The FutureSchools@Singapore programme was conceptualized in 2007. Selected schools are chosen to be ICT pathfinders, by engaging in experimentation and exploration with ICT for learning, developing innovative tools for sound pedagogical use. These Future Schools developed innovations are then taken up by the respective LCs for further innovation spread and diffusion practices to other schools within the system.

[4] eduLab was launched in 2012 to foster ideation and experimentation with educational technology. It also provides the structural supports to facilitate technology experimentation for schools and teachers.

> they are definitely more engaged than normal lessons…so I'm here to learn more about game-based design and learning…about how I can do it better for my students…more than just engagement…so the first time here, we learnt about the design principles, today I'm doing hands-on game creation…a good experience for me—Anne, Primary School Teacher

12.5.1 Scale Adaptations

Within this vein, while the DGBLC is oriented towards levelling up teacher competencies with respect to the innovation, the degrees of abstraction afforded by decoupling generic pedagogical principles of digital game-based learning inadvertently seed the need for teachers to recontextualize DGBL innovations within their own context of use. In other words, the 'scale' that DGBLC orients towards is not rooted within the spread of a tangible innovation, rather it is situated within the adaptations and recontextualization that teachers' engage in as they appropriate fundamental understandings of why and how to implement DGBL in their respective classrooms. Such an approach is observed to be more amenable to sustainability of ground-up innovations vis-a-vis top-down innovation 'roll-outs' to schools wherein the latter may initially be embraced but often wither from the lack of sustained cultivation (e.g. Carnine, 1997; Clark, 1989; Cohen et al., 2007; Elmore, 1996; Greenwood & Abbot, 2001; Kozma, 2000; King-Sears, 2001; Sannino, 2010).

12.5.2 Seed Teacher Champions

Concomitantly, it is also observed that seeding the growth of teacher leaders (champions) to sustain DGBL innovations within and across schools, afforded by the participatory structures of the DGBLC, serves to reinforce the socio-technological infrastructure necessary for innovations to take root over time. For instance, the facilitation of the DGBLC face-to-face workshops were underpinned by an intentional design of identifying teacher champions or enthusiasts who are able to co-conduct the workshops either through sharing of experiences or expertise in relation to their DGBL implementations. As reflected in Fig. 12.4, there was a 'generational' (e.g. first generation, second generation, etc.) growth of champions to provide the multiple levels of leadership (in terms of expertise and experience) in nurturing the community. For identified DGBLC champions, they were invited to co-chart the courses of the workshops they will be facilitating, providing more varied sharing as well as support to other 'novice' members within the community, while the ETD officers provide learning directions and professional development for these teacher champions.

12.5.3 *Shifts from Periphery to Core*

Although the DGBLC was helmed by the ETOs, the devolvement of control to identified teacher champions paved the trajectory for teachers to move from being members of DGBLC at the legitimate peripheries (Lave & Wenger, 1991) to being core members of the community as they establish more in-depth relations with ETOs and gained competence and legitimacy, to conduct workshops. For example, Fig. 12.5 depicts a secondary school science teacher who may be categorized as one of the generational champions within the DGBLC. In Fig. 12.5, the teacher, Mr. E, is seen conducting a games assessment topic, as part of sharing his experience and expertise in having implemented DGBL in his classrooms. Through his dialogical interactions via the DGBLC online platforms and his interactions with the ETOs, Mr. E was invited to co-facilitate the Term1 workshop, framed by a common vision and shared affinity for DGBL to enhance students' learning.

Within the Coursemology platform, the ETOs and teacher champions were also instrumental in enculturating peripheral members 'up to speed' through structured, pre-convening discussion threads. For instance, there are specific threads on the online platform that enthused peripheral members to introduce themselves and specific topics of interest set up to further engage members in dialogical interactions (see Fig. 12.6 for sample core member-led discussions).

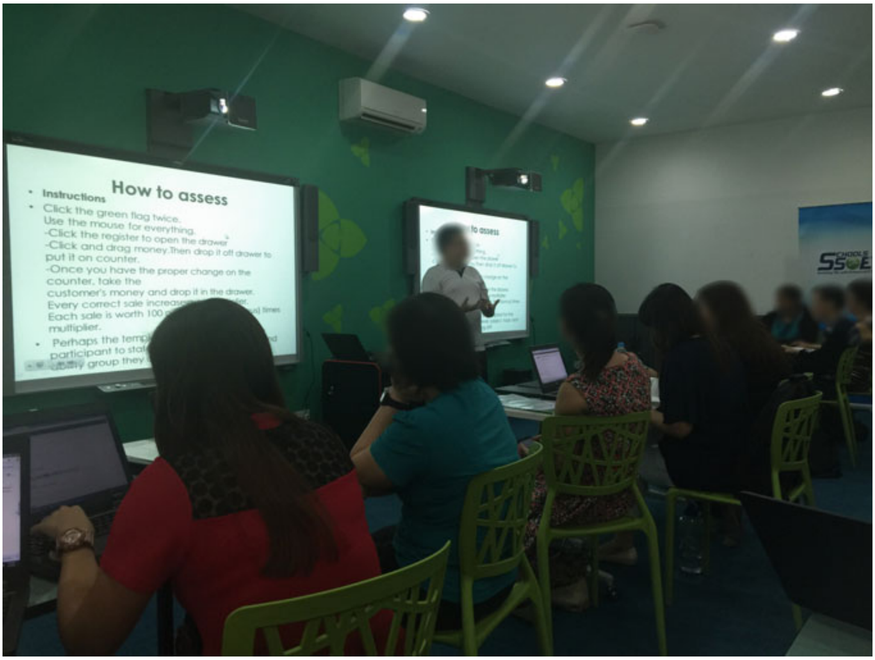

Fig. 12.5 Core 'generational' teacher champion of the DGBLC facilitating a face-to-face workshop

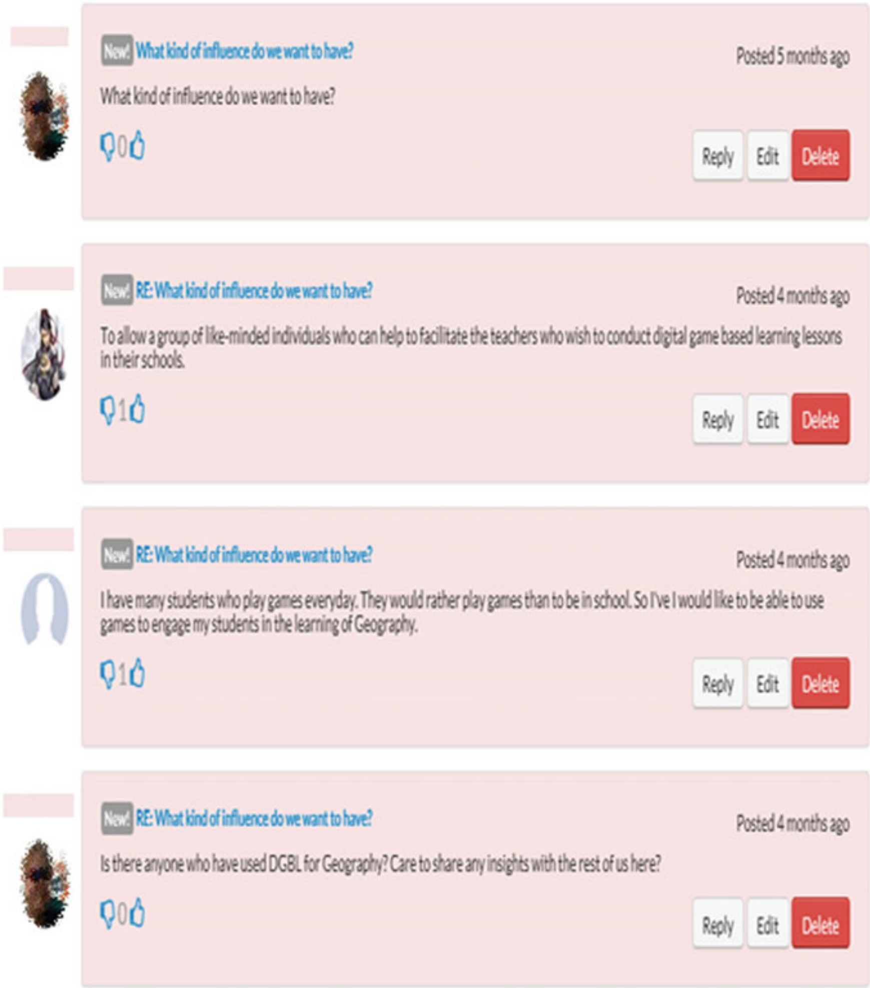

Fig. 12.6 Example of 'core member' led discussions and enculturating threads for peripheral members

12.5.4 Dialectics of 'Convergence–Divergence', 'Takeways-Givebacks'

The autonomy given to Mr. E to co-conduct the workshop, yet framed by a common overarching vision of the objectives of the DGBLC highlights the importance of a convergence–divergence dialectics at play. While there was divergence in terms of the topics related to DGBL that teacher champions could introduce to the community (e.g. conceptual understandings of games, hand-on experimentation of Scratch), the

ETOs ensured some form of convergence on common overarching narratives. Specifically, there was an explicit promoting of a narrative of 'teacher learning for student learning' that the ETOs held on fast to as they designed for sustained teacher participation through a developmental trajectory of growth. Teacher participation was not just restricted to face-to-face or online workshops but also through 'home assignments' where they were expected to continue working on their game creations (e.g., from Workshop 2). The created games, in turn, were added as repository resources for sharing within the community. In this sense, a tacit accountability measure was put in place in that, the activities of the community were not just positioned as 'takeaways' but so too required teachers' to 'give back' *meaningfully* towards the community. Observably, such structures of 'convergence–divergence' and 'takeaways-givebacks' facilitated the community's value for the purpose it was meant to serve, that is, not as a static assemblage, but rather as a process-oriented learning community, that targets continual evolvement and relevance of the DGBLC.

12.5.5 Leveraging on the 'Ecology' and Socio-technological Affordances

In a continual endeavour to meet teachers' needs, the DGBLC has a structured process in place to ensure its relevance. For instance, ensuing every face-to-face session, a request form will be emailed out to all participating teachers to allow them to request for support with respect to digital game-based implementations within their respective schools. Within this support request, the ETOs can avail themselves to go down to schools to provide further assistance to the teachers. The ETOs were proactive in continually gathering feedback from the teachers as part of a macro-'needs analysis' orientation to ensure that activities of the DGBLC remain relevant and more importantly, meaningful, for the teachers. There was also an overt leverage on the wider community of DGBLC practitioners, such as engaging game-based researchers from NIE or international game researchers, to conduct sharing and co-evaluate workshop assignments with the ETOs. The intentional design of 'feeding' the community with 'outside' expertise to mitigate 'inward focusness' was aligned with broader 'system thinking' mindsets that underpin epistemologies of digital games research.

Additionally, as part of recognizing teachers' contributions towards the DGBLC, contributions, such as workshop facilitations, were also made known to the wider 'ecology'. In other words, teacher 'givebacks' to the community was recognized through communication to their relevant school personnel or principals. Teachers' development was also made visible through the use of 'Leaderboard' on Coursemology to capture their achievement levels and ongoing participation analysis. The Coursemology platform was also harnessed upon to provide embodied learning experiences for the teachers to understand the process of gamification and draw out differences between gamification and game-based learning.

12.5.6 Building Relations Through Commonality and Diversity

At a fundamental level, the DGBLC sought to attain teachers' buy-in towards the pedagogical principles and adaptations of DGBLC through attuning to teachers' needs and constantly ensuring meaningfulness of the community activities. Through positioning the uptake of DGBLC as sharing a 'common struggle', the diversity of problems that teacher member surfaces (e.g. technical issues, assessment issues) propels '*teacher learning for student learning*' through threads of commonality (common struggle of implementing DGBL for students' learning) and diversity (every teacher faces different problems, shared with the community). Continual engagement efforts such as online training activities scheduled fortnightly within the Coursemology platform as a means to keep members up-to-date with the latest international developments in DGBL were also put in place. These sustainability-oriented efforts represent incremental steps towards engendering positive teacher relations that seed the base for sustaining teachers' interest and engagement within the community. However, in a recourse towards the acquisition-transformation teacher change process, whether these *acquired* practices translated into iterative percolations of *transformative classroom practices* oriented towards inquiry-pedagogies and reduced inequities remain tentative.

12.6 Framing of Innovation Scale Through the Lens of nLCs

The variance in how learning communities define and enact their practices and growth trajectory varies from one community to another. For DGBLC, observably, their enactments in the context of innovation diffusion are correlated to the *teacher capacity building* thrust posited from the onset. Conceptually, this may be approximated to a framing of innovation diffusion where appropriate structures need to be set up for an interactional and engagement process to encourage teachers to experiment with DGBL-resonant approaches in their respective disciplines.

These experimentations in turn are seeded within an expanded socio-cultural peer/group/ learning community context, oriented towards strengthening professional learning to increase educator effectiveness and, ultimately, attain the desired students learning outcomes. We propose that the efficacies of progressive nLCS may be approximated by tenets of *scalable* epistemic apprenticeship, as observed through

- Iterative proximal handholding
  - Senior/more experienced teachers apprenticizes less experienced teachers who would then handhold other new teachers and guide the planning, guide the design, help to execute lessons
  - The handholding process is iterated through first and second level 'champions'

- Peer-to-peer role modelling/support
  - Open classrooms, first-hand insights into what is happening in the classroom, videos, snippets of videos of what is happening in the classroom (or outside); frame to frame video scaffolding on how to enact a lesson, how to follow up, etc.
- Visible students artefacts/developmental trajectory
  - Provide a more ‘concrete’ reality of what an envisaged classroom looks like/ought to aim for
  - Show visible expressions of what happens in the classrooms through students’ artefacts such as journaling and peer feedback.
- Mitigating tensions, finding alignments
  - Tensions between transferability of 21st CC process skills vis-a-vis assessment demands.

12.6.1 School Leadership Support for Teachers to Be in nLCs

Being responsible to every child and ensuring they do well in the assessments is a very real concern for teachers, and these are very legitimate concerns of a teacher in a classroom. Moreover, schools are not giving up on the high levels of performance in all the major high stakes national assessments in the Singapore context. In other words, how do we achieve both academic performances and inquiry based learning at the same time; how do teachers become adaptive to both performances?

Thus, we realized that getting the teacher prepared in doing these innovations, facilitating for the school principal to support, and to find the resources to do the ‘out of the ordinary’ endeavour for this period of time is very key. We realized that without school support, very few teachers can actually engage in this endeavour. The dialectics of structure and agency remains critical. It is about putting in place ‘designed structures’ that gives time off for the teacher to engage in a new endeavour, while providing the latitudinal space for teacher’s agency in terms of their adaptations and recontextualization of practices relevant for their learners within the space of emergence. Concomitantly ‘designing’ for a peer support group in enacting the innovations is necessary. In other words, how can leadership support enable these curricular adaptations as there is a need to change the assumptions of the curricula to enact this new scheme of work? How do we create the support group for the teacher in the classroom to learn together with other peers; and how would this process change the teacher’s way of thinking. These are issues that are very critical for us.

To illustrate, these are some voices of principals:

> Teachers need to change the ways they teach and yet meet the curricular objectives. So if we have the end in mind, how do we work backwards although not taking the same road

> as in the past? It's not a simple substitution or replacement exercise to develop 21st century skills; there is a need to go back to the goals. We need to create a sustaining culture where teachers are comfortable, otherwise it won't work. We need professional development that builds not just the competencies but the culture in doing it. (Principal A)
>
> Why not we open up these classrooms so that the next layer of teachers who want to do this intervention can start observing first. Why don't we open up classrooms – then I told her, we should, yeah let's open it up! So if you come from the principle [of what we intend to do], we know that there's hope, you see. (Principal B)

Once we understood a core kernel and theory that has emerged from an innovation, and facilitated by good examples, we can design purposively to make them public (or visible) so that all teachers can see it. By situating these good cases into existing nLCs, these resources are intentionally factored into the workflow of teachers' busy time schedules for learning.

Teachers in Singapore schools generally would not use technology in their classroom practices if they do not see the practical *need* for using it. If in the co-design and redesign of lessons, they can rationally recognize how the affordances (e.g., freezing time and motion in simulations and helping students to observe phenomena by slowing it down) enable learning, they would be willing to do it. This experience hinges upon the shifts within the dimensions of their epistemic beliefs towards knowledge and knowing. Structuring for teachers to work together and to reflect on their practices including recognizing them for these efforts are critical. When teachers witness their students understanding concepts better as afforded by these technologies, they usually are willing to undergo the change process. They begin to realize that engaging learners from a non-didactic perspective really works better even in the milieu of high stakes performance needs.

Concomitantly with the need for strong school leadership support, teacher facilitators of nLCs also play a critical role. One important characteristic is to let members in the nLC have a voice. The culture to be borne in nLCs must be open according to the leader facilitators we interviewed. More generically, these leaders tell us that they encourage members of nLCs to have a voice and every view is important, with the intent to let discussions flow. This orientation is particular critical in an East-Asian culture where participants are typically shy with voicing in public. School leaders' support in paving the way for their teachers to partake in nLC activities and to play a leading role in these communities is also crucial.

12.7 Conclusion

We need to grow the capacity of teachers with respect to epistemic learning in Singapore, if we want to advance the Singapore education system with respect to inquiry-based learning. Teachers need to understand why something would work because if they do not understand why, adaptations might go lethal. We also need to create the social-infrastructure that enables teachers to undergo the epistemic change process.

Along these lines, how can we create networks of learning across schools since expertise in inquiry-based learning is better found beyond individual schools presently. How can apprenticeship forms of scaffolding and learning occur among teachers in nLCs. Dialogue in nLCs alone is insufficient to shift epistemologies. Teachers need to go through this journey of change from acquisition to actual embodied learning process and towards transformation. Peer support from fellow nLC members, and school leaders' encouragement and facilitating of the conditions for change in schools are crucial tenets, for successful trajectories of development at both teacher and classroom levels, as illustrated in Fig. 12.7.

In Fig. 12.7, NLCs are described as the communities initiated by MOE; nLCs are those formed by schools and clusters, and PLCs are initiated from within schools. These three kinds of networked learning communities should complement each other from a system's perspective. Moreover, according to Fig. 12.7, we differentiate between teacher-led needs vis-à-vis system initiated ones—i.e. designed needs. From the case study documented in this chapter, designed needs are not uncommon in the Singapore context. Designed needs speak to the issue that there are teachers who have gained traction insofar as the innovation is concerned and that there is no need to start from 'ground zero', implying that teachers can leverage upon existing communities to participate in the endeavours. Teacher needs include professional and performative needs, while designed needs assume that teachers may have involuntary stances in the participation within these nLCs. Hence, in such situations, there is a further need to enculturate teachers to be enthused about these designed innovations.

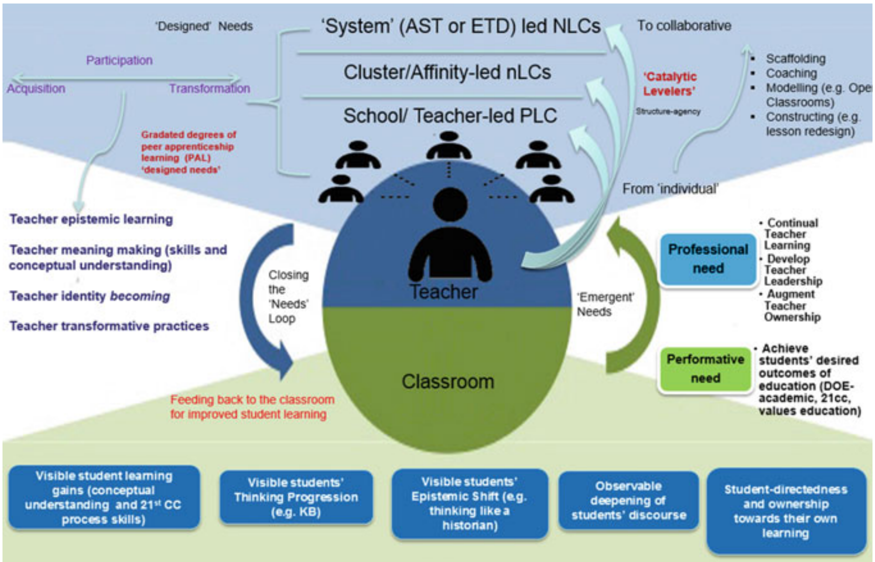

Fig. 12.7 Tenets of change at the teacher and classroom level afforded by networked learning

Within this vein, we recognize that scaling up of inquiry-based learning, which we have concomitantly argued as a teacher change in epistemology, cannot be overly hastened. It takes more than perceived cultural changes. The journey towards innovation is also a change in the larger macro, meso, and micro-ecosystem—the challenge is not just teachers but also the larger ecology—the expectations of parents and other related stakeholders. Change is thus inadvertently complex with multi-dimension and multi-layered entailments, but the journey remains necessary for our continual endeavour in developing the best for our learners to thrive in the world that is coming.

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Chapter 13
An Exploratory Approach to Teacher Professional Development in a Secondary School in Singapore

Josh Li-Yi Wang, Liang See Tan, Shu-Shing Lee, and Natalie Lim

Abstract This chapter introduces a school-based teacher professional development (PD) approach adopted by a local secondary school in Singapore in its pursuit of sustaining teaching and learning practices that could support school improvement and achieve educational success in the twenty-first century. By comparing the structure and operational guidelines of this approach with the characteristics and guiding principles of effective PD programmes identified in the contemporary literature, we argue that the approach has great potential to succeed, considering its apparent affordances for a community that (1) involves whole-school participation, (2) facilitates individual and group learning, (3) cultivates a collegial culture of sharing and learning, (4) promotes shared leadership and (5) connects with external resources and communities. Despite its promising outlook, we suggest that empirical studies on the intended conditions, enacted process and achieved outcomes of this PD approach are needed for validation, refinement and sustainability purposes.

13.1 Introduction

The twenty-first century is an era of rapid social, economic and technological changes (Friedman, 2006). Educational success in the twenty-first century emphasizes the development of skills and competencies that go beyond routine cognitive tasks,

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such as the ability to critically seek and synthesize information, the ability to create and innovate and the ability to self-direct one's learning (Dede, 2010). Education systems around the world are trying to improve their teaching and learning practices and make them relevant for the twenty-first century. Research has consistently shown that the most important determinant of students' learning experiences and outcomes is the quality of teaching (e.g. Hattie, 2003). Professional development (PD) for teachers is critical because teacher growth impacts the quality of teaching and learning (Mourshed et al., 2010). This chapter starts with a brief discussion of the contemporary research agenda in teacher PD in global contexts, highlighting the three fundamental dimensions of teacher PD and identified characteristics of effective teacher PD programmes. After that, the development of teacher PD in the context of Singapore is presented, followed by the introduction of an exploratory approach to teacher PD adopted by a local secondary school in Singapore. Finally, we examine the structures and operational guidelines of this approach by comparing them with the key features of quality PD programmes highlighted in the literature to reveal its potential and challenges. Implications of this school-based PD approach on educational research are then discussed.

13.2 Research Agenda in Teacher PD in Global Contexts

In this section, we first 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. We then look into the key features and operational principles of effective teacher PD programmes advocated by educational researchers.

13.2.1 The Fundamental Dimensions of Teacher PD

Context of teacher PD: Adult learners are self-directed, ready to learn, experienced, task-centred and intrinsically motivated (Knowles, 1983). Thus, adult learners can be synergized by situating learning at the workplace. A plethora of research on teacher PD has recognized the limitations of short-term PD conducted by external institutions on teacher learning, and researchers have reiterated that effective and sustained teacher learning has to be contextualized and situated within their respective school settings (Avalos, 2011; Campbell, 2011; Garet et al., 2001; Hargreaves & Fullan, 2012). A situative approach to teacher learning strives to engage teachers, either individually or collectively, in actively working on authentic and genuine problems within their professional practices in school contexts (Borko, 2004; Bound & Middleton, 2003; Putnam & Borko, 2000). Situative theorists conceptualize learning as changes in participation in socially organized activities and individuals' use of knowledge as an aspect of their participation in social practices (Greeno, 2003; Lave & Wenger, 1991). This form of contextualized teacher learning is seen as a powerful way to enhance teacher autonomy and teacher agency (Campbell, 2012; Hargreaves & Fullan, 2012; Schon, 1983, 1987). Teacher PD that augments teacher autonomy and agency increases teachers' capacity to make informed discretionary judgement and solve complex issues at work collaboratively. For example, solving complex problems at work is a professional practice that requires practical knowledge, rather than intellectual and rational knowledge that may only be marginally relevant to practice (Schon, 1987). However, teacher knowledge must also play an active and dynamic role in the ever-changing challenges of the school and classroom (Manen, 1995). Thus, the iterative process involving practical knowledge and teacher knowledge is the key to teacher learning. In this sense, teacher learning within and across school networks is seen as a way of revitalizing personal and institutional growth. While the alignment of personal and institutional goals of teacher PD is the key to school improvement, the links between personal and institutional goals have to be galvanized by shared goals as well as a collaborative culture. This argument seems to suggest that PD efforts within an organizational level that is aligned and coordinated, as well as taking into consideration the school's vision and goals, might be more fruitful. More empirical studies, however, are needed to ascertain the conditions of the context (e.g. school structures, teachers' readiness and leadership) of PD for quality teacher learning.

Enactment of teacher PD: Enactment is a process in which teachers make sense of what they have learned from PD and how it can be contextualized in the classrooms. In the enactment process, teachers make educational decisions that require meeting certain criteria in the realm of the curriculum. But since not all criteria are stated explicitly, teachers must deduce, reflect, and elaborate when coming to a decision (Kansanen et al., 2000). Moreover, teachers are the original knowledge workers because teaching is 'non-routine, ill-structured and creative' (Tripp, 1993, p. 140), involving a number of different kinds of expert professional judgement (Frenkel et al., 1995). Hence, by looking into the extent to which teacher PD is able to regulate the enactment process that enables teachers to make educational decisions in the classrooms, researchers are able to understand not only teachers' thinking trajectories and evolving practices, but also the tensions and challenges teachers face in the processes of 'actualizing' what they learn in their PD on a daily basis. For example, in a longitudinal study documenting the enactment process of PD, Bakkenes et al. (2010) found that teachers related the enactment process most frequently to 'experimenting' and 'considering own practice'; 'getting ideas from others' and 'experiencing friction' were the next most frequently reported categories, followed by 'struggling not to revert to old ways' and 'avoiding learning' (p. 539). These findings could be explained by Day and Gu's (2007) work on variations in the conditions for teachers' professional learning and development, revealing that teachers with varied professional background differed in their learning trajectories, and thus there might be deviations in the enactment process.

One pertinent issue in the research on the enactment of teacher PD for sustained teaching and learning is the importance of facilitators' roles (Remillard & Geist, 2002). In most cases, facilitators in teacher PD are the key position holders in the schools, such as principals, vice principals and heads of departments. In teacher PD, facilitators must be able to establish a professional learning community in which inquiry is valued and structure productive learning experiences for that community. They also must be able to use the school curriculum flexibly—reading the participants and the discourse, considering responses and possible consequences and taking responsive actions in order to balance the sometimes incompatible goals of the PD and the participants' needs. Although these in-house facilitators might understand the goals of the PD and have access to the nuances of school context, it is unknown how teachers view facilitators' double status of being agents who provide support to their professional learning as well as reporting officers who appraise their job performance in schools. A related issue to this is whether the quality of collaboration (among teachers and between teachers and facilitators), that is to inquire, learn and take action, both within and across the subjects/levels in the school, can be collegial and autonomous (Hairon & Dimmock, 2012). These issues are significant to research on teacher PD. As Guskey (2002) postulated, one of the reasons that teacher PD fail is due to the lack of understanding of the enactment process of PD by which change in teachers typically occurs. Hence, more investigation on this significant dimension of teacher PD is required in order to ascertain not only the benefits of teacher PD, but also uncover aspects which require appropriate inclusion, exclusion or refinements (Hairon et al., 2015).

Outcome of teacher PD: The outcome of teacher PD is frequently measured by teacher changes (Borko, 2004; Guskey, 1986, 2002) and student achievements (Hattie, 2003; Stronge, 2010), regardless of the fact that teacher change is a complex phenomenon and the debate on whether teacher change is a reason for or outcome of student achievements (see Guskey, 2002; Tan & Ponnusamy, 2014; Franke et al., 1998). The effectiveness of teacher PD has been documented by numerous researchers. From the findings of their review on teacher PD research, for example, Vescio et al. (2008) stated that teacher PD through professional learning communities (PLC) does have positive impact on teacher changes and student achievements, although the impact is primarily perceptive in nature. Also, in the context of community of practice (COP), teacher learning was found to occur through sharing, challenging and creating ideas about the thinking represented in students' work. Teachers became better at elaborating the details of students' reasoning and understanding students' problem-solving strategies and began to develop instructional trajectories for helping students advance their thinking (Franke & Kazemi, 2001; Kezemi & Franke, 2004). On the other hand, despite the efforts in developing teachers' capacity and expertise, for instance, in improving assessment, Scott et al. (2011) reported that confusion remained among teachers about terminology, principles and pragmatics, which undermined teachers' confidence about making sound judgements about students' work. Although teacher professional learning and development usually address teacher learning at the individual level, in the light of PD for school improvement, Newmann et al. (2000) argue that if professional development is to boost schoolwide student achievement, it should be expanded beyond the improvement of individual teachers to improvement of five aspects of school capacity: teachers' knowledge, skills and dispositions; professional community; programme coherence; technical resources and principal leadership. Several scholars have discussed the purposes and effects of PD on teacher learning from the perspective of achieving the five aspects of school capacity (e.g. Grundy & Robison, 2004; Kennedy, 2005; Lieberman, 1996; Sachs, 2007).

A relevant issue related to the effectiveness of teacher PD on teacher changes is the constraints on teachers' work when introducing innovation that expects teacher changes and that they apply the innovation directly to practice. Shulman and Carey (1984) suggest that teachers combine information received from teacher educators and researchers with what they already know, restructure it and make it fit into their perception of reality. They make different decisions after filtering new information through this reality rather than considering the information in isolation from their reality. Duffy and Roehler (1986) identified four kinds of constraints: curricular, instructional, milieu-related and organizational. They indicate that teachers have difficulties recasting traditional skills as strategies since they have routinized the procedures so much that they lack the flexibility to identify the mental operations associated with strategies and to be adaptive. In addition, teachers' training did not prepare them for making curricular content explicit. The pressure to follow the codified curriculum, class sizes and grouping patterns are also part of the environmental constraints. Disruptions to the tight routines in school lead teachers to operate in a survival mode. Innovations which disrupt these routines are resisted. Consequently, there are at least four sets of 'filters' that constrain teacher decision-making: (1) teachers' restructure of new information in terms of their conceptual understanding of curricular content, (2) teachers' conception of instruction, (3) teachers' perception of the demands of the working environment and (4) teachers' desire to achieve a smooth-flowing school day. Hence, effectiveness is a complex idea that needs to be understood both in relation to teachers' perceptions and how these vary over time in different institutional and personal contexts and in comparison with other teachers in similar contexts in terms of value-added pupil attainment (Day & Gu, 2007). Thus, each teacher makes decisions not on the basis of what the teacher educator or researcher said but on the basis of the restructured understanding of the innovations.

13.2.2 Characteristics and Operational Principles of Effective Teacher PD

The three fundamental dimensions of teacher PD have provided researchers the directions in their search for the characteristics and operational principles of effective PD programmes.

Characteristics of effective teacher learning: Through reviewing the work on teacher PD in the context of PLC, Bolam et al. (2005) summarized eight characteristics of effective teacher PD programmes/frameworks: (1) shared values and vision; (2) collective responsibility; (3) reflective professional inquiry; (4) collaboration; (5) individual and group learning; (6) mutual trust, respect and support among school staff; (7) whole-school, inclusive participation; and (8) out-of-school networks and partnerships (Bolam et al., 2005). These characteristics were also promoted by several scholars (e.g. Hord, 1997; Louis et al., 1996; McLaughlin & Talbert, 2001; Newmann et al., 1996). These characteristics highlight the significance of the establishment and maintenance of communication norms and trust that enable critical dialogues and collaborative interactions in the learning community (Borko, 2004; Grossman et al., 2001; Little, 2002). To promote these supportive yet challenging conversations and interactions, a collegial culture must be engendered (Borko, 2004; Frykholm, 1998; Seago, 2004). Teacher PD programmes with these characteristics provide teachers with (a) a deeper understanding of the subject-specific matter and how students think of and learn the subject matter; (b) ample opportunities to engage in exploration, reflection, and discussion; (c) activities that involve attending and responding to student thinking; and (d) contexts for collegial sharing, collaboration, and follow-up support during an extended period of time (Borko, 2004; Desimone, 2009; Garet et al., 2001; Sachs, 2007).

Operational principles supporting effective teacher learning: In their review, Bolam et al. (2005) identified four operational guidelines (processes) that support the eight characteristics of effective PLC including (1) encouraging shared leadership, (2) optimizing resources and structures, (3) facilitating individual and collective learning and (4) making explicit promotion of teacher learning communities. Hairon et al. (2015) considered these operational guidelines as context-embedded and observed that ‘context’ in the generic term can be divided into two sub-contexts—within and outside the school contexts. The sub-context of within the school includes factors such as school culture, structures (e.g. timetabling, organizational structure), leadership and resources. The sub-context of outside the school includes district/system factors such as district/system culture, leadership, resources and policies, and societal factors such as societal culture and national policies (Hairon et al., 2015). ‘Leadership’ within the school context, as argued extensively, does not exist only at the levels of principal, vice principal and heads of departments in the school. In teacher PD, concepts such as ‘shared leadership’ or ‘distributed leadership’ are representations of a different but more ‘healthy’ kind of leadership, inherently existing among teachers while they share, learn and collaborate in the learning communities or schools (Hairon et al., 2015; Hipp & Huffman, 2009, 2010; Huffman & Jacobson, 2003; Thomson et al., 2004).

13.3 Teacher Capacity and PD for the Twenty-First Century in Singapore

The Ministry of Education, Singapore (MOE), is committed to developing students’ twenty-first-century competencies and building up teachers’ professional capacity to deliver these competencies (MOE, 2010). The twenty-first-century competencies and desired student outcomes outlined by the MOE are shown in Fig. 13.1.

Fig. 13.1 Twenty-first-century competencies and desired student outcomes (MOE, 2010)

The MOE recognizes the importance of teachers' professional development on quality teaching and learning and has accordingly introduced the teacher growth model (TGM) (MOE, 2012). The model encourages Singapore teachers to be student-centric professionals who take ownership of their growth in understanding and delivering the twenty-first-century competencies. The model articulates the five desired learning outcomes of the twenty-first-century Singapore teachers as follows:

- The ethical educator,
- The competent professional,
- The collaborative learner,
- The transformational leader, and
- The community builder.

The MOE's endeavours to build up teacher capacity for the twenty-first-century competencies came along with the shift of teacher PD focus. In Singapore, the notion of 'Thinking Schools Learning Nation' (TSLN) marked the shift from a more 'teacher-proof curriculum' (Gopinathan & Deng, 2006) approach to one that 'value(s) competencies which are built up through experience, practice, sharing and continual learning' (Teo, 2001, p. 10). Since then, the emphasis on teacher professional learning and development has defined teaching to be 'a learning profession, like any other knowledge-based profession of the future' (Goh, 1997, p. 23). This rhetoric has led to the establishment of educational policies and organizational structures in the last decade both at the national and school levels that place great emphasis on promoting teacher professional learning and development.

At the national level, the emphasis on promoting teacher learning and development has manifested in the official status and sustained support given to PLC in the education system. PLC represents the education policy-makers' intent to develop teaching professionals with self-initiative efforts to take on more active roles in collaborative professional learning to support school-based curricular development (Hairon & Dimmock, 2012). The historical development of PLC in Singapore can actually be traced back to 1998, when the teachers network (TN) was established as a unit within the training and development division (TDD) of the MOE (Tang, 2000; Tripp, 2004). The unit aimed to (1) formulate policies that support teacher professionals to move towards excellent practices through a network of professional sharing and learning and (2) serve as a catalyst for teacher-initiated PD through sharing, collaboration and reflection leading to self-mastery, excellent practices and fulfilment. It advocated a bottom-up approach to change as evidenced in its slogan 'For Teachers, By Teachers' (MOE, 2005). In 2000, The TN introduced a PD model named 'Learning Circles', in which teachers take the lead in engaging in collaborative learning using an action research framework to improve teaching and learning (Hairon et al., 2015). In 2010, the TN and the TDD were merged and renamed as the Academy of Singapore Teachers (AST). The AST retains the goal of teachers taking the lead in professional learning within the teaching fraternity and delivering high performance in teaching practice and student learning outcomes. To achieve that goal, the AST introduced the MOE-AST PLC model. The model borrowed Fullan's 'Triangle of Success (Fullan, 2003), which refers to 'School Leadership', 'Systemness' and 'Deep Pedagogy'. To actualize the triangle of success, the idea of professional learning teams (PLTs) where groups of teachers engage in collective sharing and learning was developed to achieve 'Deep Pedagogy'. In addition, the idea of coalition teams (CTs) where a group of school leaders (e.g. principal, vice principals) that represent 'School Leadership', was also adopted to provide conducive school structures and culture, and by doing so, achieve the 'Systemness'. In this model, PLC is conceptualized as a whole-school initiative, in which groups of teachers collectively share and learn within PLTs. Teachers can have the option of choosing a range of collaborative learning tools, such as learning circles, action research and lesson study (Hairon et al., 2015).

Other than the policies and structures established at the national level, local schools are encouraged to adopt customized professional learning and development approaches with detailed implementation plans at the school level. In order to 'create a culture of professional excellence which nurtures the individual and motivates all as a team to achieve superior performance' (Teo, 2001, p. 6), schools are expected to become learning organizations where teachers and school leaders 'constantly look out for new ideas and practices, and continuously refresh their own knowledge' (Goh, 1997, p. 23). One influential consideration in the development of school-based teacher PD programmes, however, is that while educational policy-makers have ambitiously associated student learning outcomes with the twenty-first-century competencies in recent years, they expect the maintenance of high academic performance in view of ensuring the competitiveness and economic survivability of the small island nation in the global market. Therefore, Singapore schools are compelled to provide corresponding curricula that cater for a more diverse set of student outcomes, in both academic and non-academic domains (Dimmock & Goh, 2011).

13.4 The Exploratory PD Approach in SSS

13.4.1 The School-Based PD Framework and Guiding Principles

In line with TGM, Southern Star Secondary School (SSS, pseudonym) in Singapore has created a teaching and learning framework that identifies eight guiding principles of exemplary teaching and learning for academic and the twenty-first-century competencies. These principals include *transfer of learning, thinking flexibly, quality assessment for/of learning, personalized learning, independent learners, safe and productive learning environment, effective communicators and effective collaborators*. The framework and the guiding principles frame the ways teachers teach and the ways students learn in the school. The ultimate goal is to develop four student traits, including *knowledgeable learner, independent and motivated learner, creative and critical thinker and effective communicator and collaborator*. These traits are aligned with the twenty-first-century competencies.

13.4.2 The Structure, Cycles and Phases

Following the framework and the guiding principles, SSS initiated a series of PD cycles to situate and contextualize teacher learning in the school. Each PD cycle has a specific topic and follows a five-phase protocol that guides the teaching and learning practices throughout the whole cycle. The five phases are as follows:

- Phase 1: Review literature, share findings and explore directions of practices
- Phase 2: Explore and experiment through classroom practices and share small successes (e.g. lesson plans, methods and materials)
- Phase 3: Review practices and confirm directions for implementation
- Phase 4: Deepen and validate practices
- Phase 5: Sustain practices.

According to the design, whole-school participation is required throughout the five phases of each PD cycle, with Phase 4 having additional external experts or consultants who are specialized in the topic of the cycle brought in for validation and evaluation purposes. Throughout the whole cycle, regular departmental discussions (focusing on making sense of theories, translating theories into classroom practices and doing reflections of new understandings and challenges) and whole-school professional learning sessions (focusing on cross-department sharings to keep all teaching staff posted of progress and to communicate strategic directions or actions to all departments) are incorporated into the school calendar.

According to the teaching and learning framework, each PD cycle is operationalized through the curriculum, assessment and pedagogy (CAP) committee. The CAP committee is a community of instructional leaders that consists of eight–ten members, including representatives of each subject department who are usually the most capable and experienced teachers in each department. The committee is chaired by the assistant director of instructional programme of the school and is tasked to cascade the vision of the planned PD cycle through instructional leaders who engage and motivate teachers in each subject area to translate the vision into practice. Teachers reciprocate by translating and enacting what they have learnt from the activities/sessions embedded in the five phases of the PD cycle into classroom teaching. Since 2010, SSS has actively engaged in three cycles of teacher PD. Each of the first two cycles spanned two years and had planned and strategized the processes for teaching and learning with the foci on quality assessment (2010–2011) and critical thinking (2012–2013). SSS is now in the midst of the third cycle with the focus on differentiated instruction and will complete the cycle by the end of 2016.

13.5 Potentials and Challenges

The key advantage of a school-based customized approach to teacher professional learning and development is that it considers authentic PD needs for the purpose of school improvement. Therefore, we anticipate that there is possibly a higher chance for school-based teacher PD approaches to embrace the key features of high-quality PD programmes highlighted by researchers working in different content areas (e.g. Borko, 2004; Desimone, 2009; Garet et al., 2001; Sachs, 2007). As far as SSS is concerned, the approach the school has taken reveals great potential to promote and sustain professional learning and development in the school.

First, the approach *involves whole-school participation* at different phases of exploring, designing, implementing and evaluating teaching and learning practices related to the specific topics of different PD cycles. In SSS, instead of engaging in fragmented PD activities, the school adopts topic-based PD cycles that are integrated across curriculum, instruction and assessment, involving the teachers, instruction leaders and key personnel of the school in the cycles. In addition, because of the whole-school participation throughout the different phases of the PD cycles, the approach seems likely to *facilitate individual and group learning* by creating ample opportunities for the teachers to engage in exploration, reflection and discussion and have critical dialogues and collaborative interactions. Also, the approach might help *cultivate a collegial culture of sharing and learning* in the school because of the deliberate design of having regular whole-school professional learning sessions that seek individual and departmental feedback and promote cross-department conversations.

Moreover, the PD approach seems to *promote shared leadership* among teachers by taking a bottom-up approach to improve teaching and learning practices in the specific context of the school. From the very beginning of each PD cycle (Phase 1), teachers are encouraged to explore different possibilities of translating the vision (the topic/focus of the specific PD cycle) into practice, rather than being given a set of prescribed guidelines that might be marginally relevant to their work and the context for them to duplicate in their classrooms. This design provides the teachers the space and opportunities to work on critical reflections of their existing knowledge and daily practices. Following the self-directed exploration, teachers are free to take initiatives and 'experiment' with their ideas in their classes. They are also given the platform (i.e. professional learning sessions) to share their 'little successes', concerns and struggles, respond to colleagues' inquiries and offer their suggestions (Phase 2). The autonomy and agency given to the teachers are of great value in terms of promoting shared or distributed leadership in the school.

Furthermore, the approach provides the teachers with opportunities to *connect with external resources and communities*. At Phase 4 of each PD cycle, the school reaches out to experts or consultants through external networks and partnerships to help validate and evaluate the teaching and learning practices related to the topic of each PD cycle. Connecting with external resources and communities is valuable to school-based PD because a school has sometimes become too small a unit for PLC and schools need to become networked learning communities in order to connect to others and expand the fields of knowledge available (Jackson & Temperley, 2007).

Although the PD approach has shown potential to help SSS improve and sustain their teaching and learning practices, it also reveals challenges. Firstly, the composition of the CAP committee includes the former/current key position holders in the school (i.e. assistant director, heads of departments). This composition might not benefit the formation of collective responsibility as much as having teachers who are not in the management levels join the committee. One consideration could be to include experienced or long-serving teachers who are not in the management levels join the CAP committee. The inclusion of these teachers could be based on their knowledge and ability to model exemplary practices in line with the focus for each PD cycle. In addition, the implementation duration for each PD cycle is two years, which may be too short to complete an informative learning journey for teachers, considering the nature of the PD approach (continuing cycles), the required commitment to the activities in different phases and teachers' workload in the school. Insufficient time given to teachers to 'expand' their knowledge during PD programmes could make teachers feel overwhelmed and result in teachers' low self-efficacy in practising the requested tasks (Ertmer et al., 2014; McCormick & Ayes, 2009). More time may be needed for teachers to make sense of each topic selected for the PD cycle, translate and enact it in classrooms and enable sustained practices in the school. Particularly, for teachers teaching students who are in the final year of their secondary school education, pressure from exam preparations might deepen their concerns about getting too involved in the PD activities. Lastly, it is not clear how some other characteristics of effective PD programmes, including shared values, mutual trust, respect and support among school staff, are embedded or promoted in the PD approach. These characteristics, as argued, are also influential in the impact of PD programmes on teaching and learning.

13.6 Conclusion

The school-based PD approach taken by the SSS reveals potential to achieve its aim, although challenges also exist. The potential and challenges reported here are preliminary hunches after examining the proposed PD framework and its guiding principles. As part of on-going work, the dimensions of effective PD programmes and how they unfold in the school-based PD approach taken by the SSS need to be unpacked with evidences and nuances. With the school's ambition to build up an entrenched culture for teacher PD through the approach, it would be useful to delve deeply into the PD cycles and the embedded phases of the approach to understand: (1) the intended conditions that facilitate (and hinder) teachers' professional growth and teachers' perceptions of these conditions; (2) the enacted process that informs the sustenance of practice and learning and (3) the achieved outcomes such as shifts in student achievements, quality of learning experiences and teachers' readiness. Empirical studies on these three dimensions based on the approach in SSS would provide valuable findings for refinement and sustainability of teacher capacity building.

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Chapter 14
Capacity Building as a Driver for Innovation and Change: Different Contexts, Different Pathways

Shu-Shing Lee and Peter Seow

Abstract Singapore is a centralized–decentralized education system which recognizes that learning needs to integrate content–disciplinary understandings with twenty-first-century orientations and outcomes. Schools are given autonomy for innovations. One such initiative is FutureSchools. FutureSchools are exemplar schools with successes in technology-mediated pedagogical innovations and work with other schools to spread twenty-first-century learning practices. This chapter aims to understand how lessons learnt from FutureSchools inform the ways schools implement innovations and how context shapes innovation pathways. Lessons learnt suggest that changing practices is a social process requiring tight-loose couplings. Capacity building is key so teachers understand, enact, and adapt practices for their contexts. This chapter describes two case studies and implementation tenets for building teacher capacity to drive innovations and change practices towards inquiry: (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. Tight-loose couplings are unpacked by discussing commonalities enabling two schools to form partnerships and how context shapes adaptations and pathways. Findings 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. Capacity building situated within practice enables teachers take ownership, reflect, and refine changed practices as part of everyday work.

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14.1 Introduction

Singapore's education system has evolved through different phases. Each phase reinforced the previous with reviews of policies and new initiatives to ensure the system stays relevant. "Teach Less, Learn More" (TLLM), "Thinking Schools, Learning Nation" (TSLN), and the IT Masterplans are examples of policies and initiatives to improve the quality of teaching and learning and introduce twenty-first-century learning orientations facilitated by technology (Jamaludin & Hung, 2016). Such orientations of teaching and learning embrace the traditionally valued content–disciplinary understandings and develop twenty-first-century literacies, such as self-regulated learning, collaboration, and critical thinking.

Our education system is a centralized–decentralized system (Tan & Ng, 2007). Schools are given autonomy and spaces for innovations as long as it remains aligned to state policies and intentions. The system has seeded opportunities and incentivized schools to engage in innovations and change, for example FutureSchools. FutureSchools are schools with successes in technology-mediated pedagogical innovations and are exemplars for spreading twenty-first-century learning practices to other schools (Toh et al., 2014).

This chapter aims to understand how lessons learnt from FutureSchools inform the ways schools implement innovations and how context shapes innovation pathways. Lessons learnt suggest that spreading innovations and changing practices are complex processes. Change is not simply the quantitative aspects of implementing innovations in more schools (Toh et al., 2014). Achieving deep and sustained change remains a challenge (Coburn, 2003). Researchers (such as Cohen & Barnes, 1993; Cohen et al., 2013; Elmore, 2004; Fullan, 2007) argue that it is important to go beyond structural and administrative aspects of change towards capacity building. The success of spreading innovations and making changes to instruction is a social process of working with teachers to change their mindsets and support new practices. Schools may join forces with other schools to create the collaborative capital for self-improving school systems (Hargreaves, 2012). The support of other stakeholders in the education ecology, such as school leaders, is important to interpret and align state policies and reforms to fit the school context and create conditions to enable change (Spillane, 2000; Spillane et al., 2002; Toh et al., 2014). These considerations imply the tight-loose couplings that shape innovation pathways.

This chapter advances understandings of teacher capacity building as a driver for innovation and change that is nuanced to Singapore's centralized–decentralized education landscape. It unpacks implementation tenets as teachers learn on the job to enact and adapt changed practices for their needs. The chapter also describes the tight-loose couplings that help schools form partnerships while allowing spaces for context and needs to shape innovation pathways.

In the following, we review literature on innovation and change as top-down, bottom-up processes with tight-loose couplings, the role of subsystems in the education ecology, and the importance of capacity building and context for innovation and change. We present findings and draw implications from case studies to illustrate commonalities, adaptations, and pathways that two schools took as they implemented the same technology-mediated pedagogical innovation to focus on inquiry-based learning.

14.2 Literature Review

14.2.1 Innovation and Change is a Tight-Loose Coupling Involving Subsystems

Toh et al. (2014) appropriate Bronfenbrenner's (1979, 1992) ecological understandings to describe the education ecology as nested subsystems—***microsystem, mesosystem, exosystem***, and ***macrosystem***. This ecological perspective suggests that multiple stakeholders and subsystems are consistently interacting and impacting the education system to influence innovation and change. The ***microsystem*** includes influences such as teachers' mindsets and students' profiles which shape pedagogies and interactions in classrooms. The ***mesosystem*** looks at organizational attributes at the school and school cluster/district levels, for example leadership practices and structural leverages as influences on innovation and change. The ***exosystem*** concerns interactions from stakeholders beyond schools, such as parents and research partners who support the school's innovations. The ***macrosystem*** refers to national and global directions, initiatives, and policies that influence innovations and changes that schools adopt.

Taking this ecology perspective, innovations and its change process may not be exclusively top-down or bottom-up (Richardson & Placier, 2001). The top-down approach limits influences from other subsystems and prioritizes dominant forces from policy-makers for teachers to change. This approach prioritizes resources and forces for mass changes, yet it is constrained because teachers lack opportunities to understand how and why they should change. Consequently, there is limited ownership, and change becomes challenging. The bottom-up approach, in contrast, prioritizes individuals in the change process so teachers engage in deep reflection with common language and understandings to identify and address problems in practice. Changes in beliefs and practices are more deeply rooted. The fallback is that there may be pockets of unsustainable innovations and change due to limited support from school leaders and stakeholders.

Fullan (2007) describes that all innovation–change process faces the tight-loose, top-down or bottom-up, and centralized or decentralized dilemma. Command and control strategies are good for short-term limited changes. With autonomy and bottom-up strategies, the urgency and motivation for change may be lost. Different organizations and individuals exert multiple influences in the education ecology. Thus, innovation and change ought to embrace a top-down, bottom-up approach with a tight-loose coupling (Fullan, 2007). The issue is how to establish the right blend of tightness and looseness, centralized and decentralized approaches for innovation and change. Proponents of self-improving systems (Hargreaves, 2002) also advocate a top-down, bottom-up stance. Self-improving systems enable and sustain change by going beyond centralized resources and provisions to creating deep inter-school partnerships that stress professional development, partnership, and collaborative capital.

The Singapore education landscape provides a unique centralized–decentralized milieu in which this chapter explores to understand tight-loose couplings that schools embark to forge partnerships and innovation pathways. The ecological lens explained above provides bearings on our understandings of stakeholders and leverages from subsystems which influence innovation and change in schools.

14.2.2 Innovation and Change Needs to Foreground Capacity Building and Context

Another issue of innovation and change is overemphasizing quantitative aspects and downplaying qualitative dimensions. Change is not a linear, top-down process of replicating innovations to more schools or classrooms (Hung et al., 2016). Researchers in scaling and school reform argue that teaching and learning occur in different contexts, thus context sensitivity is important for deep, sustaining change (e.g. Bodilly et al., 2004; Clarke & Dede, 2009; Coburn, 2003; Elmore, 2004; Klinger et al., 2013).

The process of diffusing innovations and creating change is not a complete appropriation of the innovation but implies continuity (e.g. Hung et al., 2016; Sannino, 2010). Continuity relates to ways the innovation changes practices in schools although the overall innovation may take a different form. Part of this process involves re-contextualizing and re-adapting according to contexts. The diffusion and change process involves communicating the innovation through different channels by members of the social system over time (Rogers, 1995). This highlights the importance of school context, temporal factors, and relations of members (such as teachers, school leaders, students) to understand how the innovation can be integrated with curriculum standards, learning resources, assessments, pedagogy, leadership, and capacity building (Looi et al., 2011; Pea & Collins, 2008).

The issue of deep and sustained change is therefore not on structural and administrative aspects. Rather it is teachers' capacity of integrating the innovation and changing pedagogy and instruction (such as Cohen & Barnes, 1993; Cohen et al., 2013; Elmore, 2004; Fullan, 2007). Teacher capacity building is important because teachers have the greatest impact on student learning and outcomes (Lingard, 2005).

The social process of working with teachers is critical. Teacher learning is situated on the job as teachers engage in the innovation and address authentic problems. In line with situated learning theories [such as Dewey (1927, 1933), Vygotsky (1979), Lave and Wenger (1991), and Kolb (1984)], teacher learning or capacity building occurs as teachers interact in communities of practice within and across school settings.

Teacher learning involves expert teachers scaffolding peers and cyclic processes of experiencing, observing, applying, and testing knowledge in practice.

The literature review surfaces interrelated issues that guide our inquiry. The Singapore education landscape affords a unique centralized–decentralized context to understand how schools use teacher capacity building as a key driver for innovations and change. This context together with the ecological lens suggests that capacity building involves tight-loose couplings and leverages from multiple stakeholders and subsystems to shape innovation and change. The concern is how to embed teacher capacity building in practice as well as how school leaders bring resources and align innovations to meet schools' contexts. With these issues in mind, the research question that guides our inquiry is "*what are the implementation tenets for developing teacher capacity as a driver for innovation and change and how does school context shape differences?*".

This chapter uses two case studies to illustrate the tight-loose couplings that schools went through to establish common structures and processes to initiate the innovation, build capacity as a community, and the adaptations schools made so the innovation and changed practice met their needs.

Next, we describe our research context followed by methodologies, findings, and discussions.

14.3 Research Context

14.3.1 Macro-context: The Singapore Education Landscape

Singapore's education system has evolved over many phases—"survival-driven" (1959–1978), "efficiency-driven" (1978–1997), "ability-driven" (1997–2011), and "student-centric, values-driven" (2011–present). The focus is always on raising the quality of teaching and helping every child reach his/her fullest potential (Singapore Ministry of Education, 2010a; Heng, 2011).

"Thinking Schools, Learning Nation" (TSLN) is a key vision which inspired schools to challenge teaching and learning for the twenty-first century through participation, creativity, and innovation (Singapore Ministry of Education, 2016). Schools are called to transform practices to not just stress knowledge acquisition but to develop students' process skills, such as questioning, problem solving, and critical thinking. Schools are not only implementers of policies. They strive for continuous self-improvement through innovations. Schools ahead in twenty-first-century learning collaborate and help others attain similar stature (Singapore Ministry of Education, 2010a).

ICT Masterplans were introduced from 1997 to develop infrastructure and build teachers' capacity to innovate practices and meaningfully integrate technology into curriculum, pedagogy, and assessment (Singapore Ministry of Education, 2015a). School autonomy, in line with our centralized–decentralized landscape, continued to be a pillar for change. School leaders and teachers have the autonomy to introduce school-based innovations, with support from the Singapore Ministry of Education, as long as it remains aligned with policies and curriculum intentions (Chua et al., 2014).

"Teach Less, Learn More" (TLLM) in 2005 further realized TSLN and catalysed transformations of teaching and learning. More qualities in areas, such as classroom interaction, student expression, and character building, were emphasized and less on prescribed tests and exams (Shanmugaratnam, 2004). Content reduction created "white space" and teacher autonomy to customize lessons and use innovative pedagogies. The approach was to provide top-down support for ground-up initiatives and school-based innovations. The Singapore Ministry of Education seeded opportunities and incentivized schools to develop school-based innovations (Singapore Ministry of Education). For example, EduLab is a "living laboratory" established by the Singapore Ministry of Education and the National Institute of Education with resources to support teachers in experimenting with the meaningful use of ICT for teaching and learning. It brings together stakeholders in the education ecology to prototype, test, translate, and scale innovative practices to the wider system (Chua, n.d.). Teacher learning was also emphasized in TLLM through "time-tabled time for professional development". Teachers were given a delineated time slot to engage in professional discourse and sharing (Singapore Ministry of Education, 2010a).

Here, we highlight "FutureSchools@Singapore" as an initiative where exemplar schools become "trailblazers" to provide models of pervasive integration of ICT into the curriculum and for these schools to share, lead, and scale up their experiences to other schools. This study occurred in ICT Masterplan 4 where the goal is on quality teaching and learning empowered with technology through two enablers: (1) teachers as designers of learning experiences and environments and (2) school leaders as culture builders (Singapore Ministry of Education, 2015b).

Our study evolved from one FutureSchool where an inquiry-based pedagogical innovation supported by technology has spread over 5 years to the primary 3 and 4 science curriculum. This pedagogical innovation has been diffused to five other schools within the same geographical zone (Hung et al., 2016). Lessons learnt suggest that spreading innovations and changing practices are complex processes. Some intentional planning is possible by leveraging ecological carryovers, like structural, sociocultural, economic, and epistemic carryovers. Epistemic carryovers in the form of teachers' epistemic views to knowledge, such as student-centred inquiry, have the most leverage for sustaining innovation and change (Adner, 2012; Toh et al., 2015).

14.3.2 Meso Context: School Profiles

Conseqently, these lessons learnt informed teacher capacity building as two schools embarked on the same technology-mediated pedagogical innovation to enable inquiry for primary 3 science. School Z and School T are typical primary schools located in suburban Singapore. Most students live in public housing with a fair proportion on financial assistance scheme. The two schools were put in partnership as the cluster superintendent perceived them to be similar in school readines, teacher capacity, and student profiles.

School leaders in Schools Z and T were onboard. They were willing to create structures and resources for capacity building. They also recognized the importance of student-centred inquiry learning environments to advance beyond drill and practice.

Teachers in both schools acknowledged a need for inquiry learning as stiplated by the national science curriculum but they were unsure how to do so. School Z's teachers had gone through some training on inquiry and created school-based inquiry lesson packages. School T's teachers were aware of inquiry, but their existing practices relied on textbooks and school-based worksheets. Both schools came with the initial intention that they would work together to design and enact similar lesson plans. However, their varying contexts and objectives meant some commalities and adaptations were inevitable. School Z's intention was to build teachers' capacity to integrate technology and add value to their existing school-based lesson packages. In contrast, School T's objective was to develop teachers' capacity to revamp and resdesign lessons for inquiry.

14.4 Methdology

This study is construed as a multiple-case design (Yin, 2009). This approach aligns with our research intentions as it recognizes the interwined nature of phenomenon and context (Baxter & Jack, 2008) to unpack common implementation tenets for using capacity building to drive innnovation and change as well as how the two schools' contexts shape nucances.

This study adopts a social-constructivist perspective, aligned with our ecological view of education systems and schools. The social-constructivist perspective relates closely to our research as it embraces the dualities of individual and social. The individual focuses on understanding how capacity—building activities are designed and implemented to help teachers understand innovations. The social looks at understanding how social affordances of communities and school contexts foster teacher learning (Borko, 2004; Wilson & Berne, 1999). A social-constructivist view also necessitates interactions and dialogue between researcher and participants in naturalistic, school settings. Context is important as it has bearings on capacity-building structures and processes for each school and the differences between schools.

14.4.1 Participants

Purposive sampling is employed. Informants are not selected to establish a representative sample but to enable in-depth exploration (Mays & Pope, 1995; Morse et al., 2002). Participants are stakeholders involved in teacher capacity building for the innovation. They were selected to provide diverse insights about capacity-building structures and processes. They include personnel from the Ministry of Education, researchers from the National Institute of Education, school leaders, and participating teachers.

14.4.2 Data Sources, Collection, and Analyses

Anonymity and confidentiality are explained to participants. Ethnics clearance and written-informed consent are sought prior to data collection. Our research methods foreground qualitative analyses and data sources such as face-to-face interviews, open-ended dialogues, observations, and fieldnotes. Data are collected in meetings with school leaders, teachers' in communities of practices, classroom observations of teachers enacting innovations, and interviews about the innovation. Fieldnotes from these meetings and dialogues, videos of classroom observations, and audio recordings of interviews inform analyses.

Researchers are participant observers of the capacity building and innovation–change process—initiation, implementation, continuation, and outcome (Fullan, 2007). Thus, researchers' reflectivity in the form of memos shaped analyses. Data analyses are established through synergies. Comparisons between data sources are organized into patterns, categories, and themes. Analyses occurred at two levels, within and across cases, to provide a comparative view and further the findings' robustness (Baxton & Jack, 2008; Sandelowski et al., 1997). The two-level analyses also provided macro- and micro-perspectives. The macro-perspectives are key implementation tenets and common dimensions that enable both schools work together on capacity building for the innovation. The micro-perspective concerns differences within the tenets that evolved due to contextual nucances between schools.

14.5 Findings

We present three implementation tenets for teacher capacity building that Schools T and Z created for innovation and change. The commonalities and differences within tenets suggest tight-loose couplings that schools created to establish partnerships and yet provide opportunities to suit their needs.

14.5.1 Tenet 1: Creating Consensus and Tailoring Innovation for Schools' Contexts

The tight-loose coupling creates consensus and adaptations between schools. Schools are bounded by (1) shared problems, accountability, and innovation principles; (2) common lesson design principles; (3) similar capacity-building resources and structures; and (4) spaces for different intentions, lesson designs, and enactments. Experts beyond the schools are leveraged to support the innovation–change journey.

14.5.1.1 Shared Problems, Accountability and Innovation Principles

The Science Heads of Department in both schools agreed that they shared similar problems teaching plant science. Firstly, students are less interested in plants and fungi because the phenomenon (e.g. how plants make food and the functions of roots) is less observable and apparent. Secondly, the topic in lower primary is factual. Teachers find it difficult to design learning experiences that triggered students' curiosity and questions. These become the shared problems from practice that teachers would work on.

To strengthen their commitment, the two schools jointly developed an EduLab proposal for funding and shared accountability towards the innovation. EduLab (Singapore Ministry of Education, 2010b) is an MOE-NIE initiative that supports and spreads teacher-led, technology-mediated pedagogical innovations. With the support of researchers from the National Institute of Education and the Educational Technology Officer from Educational Technology Division (MOE), both schools agree on the innovation's core principles (see Fig. 14.1) and roles of external experts in supporting them in the innovation–change process. Teachers would use the school eco garden to create authentic experiences for students to observe plants and make connections to science concepts. Teachers guide students in inquiry by making their thinking and experiences concrete and scaffold them towards scientific understandings. Technology records students' observations and collects evidences of students' learning, so teachers could create more scaffolds and deepen understandings.

14.5.1.2 Common Lesson Design Principles, Resources, and Structures

Teachers in both schools agree that a big part of the innovation involves building teachers' capacity by redesigning, enacting, and reflecting on lesson designs and learning experiences. Conversations are initiated to establish the core principles for lesson designs to include the 5Es (engage, explore, explain, elaborate, and evaluate) instructional approach, inquiry-based learning, thinking routines, and freely available web 2.0 tools and mobile devices for learning inside and outside classrooms (see Fig. 14.2).

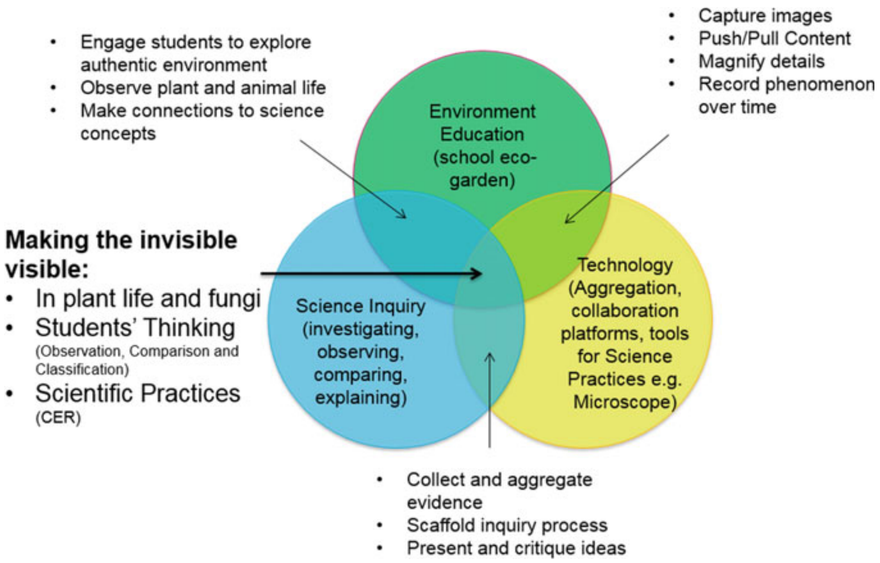

Fig. 14.1 Core innovation principles

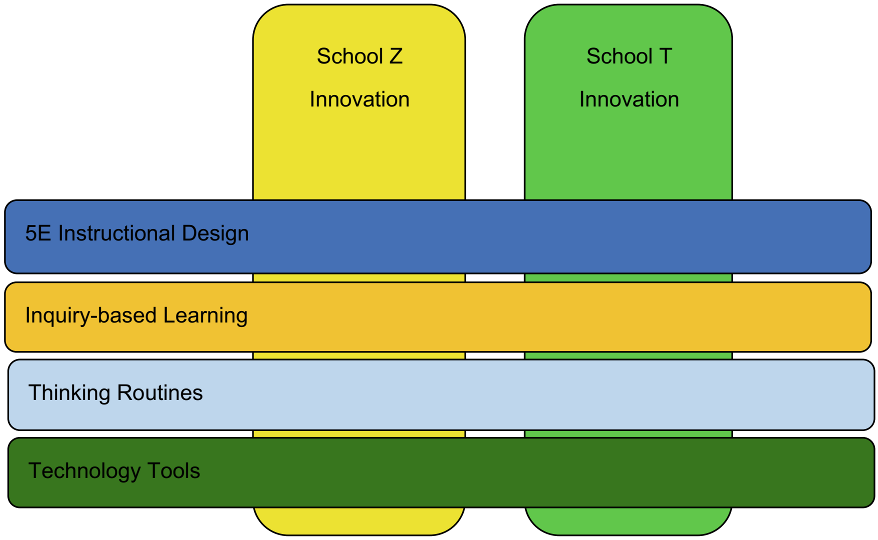

Fig. 14.2 Core principles for lesson design

School leaders pledge similar time and resources. They offload and designate free periods for teachers to work on the innovation. They give teachers autonomy to re-sequence topics and reschedule timetable for coherent teaching and learning. Both schools enacted the innovation in term 2 with similar number of 40 mobile devices. Teacher assistants are deployed to help teachers prepare mobile devices, technology resources, and record classroom enactment for review.

14.5.1.3 Spaces for Different Intentions, Lesson Design and Enactment

Teachers and school leaders acknowledge contextual differences such as school background, niche areas, and teacher capacity which shape lesson designs. School Z's teachers have prior training in the 5E instructional approach. They have created, refined, and used their own school-based curriculum for several years. Thus, School Z's intention is to enhance existing school-based curriculum through the meaningful integration of technology and thinking routines.

School T's intention is to create a new school-based curriculum for primary 3 science with technology integration and develop students as critical thinkers. They hope to share innovative science practices and resources through the partnership. While the teachers are aware of the 5E instructional approach, School T recognizes that their practices seem teacher-directed. They welcome the opportunity to design inquiry-based lessons and challenge teachers to facilitate students' deep learning and critical thinking.

Due to differing intentions, the enactment and design of lessons varied. For School Z, it is enhancing existing lesson designs. It is decided that all primary 3 teachers enacted the lessons to give students similar learning experiences. For School T, the new lesson design is enacted by two teachers in two middle ability classes.

14.5.2 Tenet 2: Forming Communities and Building Capacity Through Lesson Designs

Both schools created a community of teachers with diverse strengths and leadership to support the innovation. This community would build capacity for technology-supported, inquiry-based learning by redesigning and enacting lessons. While similar capacity-building platforms and processes are created at the across school level, existing teachers' capacities, school's intentions, and lesson design processes created variations in the within school approach. Variations happened in how schools planned lessons, learning experiences for students, and how technology is integrated to support inquiry. The roles and responsibilities that teachers take also shaped capacity-building opportunities.

14.5.2.1 Common Capacity-Building Platforms Across Schools

Capacity building in both schools takes a practice orientation, where lesson design in community settings becomes the anchor for capacity building. Researchers model inquiry-based learning in both schools. This is powerful in showing teachers possibilities for innovation and change in their own classrooms. Researchers also work with teachers to align understandings in multiple areas: (a) making sense of the 5E instructional approach and how each stage informs lesson design; (b) introducing thinking routines and evaluating how they build students' understandings; and (c) exploring affordances of web 2.0 tools to support inquiry. The goal is to translate understandings to redesign lessons and integrate technology to facilitate inquiry classrooms.

Prior to the classroom enactment in term 2, both schools, with the support from researchers, train students in using mobile devices and thinking routines. This ensures students are enculturated in thinking routines and overcome the novelty factor of using technology for learning.

14.5.2.2 Creating Communities and Lesson Designs Within Schools

Different intents of lesson designs: The community in School Z includes the science head of department, subject head, senior teacher, and two teachers. In weekly within school meetings, capacity building focuses on reviewing and redesigning lessons. For School Z, teachers redesign lessons by integrating understandings of the 5E instructional approach, thinking routines, and using technology to support learning. Teachers critique existing lesson plans to unpack if students' learning needs are met. For example, in the engage phase, they ask how to use the school garden to trigger students' curiosity about plants. Through an incremental approach, they review the entire learning package and identify sections they could redesign and replace. Conversations focus on designing learning tasks and ensuring that the experiences are linked within and across each phase for coherence. For example, they would think about how to use students' artefacts from each phase to inform their teaching based on students' thinking and ideas.

School T's community of teachers includes the science head of department, level head, and four other teachers. In contrast to School Z, their focus is not to enhance but to redesign the entire learning package. Their goal of weekly school meetings is to design lessons for deep learning by leveraging the 5E instructional approach and creating opportunities for students' thinking to be made visible. In the design process, teachers look at students' learning difficulties and misconceptions from past experiences. Then they design experiences that surface misconceptions and overcome learning difficulties. For example, in the past, they would show students videos on functions of roots, but there is limited retention. To overcome this, they design hands-on experience for students to uproot plants and experiments to observe the functions of plant parts. They plan for small-group facilitation and discussion to surface students' thinking and use hands-on experiences as a common platform for students to learn collaboratively.

Selecting and integrating technology in lesson designs: In both schools, researchers and educational technology officer support teachers in understanding the affordances of different technological tools and their meaningful use to meet learning objectives. In School Z, technology plays a key role to anchor the learning experience. The teachers experiment with technologies to evaluate its suitability to engage students in observing plant life and make students' observations visible to teachers. Teachers consider the availability of resources and ease of deployment for all six classes. Table 14.1 shows teachers' considerations and purpose when integrating technology for learning.

For School T, the focus is more on creating hands-on experiences to trigger students' curiosity and teacher facilitating students' questions and thinking for deep learning. Thus, technology supports learning so teachers could "see" students'

Table 14.1 School Z teachers' considerations in integrating technology for learning

Tool	Purpose	Limitation
Kahoot	Immediate feedback to teacher and students	Only good for multiple choice questions
Linoit	Idea splash	Students cannot shift the notes to organize their thoughts better
Google form/Docs	Document students' research	When students work on the same document, overwriting occurs
NearPod	Platform to control flow of lesson and monitor students learning	The lesson becomes teacher directed for delivery of content
ThingLink	To design learning experiences for students to interact with the environment and a platform to use various technologies to support learning, e.g. Linoit and videos	Students may be distracted by the use of the technology and focus on the task rather than interacting with the environment. They may experience usage problem such as touching the screen accidently and cannot see the screen clearly in bright outdoor environment
Time-lapsed video	Students can observe plant phenomenon at an increased pace that would otherwise be difficult to observe in real life	The videos may not be well-taken and students may need to replay the video to observe the phenomenon more closely
Tablet with magnifying lens	Students can observe plants and their parts more closely, e.g. the spore bags of the fern leave	Students may be overly excited, and the novelty factor may not lead to observing the phenomenon properly

Table 14.2 School T teachers' considerations in integrating technology for learning

Tool	Purpose	Limitation
Kahoot	Immediate feedback to the teacher and students	Only good for MCQ
Padlet	Idea splash	Students cannot shift the notes to organize their thoughts better
Google form/Docs	Document students' research	When students work on the same document, overwriting occurs
MCOnline	Students record their questions and learning throughout the topic	Teacher needs to police content and appropriateness in use of language
Sketch	Students make graphical representations of their thoughts	Not collaborative. Ideas cannot be shared easily
Mobile device with Internet search ability	A platform for self-directed learning	Students may be too engrossed in their own research and cannot participate at the desired pace in class

thoughts and for the students to construct meanings collaboratively. Table 14.2 shows School T's selected technologies and its limitations.

Community dynamics and lesson design processes: Both schools show distributed-ness in the lesson design process. Throughout the process, researchers and educational technology officer guide teachers in designing inquiry-based activities and meaningful integration of technology. School leaders give teachers the autonomy and resources to redesign lessons. However, equal rights and consensus building for ideation and critique feature more prominently in School T.

In School Z, the old lesson design process is helmed by the science head of department, subject head, and senior teacher. Lessons are designed by them and then pushed to all primary 3 science teachers for enactment. After enactment, feedback is given to the same teachers for refinement. For this innovation, the lesson design process is modified to become distributed. Teachers in the community openly contribute ideas and critique the lesson design. Teachers tasked with different roles and responsibilities would contribute in their areas of expertise. Two teachers with strengths in technology look at integrating technology in the lesson design. Three teachers develop learning resources, such as slides and worksheets. One teacher plans timetable so mobile devices could be rotated among classes. Despite best efforts, conflicts are evitable so some classes did not use mobile devices. Additional coordination among teachers is needed so lessons needing mobile devices are conducted later. Designed lesson plan is enacted by all teachers in the community for all primary 3 sciences classrooms in term 2.

In School T, the community includes the science head of department, level head, and four teachers. The science head of department ensures adherence of lesson design with the national syllabus, the level head guards the must-do activities in existing lesson pans, and all decisions are made in consultation with the community. The lesson design process is always equally shared among teachers. The community agrees on general ideas for each stage of the 5E instructional approach and alignments between stages. Then the community divides and conquers with every member designing an entire stage (i.e. one of the 5E) of the lesson. Individual teachers develop the lesson fully including instructional strategies and resources required. The science head of department organizes the timetable such that the two enacting teachers conduct lessons on the same day so they could support each other. The designed lesson plans are enacted in two classes as school leaders feel not all teachers in that level are ready. This community will propagate innovative practices when they experience success.

14.5.3 Tenet 3: Deepening Understandings Through In Situ Enactment and Refinement

Enacting and refining lessons deepen teachers' understandings of technology support, inquiry-based practices because they receive first-hand experiences of students' responses, artefacts, and personal reflectivity of new practices. These first-hand experiences together with observations from researchers and educational technology officer inform refinements. Despite varying ways of implementing the innovation, both schools experience teacher learning and change. We unpack the implementation and refinement process and extent of teacher learning below.

14.5.3.1 Different Enactment Experiences and Student Artefacts to Inform Teacher Learning

In School Z, two teachers, task with the technology integration, are the vanguard to lead lesson enactment before other teachers. This helps address issues with technology and improve lessons before others enact lessons. Between the two teachers, they collaboratively test the technology's implementation and evaluate the designed learning experiences for students. For example, if the first teacher experiences issues with technology, the second teacher tries another approach to mitigate issues. In the first few enactments, the other teachers observe enactments by the first two teachers. Teachers make adaptations to suit their students' needs. Teachers in lower progress classes provide students a more guided inquiry experience while other classes took an open-ended approach.

In weekly meetings, School Z's teachers reflect and share their lesson enactment experiences. They note difficulties students face and suggest alternatives for the following year. They review students' artefacts such as postings of See Think Wonder thinking routines by individual students on Linoit. On one occasion, they notice students had not linked ideas of the individual parts of see, think, and wonder. The teachers reason that they need to prepare students on the proper use of the thinking routine for next year.

In contrast, School T does not use teachers as vanguards. School T's teachers discuss and mentally walk through the redesigned lessons before implementation to raise issues. The two enacting teachers took lead in refining lesson plans and resources based on their student profiles with other teachers supporting them. Their peers would also find time to observe enactments.

Enacting teachers in School T similarly share their experiences of lessons such as issues and areas for improvement. Compared to School Z, School T's discussions anchor on using students' artefacts and interactions as evidences to refine lesson plans. Conversations focus on what students do and learn. The community questions if students' thinking is visible and what would be done to use students' ideas to develop understandings. Questions are raised about why students make certain responses and the lesson is dissected to look for causes of misconceptions. Discussions on learning gaps lead teachers to rethink and refine subsequent lessons before enactment which further enhances students' learning experience. This process is not planned for earlier and is made possible by the collegiality of teachers to provide feedback. To complete the refinement loop, the teacher in-charge of the lesson plan makes changes based on ideas discussed in the meeting for the next year.

14.5.3.2 Teachers Becoming Designers of Learning

In the earlier design process, School Z uses a divide-and-conquer strategy. Teacher learning and conversations centre on teachers' expertise areas. In the implementation and refinement stages, teachers are observed to becoming more open and forthcoming in suggesting refinements based on their common experiences and observations of students' learning. This also suggests that teachers are beginning to taking more ownership of the design.

The task of leading lesson designs in School Z also switched from the science head of department to the science head with the former providing guidance and managing resources. In the beginning, although the science head of department provides guidance on pedagogy and content, she does not think teachers should design lessons. Instead, teachers should implement the designed lessons by the Ministry of Education. Over time, her perspective on the purpose of design and technology use changed. This is observed by the school principal who said that the science head of department has become a proponent of designing lessons and open to the use of technology.

For School T, the team has equal rights to the activity design and feedback from the onset. Consensus is required in all lessons planned and enacted. Thus, there is shared ownership and responsibility. Teachers as a collective focus on improving activities designed, making sense of students' thinking, and creating school-based resources to help students learn by inquiry and teacher facilitation. Compared to School Z, shared responsibility helps the team review enactment more critically using students' artefacts as evidences and not teachers' performance as means of evaluation and feedback. This is pivotal to the continuous enhancement of teacher development and students' learning experiences.

In School Z where technology acts as an anchor to provide learning experiences, the focus in School T differed. School T uses technology to understand students' thinking so teachers build students' conceptual understandings. School T's teachers learn how to (1) use the 5E instructional approach to excite students and prepare resources that help students learn scientifically; (2) shift ownership of learning to students by surfacing students thought and facilitating students' thinking processes; and (3) use students artefacts from technology to redesign lessons and inform teacher facilitation.

Through designing, enacting, and refining lessons, teachers in both schools changed how they think about their students and inquiry.

> The lesson that really changed my way of teaching is the lesson where we actually show the responses of the kids to everyone. So my first impression was that the kids will not be interested in their friends' answers… I was very wrong. So it struck me that it was a very powerful tool where they can actually make use of their own questions, their knowledge…to students engage to form up the concept as a collective effort… That was really an eye opener for me. (Teacher from School Z)

> Initially, I was afraid to say the wrong things but the researchers were here to help improve the lessons. Everybody was here to talk about the lesson [based on students' artefacts] and not about me. (Teacher from School T)

> [In the weekly meetings]… our conversations focus on: why do you want the children to write this…how do you know if they have learnt through this... what do you think the children will say? (Teacher from School T)

Based on the extent of teacher learning and change, both schools have continued to redesign the technology-enabled inquiry lessons for other primary 3 science topics and implement the pedagogical ideas in the primary 4 science curriculum. This decision is made despite receiving limited support from researchers and educational technology officer. Both schools would also continue with the partnership to share practices and make inquiry-based learning more widespread in their own contexts.

14.6 Discussion

14.6.1 Balancing Tight-Loose Coupling and Partnerships Across Subsystems

Our findings show innovation and change as a complex process. Capacity building focusing on lesson design, enactment, and refinement is key so teachers understand how to infuse and adapt inquiry practices for their classrooms. Literature (e.g. Fullan, 2007; Richardson & Placier, 2001) suggests that innovation and change involve top-down, bottom-up approach with tight-loose coupling. Other researchers (e.g. Hung et al., 2016; Toh et al., 2014) highlight the need to interact with other subsystems to impact innovation. The challenge is how to balance this dilemma in different contexts and draw interactions from stakeholders and subsystems in the education ecology.

Our findings contribute to this gap by unpacking tight-loose couplings in a centralized–decentralized Singapore education context. Commonalities in implementation tenets, such as shared problem, common lesson design principles, and joint platforms for teacher learning, afford tightness that bring together stakeholders from multiple subsystems to collaborate on the pedagogical innovation. These stakeholders, such as researchers and educational technology officer, bring expertise and leverages to support technology-supported, inquiry-based learning. These stakeholders may also help two schools pull insights beyond their limited lens to enable the innovation and create sustaining change.

Our findings illustrate that consensus building is important to put schools in partnerships. While partnerships grow collaborative capital and engage in joint professional development for change (Hargreaves, 2002), our study unpacks considerations of partnership building and drawing leverages from different subsystems to support it. In our study, partnerships happen at the mesosystem where two schools in the same cluster with similar profiles are committed to collaborate. This partnership is created with the cluster superintendent's support at the mesosystem. The two school leaders show commitment by putting similar resources and structures for building teachers' capacities.

Schools in this study leverage funding, such as EduLab, at the macrosystem to further make explicit the shared accountability and commitment in a proposal for the innovation. The innovation's intentions are aligned with the ICT Masterplan 4's goals at the macrosystem. The funding brought in an educational technology officer with expertise on integrating technology for inquiry-based learning. Concurrently, the school sought partnerships with researchers at the exosystem to mentor teachers on the pedagogical aspects of inquiry-based learning. The proposal, thus, establishes coherence so expertise from other subsystems recognizes opportunities for contextualization to help each school's teachers become designers of learning. It also enables sharing of best practices beyond schools to engage others in partnership. The current partnership is budding, and time is needed to leap its impact beyond existing schools.

14.6.2 Capacity Building as a Social Process that Considers School's Context

Schools are mindful that tight coupling can be constraining so some looseness is needed. The expertise in researchers and educational technology officer works with teachers to contextualize lesson designs and processes to fit individual school's intents, teacher, and student profiles and, thus, leverages from exosystem and macrosystem, respectively, value-added capacity building at the microsystem.

Scholars (Hung et al., 2016; Sannino, 2010) stress that innovation and change involve diffusing to different contexts. Continuity is implied in how the innovation enriches school's practices although the innovation may morph differently. Teacher capacity building is key for diffusion. It involves a social process of teachers making sense of the innovation, how it fits into context, and communicating to others (Rogers, 1995; Looi et al., 2011; Pea & Collins 2008). Literature shows it is important to situate capacity building in practice as teachers participate in the innovation (Borko, 2004; Wilson & Berne, 1999). However, how capacity building is situated in the Singapore education context to support innovation and change is less known. Our findings address this gap.

Our findings show that school leaders' commitment in capacity-building structures and resources, such as off-loading teachers and providing time for professional conversations, cannot be undermined. Another aspect is to focus on the lesson design process in community settings. Common platforms are needed for multiple stakeholders to align understandings underpinning lesson designs, which include the 5E instructional approach, thinking routines, and affordances of web 2.0 tools for inquiry.

Mentoring by researchers and educational technology officer help teachers translate conceptual understandings to redesign lessons and integrate technology to facilitate inquiry. Modelling technology-supported, inquiry-based practices by researchers also show teachers' possibilities for change in their own classrooms. This motivates teachers to engage in professional conversations. These conversations help teachers unpack the school's innovation intentions and align lesson designs to these goals. Our findings also show that it takes time to make sense of the community's strengths, dynamics, and existing processes, so lesson designs, processes, and technology selected fit school's needs.

Researchers and educational technology officer broker conversations and understandings among teachers. Translating understandings to lesson designs is one level of practice-oriented understandings. Enacting and refining lesson designs deepen teachers' understandings of technology-supported inquiry in classrooms. It encourages teacher reflectivity and ownership that is informed by students' artefacts and interactions.

Figure 14.3 illustrates tight-loose couplings within and between schools for capacity building. Horizontal panes connote commonalities while vertical panes afford spaces for adapting to school's needs.

14.7 Conclusion

This chapter demonstrates implementation tenets for teacher capacity building as a driver for innovation and change. Through case studies, the tenets unpack tight-loose couplings for capacity building by leveraging stakeholders in subsystems and partnerships that is nuanced to Singapore's education landscape. Capacity building for this pedagogical innovation focuses on lesson design, enactment, and refinement to change teachers' roles and views from teacher-directed to teacher-facilitated inquiry practices. Initially, teachers saw themselves as enactors of lessons designed by the

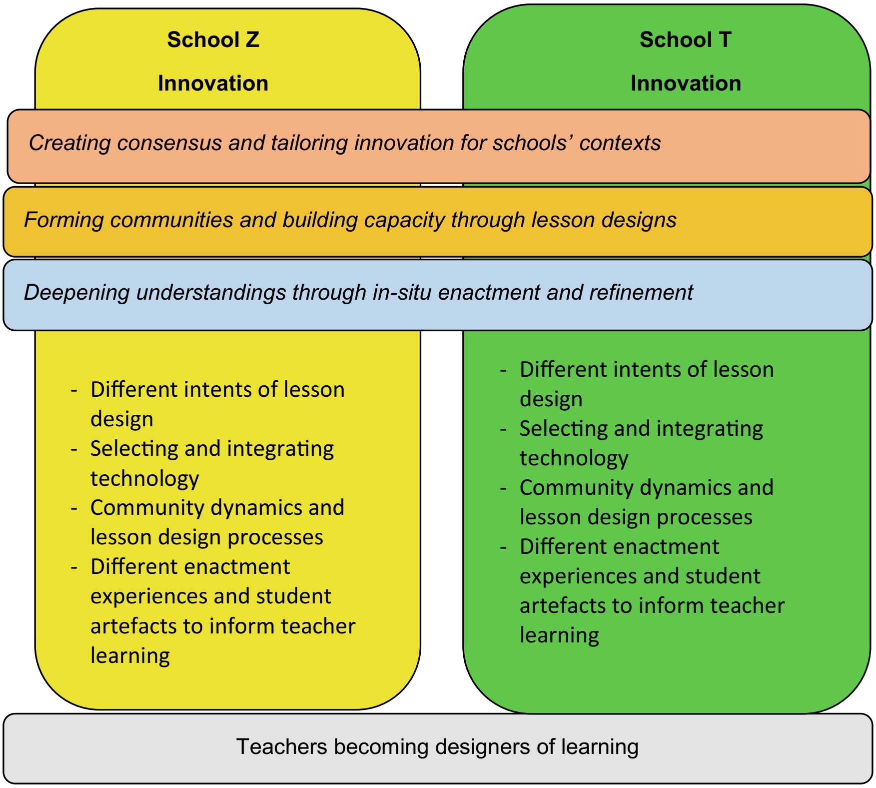

Fig. 14.3 Tight-loose couplings for capacity building within and between schools

Singapore Ministry of Education. Now they see their roles as designers of learning using student artefacts to inform design.

While teacher learning has occurred in some ways in both schools, school's social–cultural context, innovation's intentions, and implementation processes continue to shape change for each school. Future work continues to document teacher learning as a driver to spread technology-supported inquiry learning and create opportunities to bring other schools along this innovation–change journey.

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Chapter 15
The Problem of Integration: How Schools Can Fill the Skills Gap

Chloe Tan, A. A. Johannis, and David Hung

Abstract This chapter explains how the current education paradigm, which has its origins rooted in the First Industrial Revolution, is markedly different from the classroom where formal and informal learning takes place and which, as a classroom of today, is suited for the Fourth Industrial Revolution which is currently unfolding. Learning must be learner-centric with integrated formal and informal programmes in schools. Authenticity of learning of 21CC skills and its impact on skill transfer are issues discussed in this chapter. Purposeful learning leading to life-deep and life-wise learning, along with self-directed learning and motivation, are factors that lead to skill expertise and attainment. We discuss the current programmes in schools and how we can draw lessons from another education system. Other frontiers include leveraging on student agency, teachers as designers of learning, learner dispositions, and twenty-first century learning.

Keywords Informal learning · Formal learning · Fourth industrial revolution · Twenty-first century competencies · Purposeful learning · Cognidiment · Cognitive capital · Future-ready dispositions

15.1 Introduction

The Fourth Industrial Revolution places new emphasis on skills development by helping learners find their passions that are not currently attended to in schools (Schwab, 2016). Singapore schools must integrate development programmes for formal and informal learning skills in a coherent and unified manner. The development of skills does not only happen in formal learning contexts such as traditional

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teacher directed instruction in classroom settings, and skills can and indeed are already being developed in informal learning contexts such as through pedagogical innovations like seamless learning on digital trails.

By 'informal learning contexts', we do not mean the educational activities which take place outside the physical boundaries or outside the authority and planning of educational institutions. By informal learning contexts, we mean the learning opportunities that emphasises self-directed learning and indeed the self-definition of the learning process itself by the learner (Livingstone, 2001). The student decides what and how to learn. However, the integration of formal and informal learning into skills development programmes does not generally occur in most schools. Students who perform well in classroom settings may not perform well in field trips or in informal learning settings such as hackathons or digital trails. Conversely, students who do well in informal settings may not do well in formal learning settings.

Our current education system was designed for the survival phase of Singapore's economic history when training workers was the paramount need—learner interests or dispositions were simply not a priority. As Singapore's economy moves out of this survival phase, there is a need for the education system to follow suit. The survival phase led to an overemphasis on traditional academic skills and consequently to a skills gap between the skills developed in schools by learners and the soft skills needed for the future economy (WEF, 2015). This mismatch is hardly desirable from the point of view of the system as a whole. With the current emphasis on traditional academics, this skills gap is an issue which needs to be addressed in the very same informal learning contexts which need to be integrated. After all, these are the contexts where skills development happens in novel and learner-centric ways.

15.2 Discussion

In order to develop twenty-first century competencies (21CC skills) and dispositions, we make the case that differentiated instruction is required as instructional conditions must vary in order for students to gain exposure and understanding from a wide range of experiences. We envisage that schools and parents need to work together, and with students as well in a tripartite partnership, to help the latter develop these 21CC skills. Addressing the varied learning needs for 21CC skills with differentiated instruction will also go some way in addressing each learners' pace of learning in schools. And for those with unique and special needs, specialised schools have been established to attend them.

The nature of informal learning contexts, nevertheless, is such that the programs and activities involved have to be low risk with low stakes. They have to be low risk with low stakes because they need to be able to provide a safe space for exploration, tinkering, experimenting, and charting new territory. While the real world is of course a harsh and unforgiving place, students need training wheels in the initial development of their sense of wonder and desire to discover. Thus, it is important to instil in informal learning programmes a pedagogical culture that reassures students that it is safe to explore.

Informal learning may also occur through non-hierarchical communities of learners where individuals gather in real or virtual spaces to contribute to a common pool of knowledge and participate in joint generation of new knowledge. So, students need to build up their social confidence and emotional resilience before taking part in such unmoderated learning contexts. Schools have set up makerspaces as an example of informal communal learning spaces. However, we suspect that the agentic nature of learners' play in these makerspaces may not come to be fully realised because these spaces are to some extent structured and controlled. Time and space for experimentation are necessary for expressions of freedom of play. While this can also engender other undesirable unintended outcomes (such as possible distractions from academic pursuits), it remains an endeavour for research to answer the question of whether agency in play and tinkering about can be cultivated despite the regimentation of formal schooling.

Formal and informal learning should be held as equally important in developing skills and honing students' metacognition since learning in informal settings can often be more impactful than formal learning while bound to a desk. The Ministry of Education of Singapore (MOE) has made laudable efforts to create informal learning opportunities inside and outside regular school hours. The Applied Learning Programme (ALP), for example, emphasises the application of thinking skills and connecting knowledge across subject disciplines as well as niche programmes in business and entrepreneurship, design, robotics, journalism, and many other areas. The Learning for Life Programmes (LLP), on the other hand, focuses on experimental learning from real-life experiences through activities such as outdoor adventures, sports, and the visual arts in order for students to develop character and values (Lee, 2013). Additionally, the MOE has introduced the Flexible School Infrastructure programme, which funds the construction of flexible learning environments in schools. These projects create informal learning spaces that are offered to students as opportunities to tinker and explore in their free time. Examples have included a music jamming room, an outdoor music garden as well as an eco-aquarium that students can explore (Toh, 2017).

While these initiatives are commendable, there is, however, still a lack of synergy between formal and informal learning programmes. Students find it difficult to reconcile what they learn in the two separate contexts. Teachers also find themselves facing the dilemma of choosing which to emphasise in their teaching because they have limited amounts of time and resources to make preparations for both in their lesson time to satisfactory standards. Much more research has to be done on how to integrate informal learning programmes and formal learning curricula in order to leverage more out of the former without unintentionally compromising the spontaneity and freedom of expression that are its hallmark.

In this age of technological disruption and change, leveraging student agency is the next frontier in classroom lesson design. In fact, student agency can also be leveraged for collaborative learning as students may possess deeper domain-specific skills than their teachers, especially on students' topics of interest outside the standard disciplines of teacher training.

Nevertheless, teachers are still at the heart of pedagogical innovations and educational change. Innovations designed by teachers have the greatest leverage in activating skill acquisition. On top of that, teachers are also able to improve their design skills by engaging in professional learning communities (PLCs). The teachers who form PLCs are able to benefit from each other's varied professional experiences and training to discuss how best to implement and practice the pedagogical innovations for student learning in which they are interested. PLCs are also valuable as stores of knowledge on how not to do things as members learn from the negative examples of each others' mistakes. This reduces the trial and error period for individual teachers.

The integration of formal and informal learning programmes must be done in a coherent, meaningful, and purposeful manner so that there is synergy. The interplay of informal and formal learning involves the designing of informal learning so that twenty-first century skills and dispositions which are transferable across contexts are developed. Learning programmes can only be aligned in a purposeful way when the learner him or herself has defined their own purpose to learn and thus are intrinsically motivated. How then, can students learn purposefully? When purpose is constructed personally and through their own metacognition, that is, through constant reflection on one's ways of thinking and the consequent array of fine tuning adjustments and refinements made to those ways of thinking in reaction to new knowledge and new contexts. This deliberate reflexivity is what allows students to arrive at purpose; or more accurately, purposes, because there is no one singular, final purpose.

Purposeful learning, thus, comes about when the individual gains sufficient life experience that can be rationalised according to the learner's changing self and identity. This rationalisation is due to the higher order thinking process we call metacognition as just described. Such higher order cognition is separate from regular sensory cognition and epistemic cognition, as well as what we have coined as 'cognidiment', which is a form of embodied and participatory learning. When activities are done with a purpose in mind, the obtaining of skills, knowledge, values, and attitudes falls into place.

On a macro level, the integration of system-level programmes would allow for greater development and maximisation of cognitive capital (Noble et al., 2016). Cognitive capital comprises the entire set of intellectual skills as well as social–emotional and executive function skills which allow for creativity, flexibility, and working collaboratively. As Singaporeans, our cognitive capital is our main national resource. The cognitive capacities of the whole population are realised by schooling and training, which in turn involve experiential, formal and informal learning. As we know, formal learning in school was emphasised in the survival phase of Singapore's socio-economic development when it was necessary and useful for economic progress. However, today, in the cusp of the Fourth Industrial Revolution, times have changed. Formal learning is just one component of learning, whereas the Fourth Industrial Revolution requires a more holistic approach to education. In schools, the teachers' administrative loads should be reduced to enable them to act as brokers for their students' to informal learning. The Finnish school system where policy focuses on good teaching with structures supporting students in out-of-classroom learning in arts and sports is a model from which Singapore should study and draw lessons.

15.3 Findings

Change is imperative because other forms of skill acquisition not developed through formal learning must now be emphasised. An expert skill, realised through sustained skill development due to self-directed efforts, may have only developed as a result of an initial budding interest that motivates students to hone their skill to mastery. This is why it is important that the education system serves students in discovering their interests and passions, as pursuing one's interest and passion is more sustainable, self-directed, and motivated than learning without such factors. This is because when learners undergo epistemic changes, the process acts as a catalyst in their lifelong and life-deep learning. This epistemic change compels them to purposefully pursue a trajectory that interests them. When training and practice are borne out of natural interest and motivation, instead of societal, family, or school expectations, the mastery of skills requires less effort to achieve, and attaining domain expertise is more likely to reach higher peaks of excellence. This self-directed, self-driven quality is part and parcel of a life of purposeful learning.

Informal learning and the acquisition of learning dispositions are research areas on which much more effort can be made since they have not been the focus of learning in schools. Students' interest development must be nurtured and developed by way of experiential and informal learning, but we are not currently very clear on how. While it is probably not an exact science, since it depends very much on the reflexivity of the student subjects themselves, we can most probably infer heuristic methods of nurturing students' interest without explicitly or implicitly imposing the expectations of teachers, or indirectly through them, those of the school and society.

Interest-based skill acquisition is especially important in light of the Fourth Industrial Revolution, which prioritises skill and not grades. With the Fourth Industrial Revolution and the globalisation that in part drives it, the skills that employers value and search for are changing and are increasingly not found in formal academic learning. Our cognitive capital as Singaporeans must be realised through skill acquisition and expertise training in informal interest-based learning and the moulding of learning dispositions through experiential learning.

The above recommendations, however, leave us with much to do in terms of basic educational research. The medium to long term success of establishing purposeful learning in more informal learning contexts towards 21CC skills depends very much on how we approach our education research today. Five areas of interest stand out as particularly needful for future learning: twenty-first century competencies and motivation; cognitive, emotional, and social development with well-being; learning sciences and technology, including AI and learning analytics; schools, leadership, and the ability to enact and sustain change; and teacher professional development and learning (see Fig. 15.1).

The twenty-first century competencies and motivation highlighted above are crucial as the world that students are entering into today is becoming increasingly volatile, uncertain, complex, and ambiguous. Schools must prepare students to be future-ready: to possess dispositions such as motivation, self-direction, resilience,

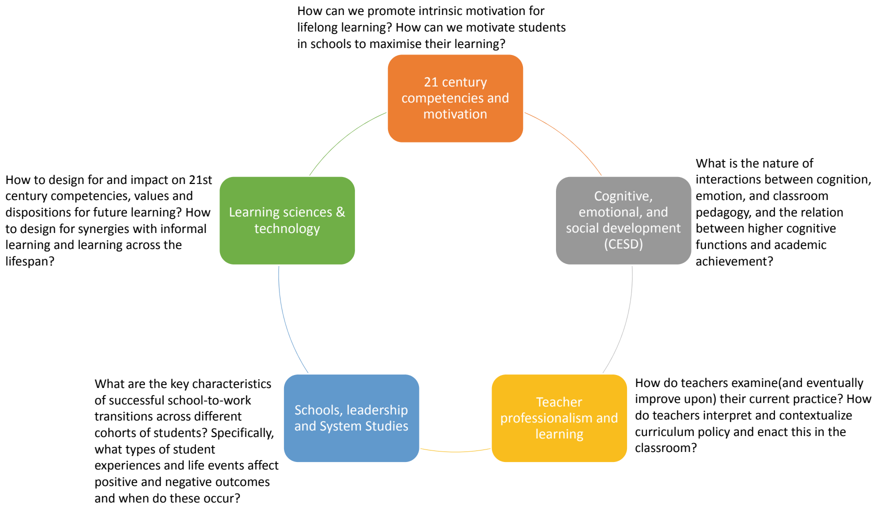

Fig. 15.1 Areas of research importance as expressed by the Office of Education Research, Singapore

and lifelong learning capability. Schools are to be places to inculcate these dispositions while taking into account joy of learning and equipping students with the 21CC of effective communication, creativity, problem solving and critical thinking. Motivation and self-regulation in schools is an increasingly important issue as it is only with motivation that we are able to maximise the student learning in developing their own knowledge and skills expertise. Teachers have to play their part as educators to enable learners to acquire such skills and dispositions, especially in building student resilience and providing opportunities for students to deal with failure positively.

The interplay between classroom teaching and student learning is another important area of research that requires further attending to in order to attain greater understanding of its impact on the cognitive, social, and emotional development of learners. The relationship between higher cognitive functions and achievement, as well as between formal and informal assessment, must be made clearer so that programmes are shown to be efficacious and calibrated to realise the ultimate aim of optimising learning and development.

In the same spirit of optimising learning and development, NIE will expand and enhance the area of learning sciences and ICT integration. NIE will leverage synergies with neurosciences to foster a more holistic science of learning perspective and increase efforts to translate learning sciences knowledge to applied classroom practice. The work will be geared towards key challenges in the learning sciences, such as maintaining institutional relevance in a world of ubiquitous information, enhancing informal learning, creating multiple educational pathways for students, leveraging new opportunities for assessing, and facilitating learning trajectories. One example of this work might be to look into how to harness learning analytics and new technologies such as AI, augmented and virtual reality, and the Internet of Things to prepare students to be creators, designers, problem-solvers, and entrepreneurs needed to realise Singapore's Smart Nation Initiative.

Research in effective teaching and learning practices and their impact on student educational outcomes, however, will remain at the core of education research, policy, and practice. Research will be focused on learning and teaching in different subject domains and in diverse classrooms and contexts in and outside of Singapore schools, but also engage in understanding the multi-level influences across Singapore's social and educational ecology. This requires contextually relevant and rigorous knowledge generated through research conducted in our local classrooms, schools, and communities. One example is to understand what the different types of pathways students actually take after leaving secondary school are and whether this pattern is consistent through time or unique to each cohort. Finding out will require longitudinal tracking of student transitions from school to work in order to examine the extent to which education contributes to labour-market success.

Still, as alluded to earlier above, teacher quality contributes significantly to student learning and experiences in school. It is the most influential school-related factor in explaining student achievement. Singapore's education system must therefore maximise the process and structures that support teacher learning and professional development to ensure not only continued teacher effectiveness, but also their pedagogical adaptability.

It remains necessary for schools to collaborate with agencies such as the Science Centre, museums, and other similar organisations 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. Are there checks and balances we should look into to police our students' natural propensities for youthful indiscretions? Perhaps large-scale mentorship programs are in order to gently nudge our youth towards worthwhile endeavours and nurture their idealism for contributing to society and the common good.

Now, that we have seen what is to be done and how we may begin to achieve it, we would like to leave you with the imperative to join hands with educators and researchers as well as the youth of Singapore to pursue a brighter future for them and future Singaporeans as they meet tough challenges ahead. As more experienced Singaporeans, we have always met the challenge of competing with the world's best with some amount of confidence as it turned out that we are world class planners and structure builders. However, a large part of the challenge of the Fourth Industrial Revolution is the uncertainty, ambiguity, and intangibility of some of its demands and characteristics. We have tried to lay them out for you as clearly and as best as we could, but it will take a team effort and a commitment to be flexible yet resilient in order to transform the educational sector in Singapore into one that will flourish long into the twenty-first century.

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Part IV
The International Perspective

Chapter 16
Exemplary Career Educational Practices of Joetsu City in Japan

Takao Mimura and Darryl Takizo Yagi

Abstract The development of career education in Joetsu City, a major city in Niigata prefecture in Japan, focuses on innovations in schools. In 1999, the word "career education" first appeared in Japan as an official educational nomenclature (Gong et al., Career counseling in Asian countries: Historical development, current status, challenges and prospects. Journal of Asia Pacific Counseling, 3(1), 9–33, 2013). A policy report entitled "The Future Vision on Career Education and Vocational Education at School" redefined career education as education which encourages career development by cultivating the competencies and attitudes needed to raise the social and vocational independence of individuals (Central Council for Education, 2011). The future vision on career education and vocational education at school.). While Japan has a 100-year history in vocational/career education, it is only in the last ten years that there has been a concerted push for career education in the schools (Mimura, Bulletin of Graduate School of Teacher Education Waseda University 8:19–34, 2016). Joetsu City's career education exemplary practices show how a school system builds an educational base among stakeholders for a seamless program 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.

Keywords Career education · Workplace experience learning · Career counseling · Project-based career education study · Joetsu City Board of Education

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16.1 Introduction

Joetsu City is a major city in the west region of Niigata prefecture, located adjacent to the Japan Sea on the island of Honshu in Japan. The city was incorporated with the merger of two large cities in April 1971. As a result of the further merger over the years of 14 cities, towns, and villages, Joetsu became a city in 2005 as it exists today. Most of the towns and villages were under populated. In April 2007, Joetsu City was declared a special city due to the city becoming the most under populated area in Japan, according to the Depopulated Area Promotion Special Measures Law. According to the 2005 Census, the population was 208, 082 (Joetsu City Creation Administrative Research Center, 2006). In combination of under population and a decline in new development, Joetsu City faced an economic crisis.

To address this economic crisis, there was a call to action from Joetsu City with education, specifically in career education, as a central effort. Key city officials and educational leaders and grassroots citizens led the way. The objective among these stakeholders was to build an educational base and establish career education practices toward revitalizing the economy. A collaborative approach and cooperative effort to meet this objective is described in this chapter.

Joetsu City is also the grounds of Kasugayama castle, once inhabited by famous Sengoku era war-general Kenshin Uesugi. To this day, many Joetsu citizens believe in a term demonstrated by Kenshin. “The First Principle” is a term that appears in Zen script, referring to “The Truth of All Things” perceived by Buddha. “The First Principle” still permeates among the citizenry in Joetsu City for over 400 years. For example, there is the phrase, “Let’s link our hearts to the First Principle,” in the opening message on Education Day, which was established in Joetsu City in 2014.

As for compulsory school education in Joetsu City, there are 53 elementary schools and 23 junior high schools in 2015. And there were almost 10,000 elementary school students,including 384 special needs students and there were slightly over 5000 junior high school students, including 133 special needs students. There are a number of private and public high schools as well as vocational high schools. In Joetsu City, there are nine public high schools, including three for special needs education. In addition, there are two universities in the city—Joetsu University of Education and Niigata College of Nursing.

Japan’s Fundamental Education Law, which was the basis for post WWII democratic education in Japan, was revised in December 2006. The significance of this revision enabled the purpose and goal of education to be better aligned with the changing times. There were five goals in the second article of the Law. Goal 2 pertains to career education. It is described in the second clause of the article, as “to respect individual dignity, enhance one’s abilities, foster creativity, grow autonomy and independence, and care for the relationship between life and labor, thus nurturing a positive will to work”.

The revision to Japan’s Fundamental Education Law required the government to report its basic plans for education and for regional governments to create their own basic plan for education according to regional needs and with reference to the national education promotion basic plan. Joetsu City board of education completed its basic education plan, the "Joetsu City General Education Plan", in August 2007 (Joetsu City Board of Education, 2014). This plan was designed with a ten-year scope and sequence from 2007 to 2016. The national basic education promotion plan would be reviewed every five years.

16.2 Methods

The Joetsu City General Education Plan forms the foundation to build an education base (see Table 16.1). This plan has three components: basic concept, basic plan, and implementation plan. The basic concept and plan were formulated in 2006, and their scope and sequence were from 2007 to 2016. The basic plan would be reviewed every three years. The implementation plan was formulated in 2007, 2010, and 2013. Table 16.1 outlines the Joetsu City General Education Plan Scope and Sequence.

The basic concept in the plan cites a "zest for living to support the future". This has become a goal for the current school education curriculum. The basis for this goal is for students to adjust to the rapidly changing society by developing a strong character for life and living through career education and career education practices. The curriculum can provide actual experience where students can gain a sense of reality in their academic activities.

The basic plan was for Joetsu City to create a Career Start Week Project Executive Committee to undertake Career Start Week projects and to implement Career Start Week, as a centerpiece of career education. In the Joetsu City General Education Plan, the overarching framework was for career education to assume the role of "education to carve out the future independently" as part of "education for dreams, hope, and the future" (Joetsu City Board of Education, 2007).

Prior to 2006, Joetsu City had placed career education as a "practical priority of school education". City schools implemented career education practice. Table 16.2 shows the results of the 2006 implementation status survey. The career education

Table 16.1 "Joetsu City General Education Plan" composition and project period (Joetsu City General Education Plan, 2014)

	2006	2007	2008	2009	2010	2016
Basic concept	Planning					
Basic plan (priority projects)	Planning	Implementation				
Implementation plan		Planning	Implementation		Evaluation Planning	

Table 16.2 Career education implementation status survey in Joetsu City (22 junior high schools, 54 elementary schools)

2006	Perspective of practice	Main practice contents	Level[a]	4 (%)	3 (%)	2 (%)	1 (%)
Promotion of career education which fosters admirable views on labor/occupation and nurtures an active attitude/ability toward course choice	Preparing school systems for career education introduction and promotion	Founding an in-school organization introducing and promoting career education	Elementary	9	48	41	2
			Junior high	14	59	23	5
		Conducting in-school training for deepening understanding toward career education and propelling its practice	elementary	11	33	50	6
			Junior high	23	36	41	0
	Placing and conducting career education in the curriculum	Reviewing and focusing educational activities from a career education viewpoint	Elementary	6	44	48	2
			Junior high	18	41	36	5
	Conducting enlightening experience activities for fostering admirable views on labor/occupation	Occupation experience activities with cooperation from guardians and the region along with abundant beforehand and afterward guidance	Elementary	24	48	28	0
			Junior High	64	32	5	0

[a]Level—4: satisfactory 3: mostly satisfactory 2: some aspects are unsatisfactory 1: unsatisfactory

practice set the stage for the Joetsu City General Education Plan. From the evaluation of the survey and in conjunction with the 2007 start of the Joetsu City General Education Plan, career counselor utilization projects were initiated, career education training sessions for teachers were conducted (see Fig. 16.1), and a Joetsu City Career Education Textbook was created for each school (see Fig. 16.2).

The 2005 school year first semester focused on promotion of career education in Joetsu City. The city education center organized the career education research promotion committee, selecting committee members from three different in-city junior high school districts. The committee conducted practical research on "the cooperation of

Fig. 16.1 Training session for career counseling

Fig. 16.2 Joetsu City career education textbook

elementary and junior high schools for the promotion of career education." In the second semester, regional training sessions were held in each of the 3-research promotion committee affiliated junior high school districts. Joetsu University of Education career education researchers assisted the committee with the practical research results and provided the committee with direction and guidance for promoting career education.

The Joetsu City career education project, Challenge Shop "Rikka," was introduced in 2006, during the school year August training session. This will be discussed in detail in the Project-based Career Education Study section. The February training session was directed toward the utilization of the Joetsu City Career Education Textbook.

The creation and utilization of the textbook were through the efforts of the career education research promotion committee who conducted advanced practical research of career education curriculum development with the elementary and junior high school's cooperation. The research results were used in the creation of a textbook for the introduction and practice of career education, entitled the "Joetsu City Career Education Textbook". The textbook covers career education theory, its position in the curriculum, examples for practice, and methods of evaluation. In February 2007, the textbook was distributed to each in-city elementary and junior high school career education staff.

The 2007 school year continued with training sessions for the promotion of career education, which ranged from practical research to enhancing the teachers' practical skills in career education. Teachers from schools attended the career education open courses at Joetsu University of Education. Joetsu City and Joetsu University of Education furthered their collaboration and cooperation for career education. Between 2007 and 2013, Mr. Toshiaki Nakano, the Superintendent of the Joetsu Board of Education, laid out distinctive educational activities across the curriculum for the enrichment of special needs education and in promoting special needs students' independence and dreams for the future.

A major theme in career education in Joetsu City is to "create the future yourself", in reference to students' "education for dreams, hope, and the future". The key idea is promote project-based career education practice. The goal for career education is to increase workplace experience learning for students to view their way of life and future and enhance basic/common skills necessary for social/occupational independence. Table 16.2 sets indicators for the evaluation of career education in the schools.

In 2014 and 2015, the results of the evaluation exceeded the goals. The results of 2016 have not been determined due to the school year (April 2016–March 2017) in Japan. On April 1, 2015, all local public organizations were required to develop a General Education Council, which included the mayor and the board of education. The council provided the mayor and the board of education the opportunity to share their insights on educational issues and goals and cooperatively work together to move educational administration forward. In November 2015, the council drew up the Joetsu City Education Outline that helped determine its goals and activities (Joetsu City Board of Education, 2015).

16.2.1 Project-Based Career Education Study

16.2.1.1 Joetsu "Dream" Challenge Project

Even though career education was introduced in Japan in 1999, many Japanese do not understand and many educators, including teachers, do not grasp what career education is. Vocational guidance and career education were used interchangeably. In order to better understand career education, the Ministry of Health, Labor, and Welfare and the Ministry of Economy, Trade and Industry cooperated with the Ministry of Education, Culture, Sports, and Technology to initiate "Career Start Week," a career education practice project in which students attend five or more days of workplace experience in 2005.

In 2005, some 1000 junior high schools from 134 regions around the nation took part in the project. The project, being linked with the promotion of career education, was one of the countermeasures against youth's lack of interest toward labor and employment. Prior to 2005, most junior high schools had started their workplace experience in 2002, with one or two days of workplace experience. In cooperation with the two cooperating ministries, the Ministry of Education, Culture, Sports, and Technology led the way to emphasize the importance of workplace learning and expanded the workplace experience to five or more days.

In Joetsu City, there is a basic concept of career guidance with a clear perspective of career education for workplace learning and experience. In collaboration with community workplaces, the schools worked together to share their ideas for career education and workplace experience and to work toward effective workplace management and student learning.

As a result of the collaboration and cooperation between schools and workplaces, two junior high schools were designated as advanced workplace experience practice by the Ministry of Education, Culture, Sports, and Technology in 2006. The Joetsu City General Education Plan meeting hosted an intermediate presentation to support the Joetsu City Career Start Week practices to workplaces, parents/guardians, and citizens. The two schools conducted five days of workplace experience. A summary of the workplace experience, which demonstrated positive student workplace learning and enriched experiences, was compiled in a report (Joetsu City Office of Education, 2006).

From the positive results in the two schools, seven schools were designated for workplace experience practice in three different implementation periods from 2007. With the workplace experience for students, the Joetsu "Dream" Challenge Project expanded its goal to promote and upgrade workplace learning and experience for junior high schools.

The consensus from schools and workplaces shows that the workplace experience practice affirmed students' reassuring views on labor and occupation, students' social growth and enhanced sense of usefulness, and increased cooperation and coordination with schools, workplaces, communities, neighborhoods, and families. From this experience, there were areas of improvement, which needed to be addressed. One problem area was the confusion in the workplaces when multiple schools were having student workplace experience practice in different implementation periods. The other related problem area was the tedious paperwork in the workplaces due to a lack of standardization implementation methods in the junior high schools.

Joetsu City's junior high school principal's board convened a special meeting to address the areas of improvement. The principals discussed the need for a standardized program for junior high schools to systematize the workplace experience in different implementation periods, which included methods of implementation for supporting the workplaces, and to make the program seamless. The outcome of the

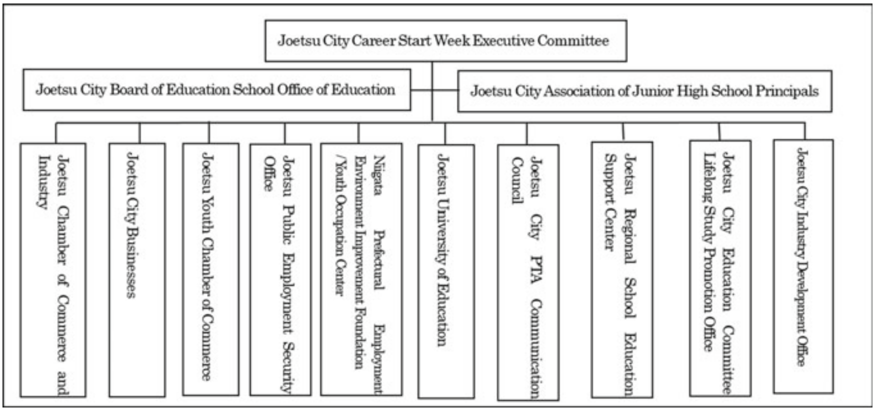

Fig. 16.3 Joetsu City Career Start Week Executive Committee

meeting prompted the Joetsu City Board of Education to start five days of workplace experience in all of the 22 city junior high schools for second year students, which heightened the Joetsu "Dream" Challenge Project.

In 2006, the Joetsu City Career Start Week Executive Committee was established (see Fig. 16.3). The executive committee collaborates and works with the Joetsu City Board of Education School Office of Education and the Joetsu City Association of junior High School Principals. The executive committee's task was to create an effective system for managing the five-day workplace experience for second year students in all of the 22 city junior high schools. The unified system would include cooperation between the schools, receiving workplaces, and administration. There were almost 2000 second year junior high school students from 22 schools, which needed 500 work experience placements for five days of work experience and learning. The goal was to have over 90% of the students realize the meaning of labor and their future.

The Joetsu City Career Start Week Executive Committee itself is a region-linked organization. The executive committee secures admitting workplaces for work experience learning while supporting schools that conduct workplace experience (see Fig. 16.4).

The executive committee sent the Joetsu City Career Start Week project report to participating workplaces in order to assist them in their role and function in the workplace with students. The executive committee made leaflets and pamphlets that were distributed to city workplaces to encourage their participation in student workplace practice and learning. The Joestu Chamber of Commerce and Industry, Niigata Prefectural Employment Environment Improvement Foundation, and the Joetsu Public Employment Securities Office sought to find interested workplaces. These organizations cooperated with the region while systemizing workplace admittance.

Joetsu City junior high schools have implemented a career education support software system, which is called School Office groupware. The groupware is a

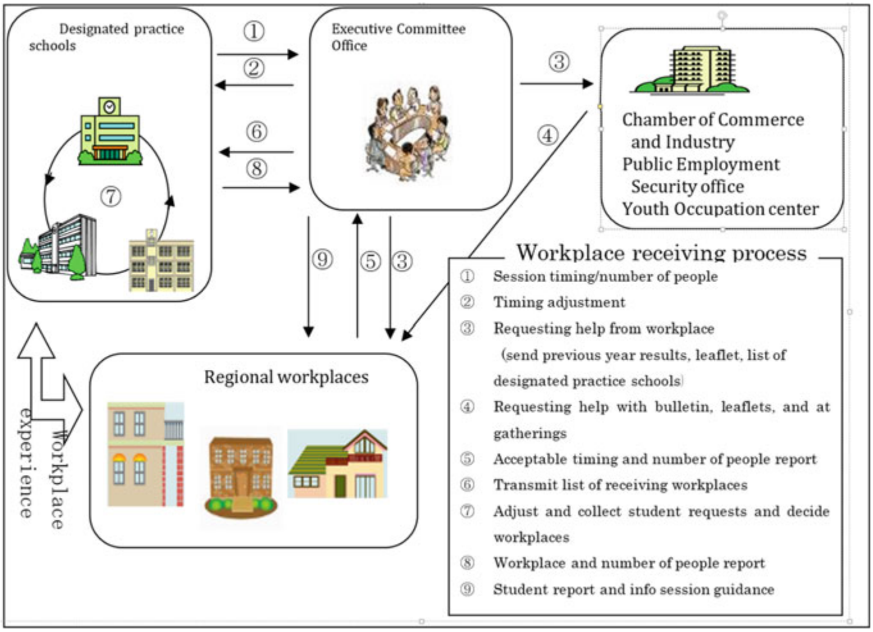

Fig. 16.4 Workplace admittance system model

sharing system that connects the designated work experience schools, the executive committee offices, and the regional workplaces. The students create an account, select workplace period for the school, and gain further information about the workplace. Once the workplace is confirmed and the work experience has started, the student enters daily work experience activities into the account. The career guidance teacher provides career guidance and assists students in work experience placement (see Fig. 16.5).

One junior high school in Joetsu City, Johoku Junior High School, is a model of career education, including work experience. Some teachers integrate career education with academic subjects. Students can observe and learn the relationship between school and work and career in their classes and in the workplace. The students engage in pre-guidance (beforehand work experience) prior to workplace experience practice. Entrepreneurs in the region are invited to give talks about labor and business manners. Students write self-introduction cards and visit workplaces prior to the workplace experience. Students build a clear sense of purpose for workplace experience. After the workplace experience practice, students engage in post-guidance (afterward work experience). Table 16.3 describes the pre-post work experience guidance. "Vocational Readiness Test" in the chapter is the assessment developed based on Theory of Career Choice (Holland, 1973).

The study of the Joetsu "Dream" Challenge Project is explored in one research sample junior high school, Joetsu City Johoku Junior High School. The action-oriented research studied the educational effects of 133 second year (8th grade)

Fig. 16.5 Work experience placement (Beauty Salon)

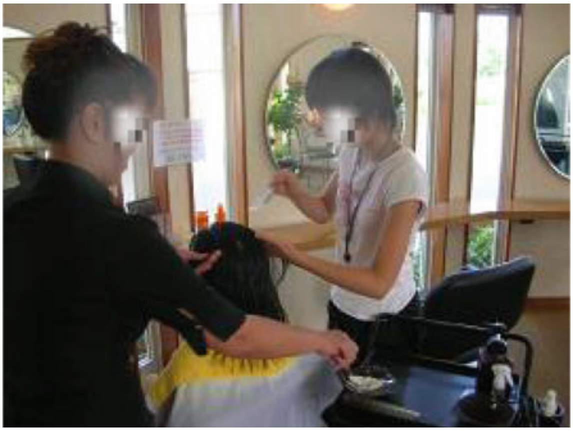

Table 16.3 Beforehand/afterward work experience guidance in Johoku Junior High School

Beforehand work experience guidance	April May June July August	• Workplace experience learning guidance • "Vocational Readiness Test" implementation and analysis • Looking at nearby occupations and the significance of working and learning • Occupation lecture "learning from working people" and "business manners" • Deciding receiving workplaces • Making self-promotion card • Preparation for pre-visit • Workplace pre-visit • Pre-workplace experience guidance • Course self-efficacy pre-experience survey
Day of event	19–25 September	• Beginning ceremony • Joetsu "Dream" Challenge (five-day workplace experience learning) • Closing ceremony
Afterward work experience guidance	September October	• Course self-efficacy post-experience survey • Writing a thank you letter • Summarizing workplace experience diary • Summarizing workplace experience • Workplace experience learning presentation session

junior high school students, boys and girls, ages 12–14, median age of 13, in a comprehensive junior high school on their five days of workplace experience in 2007.

The Career Determination Self-efficacy Scale (Mimura & Shiraishi, 2003) was used for the study. The self-efficacy scale was developed in the Japanese language and based on the studies of career decision self-efficacy (Betz et al., 1996; Taylor & Betz, 1983). The Career Determination Self-efficacy Scale assesses the degree to which the individual's readiness for career learning, flexible attitude toward career decision making, and self-career realization are made.

The Career Determination Self-efficacy Scale was administered on September 14, 2007, before the workplace experience and on September 25, 2007, after the workplace experience. The method of analysis used was a variance analysis with Java Script-Star, version 4.2.7j statistic program (Tanaka & Nakano, 2006). Table 16.4 and Fig. 16.6 describe the analysis.

"Readiness for career learning factor" ($F(1,1861) = 295.10$, $p < 0.01$).

"Flexible attitude toward career decision-making factor" ($F(1,797) = 92.89$, $p < 0.01$).

"Self-career realization factor" ($F(1,664) = 55.55$, $p < 0.01$).

Table 16.4 Factor point average and standard deviation

	Readiness for career learning		Flexible attitude toward career decision making		Self-career realization	
	pre	post	pre	post	pre	post
N	1862	1862	798	798	665	665
M	2.8710	3.1582	2.8308	3.1103	2.9053	3.1338
S.D	0.8122	0.7351	0.7916	0.7561	0.8235	0.7470

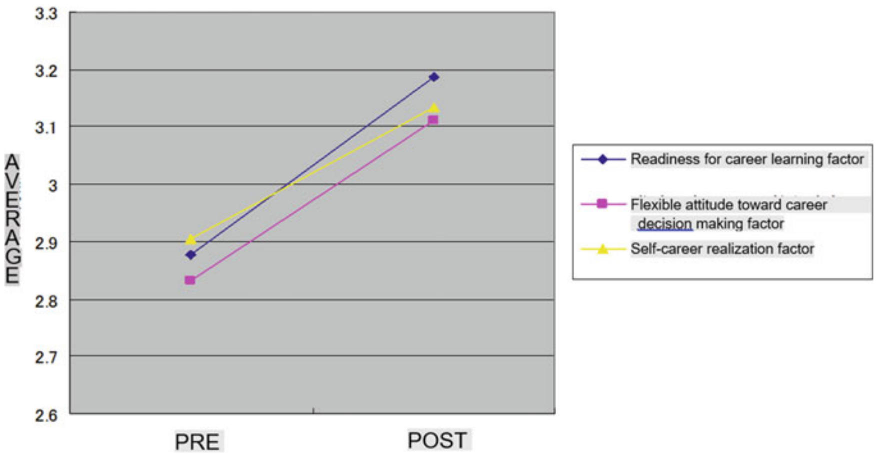

Fig. 16.6 Factor point transition

The study showed that second year Joetsu City Johoku Junior High School students demonstrated a readiness for career learning, had a flexible attitude toward career decision making, and a self-career realization from their workplace learning and experience. Anecdotal notes from students, parents/guardians, and workplace staff accentuated the findings and observations from workplace staff and customers supported the findings.

In 2016, the Joetsu City Board of Education conducted a survey at the end of the 2015 Joetsu "Dream" Challenge Project (Joetsu City Board of Education, 2016). The survey included ten years of data from the project. According to the data from 2014, 1755 second year junior high school students in Joetsu City participated in five days of workplace experience. 514 workplaces received students for workplace experience and learning. From the workplaces, the survey results indicated that more than 85% responded positively to the survey items regarding workplace experience and learning and 95% responded positively regarding student workplace experience practice.

According to the data from a national research center in 2015, among the 180 public junior high schools in Niigata prefecture, only 25 have five days or longer workplace experience, and 22 of them are located in Joetsu City (National Education Policy Research Student Guidance/Course Guidance Research Center, 2015a,b).

16.2.1.2 Challenge Shop "Rikka" Interschool Cooperative Shop Management

Challenge Shop "Rikka" is a grassroots approach to career education practice through the cooperation of schools at the elementary, junior high, and senior high school and university levels and by the schools working together for work experience in cooperative shop management.

In Niigata prefecture, Takada Commercial High School students had been examining and researching changes and revitalization of the Joetsu regional economy. In 2003, they had founded Challenge Shop "Rikka" with the hope to revitalize the neighborhood commercial strip. A Takada Commercial High School teacher, Kenichi Naito, had been conducting research in career education in the United States. From his research, he believed that career education should be community-based. He was the instrumental person that created a community-based career education practice with interschool cooperation in Joetsu City. He searched for ways to link the commercial high school's career education activities to elementary schools, junior high schools, and colleges in the region. As a result, neighboring Joetsu City Omachi Elementary School, Joetsu City Johoku Junior High School, and Joetsu University of Education agreed to cooperate with Takada Commercial High School students to develop a community-based career education practice, which began in 2006. As the community-based career education evolved, members of the neighborhood Honmachi 5-chome Commercial Strip Promotion Association and the Joetsu City Board of Education joined forces, resulting in the establishment of the Challenge Shop "Rikka" Executive Committee (see Fig. 16.7).

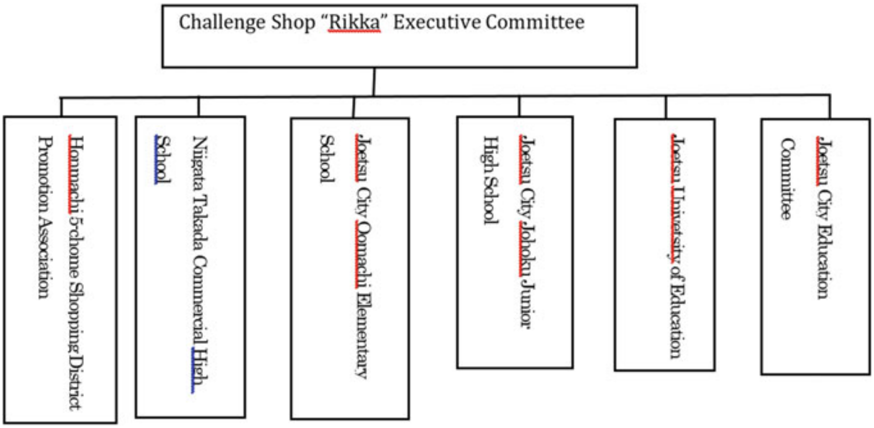

Fig. 16.7 Challenge shop "Rikka" executive committee project experience

The executive committee discussed concrete project plans and activities along with who would be in charge of them. Commercial high school students played a significant role in the discussions. The central force of the commercial high school students was the Commercial Club member. The Commercial Club is an independent organization that exists in all commercial high schools around the nation. The clubs are all connected, forming a network. The members of the Commercial Club took a leading role, explaining the goals of the project to cooperating elementary schools in May and to junior high schools in June 2006. The schools were given time to determine how they could support the project. The schools decided that their first year junior high school students and second year elementary school students would work on the project during the period of integrated study hours and socio-environmental studies, respectively. In 2006, community-based Challenge Shop "Rikka" was established under the major operation of 54 Joetsu City Oomachi Elementary School second year students, 172 Joetsu City Johoku Junior High School first year students, 12 Niigata prefecture Takada Commercial High School students, six Joetsu University of Education undergraduate students, and 12 graduate students.

The Commercial Club students that experienced the first year of Challenge Shop "Rikka" improved the project further in 2007. Challenge Shop "Rikka" continued in the 2016 school year, but the description and report for this study emphasize mainly on the 2007 project.

The interschool cooperative shop management practice is described with each school level starting with the cooperation of Joetsu City Oomachi Elementary School. The career education goal for the cooperation with the elementary school was for students to communicate with various people as a member of the Challenge Shop "Rikka" store and deepen their self-understanding through selling self-grown vegetables. From the elementary school, second year students took part in the project. Not only did they enjoy the vegetables they grew in their socio-environmental studies

Fig. 16.8 Elementary school students learning how to use a register

period by themselves and with their families, they also envisioned selling them in order to have "more people enjoy their vegetables."

On July 7 and the 14 during summer break, the elementary school students also had the opportunity to interact with the commercial high school students selling vegetables at the "Rikka" store. On the first day, students learned how the vegetables are delivered to customers. They also did some role-play as store staff and practiced greeting and answering people. On the second day, they simulated store management using actual money and registers (see Fig. 16.8).

The commercial high school boys and girls were all new to the children, and the children gradually got along with them, holding the commercial high school girls' hands and remembering their names and talking with them. On the impression sheets after the gathering, children wrote, "I hope the vegetables sell well. I have properly greeted people so the next time I'll try in a more enthusiastic voice." "I want to sell vegetables soon. I want to show the high school students my vegetables." From the commercial high school students, the elementary school students learned to think about social activities, such as selling vegetables and greeting people.

A new idea from 2007 was to attach message cards to vegetables and receive impressions and store evaluations from customers. In sale procedures, elementary school students would voluntarily talk to customers and explain their vegetables (see Fig. 16.9). They later checked the message cards to see what the people thought about their service and vegetables. Regional social activities made it possible for elementary school students to realize their internal growth changes and deepen their self-understanding.

Cooperation with Joetsu City Johoku Junior High School is described in the inter-school cooperation shop management practice with all first year students' participation, and participation was designated as a part of integrated study hours. The career education goals were comprehensive and stated that students will be able to

- succeed in shop management by cooperating in sales preparation and customer service practice with various people

Fig. 16.9 Elementary school students explaining their vegetables to customers

- come up with ideas for store decoration and promotion with various media sources
- understand the meaning and characteristics of the “Rikka” store, choose a role in which their own abilities and preferences can shine, and work hard to contribute their abilities toward the success of the “Rikka” store
- interact with workplaces and workers and think about what they can do for regional revitalization, and do it
- see the world of occupations, learn the pride of labor, and reflect upon these experiences in future plans.

A career education plan was written with activities that would meet the career education goals. A secondary educational goal was to make the transition from elementary school to the junior high school first year a smooth and meaningful one. In junior high school, students may experience adjustment problems in the first year. The career education goal, plan, and activities combat maladaptive behaviors and build a sense of common bond among the students entering junior high school from three different elementary schools.

The efforts of the commercial high school students were essential to the Joetsu City Johoku Junior High School career education plan. The visiting commercial high school students taught the junior high school students business manners along with the basic ideas behind the “Rikka” store and spent time together with them on how they could make the “Rikka” store work (see Fig. 16.10). Through the commercial high school students’ interaction with the junior high school students, the junior high school students were given the role of public relations and advertising along with store decorating during pre-opening store preparation. In order to make workplace learning feel more realistic, the junior high school students were divided into five groups: human resources/general affairs, sales, sales promotion, advertising, and store design. The students were able to choose groups freely, beyond the boundaries of their homeroom classes, and according to their preferences, which enabled them to learn enthusiastically. The students worked in their groups from May to September under the commercial high school students’ guidance to fulfill their roles.

Fig. 16.10 Junior high school students learning business manners from high school students

On the day of the opening of the "Rikka" store, ornaments and signs made by the junior high school students decorated the store. On the shelves of the store were items made by the commercial high school students (see Fig. 16.11). The store ceremoniously opened with a short play called, "Princess Rikka." The students started handing out leaflets and calling people in. While attending to the customers with light-hearted greetings and polite demeanors, the students actively placed their efforts in various areas to make the "Rikka" store a success.

After the career education practice, teachers and students reviewed the goals and discussed their achievements in meeting their goals during the integrated study period. Through the work experience practice and learning before and during the "Rikka" store cooperative shop management, students were able to accomplish their goals, as described in the interschool cooperative shop management practice and depicted in the photos. The students were able to deepen their understanding toward labor while thinking about and practicing with other students and by their own abilities and possibilities.

Fig. 16.11 Junior high school students selling items made by high school students

Niigata Prefecture Takada Commercial High School was the catalyst for the Challenge Shop "Rikka" Interschool Cooperative Shop Management, and its Commercial Club members were instrumental in working with elementary and junior high school students and with university students. The commercial high school students' goals were to apply what they had learned in their business courses, understand and work with the regional economy, and to help revitalize the regional economy. Through the interschool cooperative shop management process and workplace practice and learning experience, students had practical experience and acquired business learning through general commercial activities (i.e., accounting, product ordering, marketing, and sales); selling specialty products of the Joetsu region (i.e., production methods); selling products and original goods from regional specialized high schools and commercial high schools around the nation; selling products made by specialized schools in the Joetsu region, and revitalizing regional economy through researching and exploring for ways to make the Honmachi Commercial Strip the center of the Joetsu City economy.

The Joetsu University of Education undergraduate and graduate students cooperated with the commercial high school students and supported them by assisting with various aspects of management. The university students provided a helping hand throughout the "Rikka" store operation (see Fig. 16.12).

Challenge Shop "Rikka" gained regional television coverage and print media. Approximately 2500 customers came to the "Rikka" store and helped the revitalization of the Honmachi Commercial Strip. The Challenge Shop "Rikka" interschool cooperative shop management project has been continuing for more than ten years. Shop management by high school students has spread throughout the nation. Yet, Challenge Shop "Rikka" is unique in interschool cooperative shop management and not common in Japan. It has sustained a decade and is forever moving forward.

Fig. 16.12 Graduate students checking greetings for elementary school students

16.3 Summary

The development of career education in Joetsu City illustrates a system-wide approach toward 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. Innovations in schools in Joetsu City are demonstrated by the project-based career education study, as described in two exemplary career education practices: the Joetsu "Dream" Challenge and the Challenge Shop "Rikka" Interschool Cooperative Shop Management.

The Joetsu "Dream" Challenge Project is a collaborative region-linked five-day workplace experience learning for all second year junior high school students since 2007. The transformation of learning from the workplace practice shows that the quality of career education is meeting its goal that career education is assuming the "role of education to carve out the future for the student".

Challenge Shop "Rikka" is a grassroots community-based career education project. Challenge Shop "Rikka" is an interschool cooperative shop management with the school cooperation of an elementary school, all second year students, a junior high school, all first year students, a commercial high school, and the Joetsu University of Education since 2006. Challenge Shop "Rikka" shows how a teacher can build capacity for school leadership and develop partnerships between schools and higher education.

The project-based career education study of the Joetsu "Dream" Challenge Project and the Challenge Shop "Rikka" Interschool Cooperative Shop Management Project is not only innovative in the schools, but has sustained a decade of exemplary career education practices.

Efforts toward career education in Joetsu City for the social and occupational independence of students are exceptional on a national level in their organization and continuity. This may be the reason that there is a cultural support by the region toward the Joestu "Dream" Challenge Project and the Challenge Shop "Rikka". The fact that the two projects share the word "challenge" may just be a coincidence. However, Joetsu City citizens may have a preference toward challenges, according to "the First Principle." Such regional culture may very well be the cornerstone of the future.

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Chapter 17
The Evolution of Efforts to Improve Education in New York City (2001–2016)

Thomas Hatch, Jordan Corson, Deirdre Faughey, and Sarah van den Berg

Abstract To provide a contrast to the work on school improvement and innovation in Singapore, this chapter 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.

Keywords School reform · School improvement · Accountability · Innovation · Education policy · Small schools

17.1 Introduction

> Should schools be improving what they already do, and undertake everything in their power to make it better, and more effective? Or should they be embracing innovation in terms of new ideas, outcomes, and practices-not merely making their existing practice more effective,

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> but transforming that practice and perhaps even the nature of their institutions altogether? (Hargreaves & Shirley, 2009, p. 210)

Times change. Even in education. In the USA for example:

- What was once a largely White student population has grown much more diverse with almost 50% of the student population in 2014 composed of students of color (National Center of Education Statistics, 2014)?
- Teachers who once came almost exclusively from university-based teacher education programs now also emerge from a bevy of "alternate route" programs, including Teach For America, that often get them into classrooms after only a few weeks of preparation.
- A variety of new, often small and specialized, schools have emerged, including a whole new sector of "charter schools" that operate outside the control of many requirements and regulations.
- States have adopted new standards, new accountability measures, and new procedures for teacher and principal evaluation.

But even as things change, many things remain the same.

- An increasingly diverse group of students are still taught by teachers who, on the whole, are largely White and female (New York City Independent Budget Office, 2014).
- Most students still study the same subjects, in the same groups, with the same kinds of grades and assessments that they have had for some time.
- For the most part, school systems continue to be governed by local elected school boards, with conventional administrative structures, including a district superintendent, central office administrators, and school principals.

Both these changes and the endurance of basic school structures are particularly apparent in districts like New York City. For example, between 2000 and 2010 the population in New York City overall became more diverse with declines in the White and Black populations and increase in the Hispanic and Asian population (Center for Urban Research, 2011). At the same time, the population of teachers remained predominantly female and White (New York City Independent Budget Office, 2014). In addition, the election of Mayor Michael Bloomberg in 2001 and the subsequent appointment of Joel Klein as Chancellor of the New York City Department of Education ushered in a variety of changes. Those included the conversion of many large, comprehensive high schools into a series of smaller, often specialized high schools. In the process, between 2002 and 2008, 200 new small high schools were created. Bloomberg and Klein also designed a dramatic shift of power and autonomy from regional superintendents to schools, networks, and principals. In that shift to a decentralized system, school leaders gained control over many aspects of decision making in return for an agreement to be held accountable for results. Nonetheless, the superintendent structure dismantled during the Bloomberg era was re-established once a new mayor, Bill de Blasio, and a chancellor, Carmen Fariña, came into office in 2013. Furthermore, even as New York City made a concerted effort to encourage all teachers and schools to shift their teaching to focus on the new Common Core Standards emerging after 2010, in order to graduate, students still need to pass the Regents exams (a New York state version of an exit exam) that have been in place for years.

This same "the more things change…" debate rages over student outcomes as well. On the one hand, high school graduation outcomes in the USA have risen to 82%, the highest rate on record (National Center for Education Statistics, 2015). On the other hand, indicators also show that many of those graduates still are not ready to succeed in college. In fact, the National Assessment of Educational Progress (a national sampling test used to assess overall state and system performance) estimates that less than 40% of students are actually prepared for college (NAEP, 2013).

Outcomes for New York City students paint a particularly stark portrait of both the progress some students have made and the problems that many students continue to face. An examination of the trajectory of the "class of 2009" illustrates the endurance of this conundrum of change. By 2009, there were 16% more graduates from New York City high schools than there were in 1999 when the class of 2009 began kindergarten. Yet, of those students in the class of 2009 who failed to meet the standard for proficiency on the test in English language when they were in third grade, only 2.7% went on to meet or exceed the standard in eighth grade, and only one in three of those students who failed to demonstrate proficiency in third grade went on to graduate (Ready et al., 2013).

Given these drastically different odds and outcomes for students in New York City, the existing system needs to improve the support for those students who can see a path to success. Simultaneously, the system also needs to be reinvented to remove those predictable and systemic barriers that prevent many students from making progress. While many in education who have attempted to develop new schools and programs often describe their challenge as one of them trying to build a plane while flying it, the dual demands described here suggest that the challenge may be even more complex: We have to learn how to fly the plane while we take the whole system apart.

This chapter explores these issues by considering the evolution, possibilities, and limitations of educational innovation in New York City. To do so, the chapter examines the recent history of New York City schools as an educational ecosystem (Lee et al., 2015) and traces the development of two organizations within the city that have often been referred to as innovative and as supporting the development of more innovative schools. To develop this analysis, we reviewed articles related to the development of school improvement efforts in New York City as well as documents from the New York City Department of Education and the two organizations that are the focus of the case studies. We also conducted interviews with key members of each organization, as well as with experts on the recent history of educational policies in New York City. We drew as well on our own work and experiences with some of the small schools and the organizations supporting small schools over the past fifteen years.

First, the chapter outlines conditions and problems of school improvement and innovation within education systems. Then the chapter traces the past quarter century of major changes in the New York City school system, highlighting several notable shifts in funding, policies, and structures. The chapter then explores how the two organizations evolved in New York City, examines how they navigated these historical shifts, and considers why they evolved in particular ways. The chapter concludes with a brief commentary on how these organizations survive and operate within New York City's complex educational ecosystem.

Throughout the chapter, we concentrate 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, through our analyses, we hope 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.

17.2 The Problem: The Conditions for Improvement and Transformation Are Not the Same

The history of school improvement efforts as well as research on organizational learning suggests that improving and transforming schools and school systems at the same time are extremely difficult (Hargreaves & Shirley, 2009). At least in part, this challenge reflects a basic dilemma of organizational development: The demands and supports for increasing efficiency and improving performance of schools and other organizations in the short-term are substantially different from those needed for making and sustaining radical changes over the long term (Garud et al., 1997; Herriott et al., 1985). In education in particular, many existing structures and incentives favor efficiency and short-term improvement over long-term learning and transformation. On an individual level, this encourages teachers and students to concentrate on the development of routine skills that do not build deeper and more adaptive expertise. On an organizational level, this encourages schools and related organizations to concentrate on making existing operations and routines more efficient in order to increase performance on short-term indicators of success like annual test scores. Under these conditions, educators face the challenge that the more radical their innovations are, the more difficult it will be for those innovations to take hold and to spread throughout current education systems (Hatch, Corson, & Van den Berg, 2021). Furthermore, the most radical innovations may be dismissed out of hand as impractical or inapplicable in the current system.

Complicating matters further, schools in the USA in particular operate under constantly changing conditions. Such turbulent conditions also contribute to challenges for organizational and individual learning, because they make it difficult to predict what will happen in the future and to develop productive long-term strategies that respond to those possibilities. In turbulent conditions, organizations are also likely to focus on increasing the efficiency of their current practices and approaches rather than to invest in exploring new ideas. While such "exploitation" of conventional, successful practices can lead to incremental improvements, it can also leave the organization unprepared for the inevitable changes in a turbulent environment and discourage organizations from taking the kinds of risks that can help them to grow, expand, or just sustain their work (Leavitt & March, 1988; March, 1991).

While some of the turbulence within which educational organizations work reflects economic and cultural forces that are far beyond the control of any individual or group, some aspects of the conditions can be made more or less turbulent by the actions of funders, policymakers, and educators themselves. In particular, centralized education systems can make deliberate decisions about funding priorities and policies related to the practices, incentives, and structures of schools and schooling that can change the conditions and foster or dampen the turbulence of the educational environment. An education system like Singapore's can pursue consistent, public strategies to make it easier for schools to respond to new policies and directives and to prepare for the future. For example, the Ministry of Education in Singapore reviews and revises curricula and standards in each subject area on a regular, published schedule. Furthermore, the government shares information about major policy directions and upcoming changes to policies and regulations well before those changes are to be implemented (Lee et al., 2015). Notably, however, centralized systems can also increase turbulence by making rapid changes among a variety of different policies and demands. In decentralized systems, it may be harder for any one group or individual to control policies and expectations, and unpredictable changes may proliferate. At the same time, autonomy at the school or municipal level and a "let a thousand flowers bloom" approach can create new opportunities and allow for the emergence of new practices that are unanticipated. Many market-based approaches such as those pursued in countries like England and Sweden (see Greany, this volume) follow a similar logic, suggesting that limiting top-down regulation and fostering competition can increase these opportunities for innovation for individual organizations.

In either case, however, knowledge is central to the ability to manage and even take advantage of turbulent conditions. Understanding of historical patterns, knowledge of current realities, and early information about what other key organizations are doing and planning, and what kinds of funding and policy decisions are likely to be made can all help an organization to anticipate how conditions may change and to devise productive responses. For that reason, schools and organizations that are connected closely to policymakers and funders, and those that are privy to inside information on how policies, research, funding, and other supports for education are changing, are likely to have a distinct advantage in predicting what might happen (Hatch, 2009). Nonetheless, tracing the changing conditions in which schools and other educational institutions in New York City have operated over the past fifteen years makes clear how difficult it is to predict what might happen in the future and to develop and sustain innovative visions and practices over the long term. As a consequence, these educators and educational organizations have spent considerable time and energy responding to and reacting to changes in the surrounding environment even as they have tried to stay focused on their goals, to reflect on their progress, and to improve their effectiveness.

17.2.1 The Changing Conditions for Educational Innovation in New York City 1990–2000: The Emergence of Systemic Reform and the Small Schools Movement

While it is impossible to write a singular history of educational reform in the USA, two trends in the 1990s set the stage for many of the school improvement efforts pursued in New York City after the turn of the twenty-first century. Those two trends included the development of systemic reform and standards-based reform efforts (O'Day & Smith, 1993) and the growth of the "small schools" movement (Meier, 2002). In many ways, both reflected the emerging belief that "piecemeal" reform was insufficient—focusing on making improvements in one aspect of schooling at a time such as curriculum, or professional development, or school organization, or parent and community involvement was not enough. Instead, advocates of systemic and standards-based reform argued that new higher learning standards needed to be established for all students and then changes needed to be made in all the key aspects of schooling so that curriculum, teacher preparation and professional development, and assessment in particular were all aligned with those new standards. Central to that argument was a belief that this kind of standards-based and coherent approach to schooling was a key element of the success of many higher-performing educational systems and a critical means of enabling students in the USA to reach "world class" standards. This work was evident as virtually every state adopted new standards by the year 2000 and by the emergence of a number of efforts to make districts central players in coordinating changes in curriculum, instruction, professional development and assessment across their schools.

In New York City, efforts to create more comprehensive and coherent district-based approaches were also in evidence. In fact, New York City began in the 1990s with a collection of elected local boards in charge of thirty-two different districts, an appointed Board of Education that appointed a chancellor to oversee central operations. But by the mid-1990s, several efforts were underway to create stronger districts that promoted more comprehensive and district-wide reform efforts. In particular, a "Chancellor's District" was created by Chancellor Rudy Crew in 1995 to prompt improvements in many of New York City's worst-performing schools. In addition, from the late 1980s through most of the 1990s, Anthony Alvarado and colleagues in Manhattan's District 2 pioneered district-wide approaches to improving literacy and then math instruction. Both the Chancellor's District and the work in Community School District #2 served as models for district-based reform efforts that spread across the country at the end of the 1990s (McDonald et al., 2014).

Even as efforts to create more centralized and comprehensive reforms emerged at the district level, however, a number of school-based reform efforts also grew. Like systemic reformers, advocates for focusing improvement efforts at the school level also believed that changing one aspect of a school at a time was likely to fail, but they felt that principals and teachers in schools were in the best position to develop the new ideas and practices that could help all students succeed. As a consequence, terms like "whole-school" reform and "comprehensive reform" became the mantra, as numerous individuals and organizations began to develop and implement new models for schooling in many sites across the country throughout the 1990s.

Those beliefs were in evidence as early as the 1980s in New York City, where several of the most prominent leaders of the small school movement, like Debbie Meier and colleagues, were at work. In the 1990s, these beliefs were evident in the Annenberg Challenge which offered funding for the development of new small schools in cities like New York, Chicago, and Los Angeles; they were evident in the development of new organizations like Success for All, Expeditionary Learning Outward Bound, and the Coalition of Essential Schools that sought to develop new schools and create networks of new schools (Hatch, 2003); they were evident in the passage of the Comprehensive School Reform Demonstration Program, which allocated funds for schools to work with organizations like Success for All and others to "turnaround" or transform all aspects of their operations; and they were evident in the emergence in 1991 (first in Minnesota) of legislation allowing the creation of "charter" schools that could work outside many district regulations with the expectation that they would develop new and innovative models for schooling that might influence schools in the "conventional" system. Ultimately, this belief was reflected in the decision of the newly established Gates Foundation to support the development of new small schools and small schools networks in New York City and across the country (Bill & Melinda Gates Foundation, 2003).

17.2.2 2001: Accountability Arrives

Even as efforts to promote district-wide reforms and to create and replicate new small schools began to spread, at the national level the passage of the No Child Left Behind (NCLB) Act in 2001 made increasing accountability another central driver of school improvement at the turn of the twenty-first century. At least in part, the demand to increase accountability reflected the continuing frustration with relatively low educational performance in comparison with other countries: no dramatic increases in students' performance on NAEP (the sampling test referred to as "the nation's report card") and persistent gaps in performance between Black and Hispanic students and lower-income students and their White and Asian and their higher-income peers.

This frustration with what some perceived as the failure of systemic reforms of the 1990s contributed to the belief that beyond creating more coherent and comprehensive approaches, individuals and schools needed to be held accountable for their performance. In this approach, the emphasis was placed on getting the "incentives" right, rather than on building the capacity for reaching higher standards. For example, NCLB put in place specific requirements for annual tests of students in grades 3–8 in

English and math and to establish sanctions for schools that did not show acceptable levels of growth. Notably, in the process, NCLB shifted the focus from ensuring that all students could reach “world class” standards in many subjects, to requiring that students in all schools achieve “average yearly progress” in reading and math and to achieving proficiency in those subjects by 2014.

In short, at the turn of the century in New York City, new small schools were increasing, pressure for more systemic and comprehensive improvement efforts were continuing, and new mechanisms for holding schools accountable were growing. Each of those efforts was designed to spur improvements, and in many ways, they reflected an amalgam of the beliefs of the small schools movement and the systemic reform movement: changes need to be made in all aspects of schooling and educators and schools are most likely to make innovative changes if they have autonomy. At the same time, the changes in policies at the turn of the century also suggested that the role of the system should shift from driving curriculum, instruction, and preparation in a particular direction to creating incentives for and holding individuals and schools accountable for making the changes necessary to increase performance.

17.3 The Evolution of Educational Innovation in New York City in the Twenty-First Century

As Bloomberg took office in New York City, a growing number of new small schools were striving to develop a wide range of approaches to many different aspects of school operations. Among those efforts, several organizations including New Visions for Public Schools and New York City Outward Bound Schools were beginning to launch and nurture new schools. Although New Visions was founded in 1989 on the belief that public/private partnerships could help improve the dropout rate in New York City schools, by 1993 they had received a $25 million grant from the Annenberg Foundation to create 14 new small schools in New York City. By the turn of the century, New Visions had helped to launch 34 small elementary, middle, and high schools. These schools reflected a variety of different educational philosophies but shared a commitment to the idea that a personalized education in small schools built on school/community partnerships could produce more effective educational experiences.

NYC Outward Bound began by bringing to existing New York City schools an approach to outdoor and experiential learning established in 1941 in Wales by a related organization, Outward Bound, which came to the USA in the 1960s. That approach was designed to foster participants’ growth through explorations of nature and tests of physical and mental strength. This early iteration of NYC Outward Bound conducted learning programs for New York City residents, particularly focusing on youth. The organization also partnered with five public schools to develop curriculum and co-create academic classes during the school day that could be restructured to reflect the Outward Bound approach. In the early 1990s, however, in conjunction with the National (US) Outward Bound organization and with support from a major new funder at the time—the New American Schools Development Corporation—NYC Outward Bound also launched a new small school built around the Outward Bound experiential education philosophy. While NYC Outward Bound focused initially on the development of that one school, it began in the twenty-first century poised to expand and replicate their alternative educational approach.

These organizations began in the twenty-first century as pioneers in multiple ways. Their schools reflected a variety of unconventional approaches to teaching and learning, with NYC Outward Bound Schools, in particular, emphasizing experiential, transferable, and "hands-on" student-centered instruction. The New Visions schools reflected a variety of instructional approaches (often focused around a particular theme such as the arts or technology), but perhaps more importantly, their schools served as models of emerging beliefs about the organization and structures of schools including that schools should be:

- Small in size and organized to support close personal relationships between students and teachers,
- Developed and run in partnership with community organizations,
- Designed and led based on organizational principles drawn from research on effective schools.

Since that time, these two organizations have worked to stay true to their original visions while both dealing with and taking advantage of the turbulence of the New York City educational environment. Among other things, these organizations have had to contend with significant reorganizations of the public school system in New York City in 2004 and 2013 and significant changes in policies and regulations at the federal, state, and local level as new approaches to teacher evaluation and the Common Core began to talk hold after 2010.

17.3.1 The Evolution of New Visions for Public Schools

In 2001, New Visions began a new chapter fueled both by the interest of major funders in small schools and Mayor Bloomberg's election and efforts to transform the way New York City schools were organized. In fact, reflecting the success that New Visions and others had had in opening and operating new small schools in New York City, the New York City Department of Education under new Chancellor Joel Klein developed a major initiative to replace large, failing, high schools in New York City with a whole new cadre of small public high schools. With the support of the Bill & Melinda Gates Foundation, the Carnegie Corporation, and the Open Society Institute, New Visions launched a whole new chapter of its work by developing and leading a new school design process that brought together dozens of teams consisting of educators and external partners to propose designs for new small high schools that would meet New York City's demand. As a report on this "New Century High Schools" initiative explained:

The New Century High Schools model fosters “disciplined innovation” to meet student needs, a shared commitment by schools, partners, and New Visions to:

- High expectations for student performance including a key performance goal of 80 percent graduation and 92 percent attendance rates
- Ten principles of effective schools—clear focus and high expectations; rigorous instruction; personalize learning environment; instructional leadership; school-based professional development; meaningful assessment; partnerships; parent/caregiver engagement; student voice and participation; and integration of technology.
- Continual improvement through ongoing, timely collection, analysis, and use of data
- Peer-to-peer learning and knowledge sharing that facilitates inquiry, self-assessment, and accountability among New Century High School Initiative (NCHSI) leaders, faculty, and community partners (New Visions for Public Schools, 2007 p. 2)

Notably, for New Visions and the New Century Initiative, the emphasis was on the “disciplined” approach and effective management and organization not on one particular approach to teaching and learning.

The New Century Initiative began with the launch of 14 schools in 2002, but quickly expanded as New Visions opened 83 small high schools by 2006. Building on some promising early results, the New York City Department of Education made its own commitment to replace large, failing high schools with small schools like those of the New Century Initiative. In fact, by 2006, New York City had added another 100 small high schools with 13 other “intermediary” organizations, like New Visions, helping to launch those schools.

The focus of New Visions’ work was also consistent with the growing emphasis on effective management, attention to data, and continuous improvement by the Bloomberg administration and funders like the Gates Foundation. As veteran reformer and researchers studying the development of the small schools movement described it, after Bloomberg took office, the NYC Department of Education “filled up with people from such fields as investment banking, law, corporate accounting, and management consulting, all eager to play out an encouraging belief about what business can teach education” (McDonald et. al., 2014, p. 47).

New Visions was also able to take advantage of the efforts of Mayor Bloomberg and his colleagues to dismantle the conventional, bureaucratic administrative structure of the New York City public schools and replace it with a whole new model of governance. That work began when Bloomberg successfully lobbied the New York state legislature to give him “mayoral control” (building on a similar initiative in Chicago) over New York City public schools. One of the Bloomberg administration’s first moves was to replace the 32 community school districts with ten instructional regions. Although the New York City Department of Education first experimented with the implementation of a citywide language and math curriculum across all ten regions, Bloomberg and newly appointed Chancellor Joel Klein quickly shifted to instituting a radically decentralized model of school governance. That model was designed to replace what the Bloomberg and Klein administration saw as an inefficient and overly centralized school bureaucracy by releasing schools from direct oversight by area superintendents. To that end, in 2005 they created an "autonomy zone" in which local schools and principals gained decision-making power over many aspects of their curriculum, professional development, and school operations in return for an agreement to be held accountable for improvements in student performance. The following year, that "autonomy zone" was expanded as the primary mode of governance for public schools in New York City. As an early report on the work of the New Century Initiative put it, these central strategies of what Bloomberg and Klein dubbed "Children First" "established the environment for small high schools to take root. It positioned high school transformation as a priority and regarded the New Century High Schools Initiative as a flagship school improvement strategy, with the initiative's partners [like New Visions] emerging as leaders." (New Visions for Public Schools, 2007 p. 5).

The development of this decentralized approach included the creation of a competitive environment in which School Support Organizations tried to attract schools that would pay for services previously provided or determined by the New York City Department of Education. At least in part, the blueprint for these School Support Organizations was based on New Visions' success as an "intermediary organization" helping to incubate new schools. At the same time, the establishment of this new educational marketplace for intermediary organizations gave New Visions the opportunity to pursue a new revenue stream. Rather than having to rely entirely on funding from private philanthropy to support its work incubating new schools, New Visions could now become a "network provider," under contract with the New York City Department of Education, to market its services directly to both new and existing schools.

This new opportunity, however, also meant a change in New Visions basic approach. Instead of working with a group of small schools that shared a commitment to a set of principles of organization and management, New Visions took on the task of working with schools of conventional sizes and structures. As a result, New Visions expanded to work with both large and small schools, as well as transfer schools (schools designed to re-engage students who have dropped out or who have fallen behind in credits) and grade 6–12 schools. Although perhaps unanticipated at the time, New Visions' subsequent experience as a network leader and a School Support Organization gave it an opportunity to learn how to manage schools of all kinds, not just launch small schools. As Mark Dunetz, New Visions' current President, described the work at the time, it was a "laboratory for doing deep work on the day-to-day of everything happening in schools."

In some ways, this experience in supporting both new and existing schools set up New Visions for the next major re-organization of New York City Public schools that took place in 2015. Following the election of a new mayor in 2013, Mayor DeBlasio, Carmen Fariña was appointed the new education chancellor for New York City schools. Fariña, a veteran New York City educator who left the Department of Education relatively early in the Bloomberg/Klein administration ushered in changes to the organizational structure of the system that included re-establishing the role of local superintendent and eliminating the competitive marketplace for School Support Organizations. However, because New Visions, along with a few other organizations, was regarded as an effective network provider, it was allowed to retain its network of schools. As a result, New Visions has continued to work with a select group of schools; however, the support is no longer provided in a marketplace environment. Schools can opt to be members of the New Visions Network for a three-year period. As Dunetz put it, in this new environment New Visions can play out a set of strategies and focus more on developing innovative approaches for their schools and spend less time competing with other network providers.

New Visions has taken advantage of this environment to expand its work to develop new programs and resources that address many of the core functions of schooling. While they continue to maintain a network of 70 public schools and seven charter schools, New Visions' expanded work includes urban teacher preparation "residency" programs for teachers in public schools and in charter schools; a two-year master's program for school and district leaders; and coaching for assistant principals. New Visions expanded work also includes the development of a host of resources such as a curriculum for core high school courses, support for the design and implementation of intensive literacy instruction, and protocols and tools to improve administrative planning. All of this work directly benefits their own schools, but it has also positioned New Visions to support many other teachers, school leaders, and schools in New York City and beyond.

While there was always an explicit expectation that New Visions would work on a set of strategies that would in theory have value for the larger system, in some ways they are also back in a place where they can serve as an innovation laboratory and incubator. But in this case, the focus is more on the development of new tools and practices that address some of the key problems that their schools and others face, rather than on developing new, comprehensive, and models of schooling. For example, New York City has a complicated set of graduation requirements that makes it very difficult for schools to keep track of which students are making progress at an appropriate rate. Staff at New Visions, like Dunetz and others, were able to look across their network and see that this was a common problem that all of their principals and schools had to address on their own. Consequently, New Visions has worked with their schools to develop a scheduling tool that makes it possible to see whether students are enrolled in the appropriate classes and are gaining the credits that they need to be on track for graduation. Furthermore, after piloting and refining this scheduling tool along with structured protocols to guide its use, New Visions can now share that tool widely with schools beyond their own network. In the process, New Visions has overturned the conventional process in which schools and support organizations have had to rely on outside vendors to solve many of their technological problems. As Dunetz described the issues and their current approach:

> We came to appreciate the critical role technology can play in enabling transformative work at scale when it is designed with the educators in classrooms, schools and districts who are the ones enacting the change. The functionality of the tools available to those leading schools is often itself an independent factor determining the effectiveness of any efforts to improve schools—something we as a profession have been late to acknowledge. Our tools

> are designed in integrated ways within the initiatives they are intended to support, with a deep understanding of the environment in which they will live and the specific types of teacher and school leader behavior we believe will lead to better outcomes for students.

To carry out this crucial technical work, New Visions quickly grew to have over twenty staff members working on data analytics and designing systems and structures that can be used by their schools and others.

In short, New Visions has expanded from starting small schools, to incubating small schools, to leading a network of schools. Now, it serves as an example of a new kind of educational organization that goes beyond school design and school support to develop tools and practices that meet the day-to-day needs of teachers and principals in schools of all kinds.

17.3.2 NYC Outward Bound Schools

NYC Outward Bound Schools emerged in New York City in the late 1980s with support from the Fund for the city of New York, an agency tasked with supporting nonprofit organizations. With a staff of a dozen people, this initial version of the organization focused on two educational endeavors. First, NYC Outward Bound ran outdoor and experiential learning programs throughout New York City. In this work, they particularly emphasized pairing youth from New York City public schools with adults, business and civic leaders. In addition to the direct benefits from experiential and field-based learning, NYC Outward Bound CEO Richard Stopol suggested that these pairings allowed many influential New Yorkers to see the benefits of an NYC Outward Bound education for youth.

Second, NYC Outward Bound partnered with existing public schools in the city. Through these partnerships, NYC Outward Bound created programming intended to address issues such as racial tension or low attendance rates within a school. Working with teachers and administrators, members of NYC Outward Bound's small team also offered professional development programs and helped develop curriculum that reflected the Outward Bound philosophy. Specific parts of the school day became devoted to teaching that was greatly influenced by an Outward Bound approach. For instance, students might go on an Outward Bound urban expedition, and then in social studies class they might work on a series of assignments related to the expedition. With a number of early successes, Stopol recalls a recurring question from students at the time: "why can't the rest of my day be like Outward Bound class?".

While NYC Outward Bound Schools worked in schools almost from its inception, the organization did not expand to operating schools until the 1990s. Receiving funding from the New American Schools Development Corporation (NASDC), an initiative that sought to create schools that would "break the mold" of traditional schooling (Hatch, 2000), the national Outward Bound organization created Expeditionary Learning (now known as EL Education), a model for schools that reflected the Outward Bound mentality philosophy and approach to experiential education.

Several schools opened in New York City, and it was quickly determined that EL schools in New York City would be operated by NYC Outward Bound Schools.

NYC Outward Bound continued operating a limited number of EL schools until Michael Bloomberg was elected mayor in the early 2000s. With the structural shift toward schools and networks, NYC Outward Bound found an opportunity to expand. Like New Visions, NYC Outward Bound also benefitted from the support for small schools offered by funders like the Gates Foundation and by the initiatives of the New York City Department of Education. In fact, with Gates funding, NYC Outward Bound expanded (to 11 schools) in New York City, beginning in 2004, just as the New York City Department of Education began experimenting with the autonomy zone.

While the increased autonomy provided some flexibility for NYC Outward Bound and its small group of schools to pursue their alternative instructional approach, the demands for accountability also created challenges. In particular, as part of the "autonomy for accountability" trade-off, the NYC Department of Education established school report cards that gave schools grades based largely on how their students performed on annual standardized tests. For the most part, the demands of these conventional standardized tests were inconsistent with NYC Outward Bound Schools' focus on engaging students in projects, requiring problem-solving, and higher-order thinking. Perhaps not surprisingly, under these conditions, NYC Outward Bound focused on deepening their approach and developing a successful model in these ten schools over the next ten years. For support, the schools relied largely on NYC Outward Bound, relatively unencumbered by their relationship with the School Support Organizations designated by the NYC Department of Education.

When the Bloomberg administration created the new school and network-centered structure, NYC Outward Bound purposefully resisted a larger expansion. Between 2004 and 2013, NYC Outward Bound spent their time nurturing and sustaining their experiential and student-centered educational approach in a small number of schools, rather than on building a large network of schools.

De Blasio's mayoral election in 2013 and the subsequent shift in the organization of New York City schools, however, also created new opportunities for NYC Outward Bound. In New York City Outward Bound's case, however, the shift back to a superintendent structure could have meant having to give up some of their autonomy and the control of their instructional and organizational approach. To deal with this concern, the NYC Outward Bound Schools joined together with a group of schools that shared their belief in student-centered learning and that all used alternative assessment approaches that often conflicted with the demands of conventional standardized tests. This group then was able to advocate for the establishment of an "affinity group" (one of six established at the time) that brought these like-minded schools under the aegis of a single superintendent (in this case one already familiar with the work of these "alternative" schools). The hope was that organizing these schools under a single superintendent would allow that leader to gain a deeper understanding of the needs of these schools and the kind of support required. As a consequence, despite the dramatic shift in New York City schooling, NYC Outward Bound Schools continued operating with relative autonomy.

Although NYC Outward Bound focused on developing and sustaining their alternative approach in eleven schools, they have still looked for opportunities to expand their influence. While they eschewed the opportunity to open more schools, like New Visions, as the New York City DOE's emphasis on opening new schools has waned, NYC Outward Bound has begun to take advantage of the demand that has built up from existing schools for support and services of all kinds. Thus, in 2014, NYC Outward Bound began establishing relationships with what they call "associate schools." In the process, Outward Bound has begun "unbundling" different aspects of their approach (or what one NYC Outward Bound staffer calls "pulling the strands apart") so that the associate schools could use particular resources, enlist some professional development services, or take advantage of technical support to implement particular aspects of the model rather than to pursue comprehensive and wholesale school transformations. For example, associate schools might look at making their curriculum more aligned with the expeditionary approach. They also might want to revise their advisory model. Over time, however, the hope is that some of these "associates" might become full-fledged NYC Outward Bound Schools. While work with associate schools is in early stages and ongoing, NYC Outward Bound see it as a means of scaffolding the development of these schools and helping them grow toward the whole-school model.

Still early in the process, ten schools have become "associates" as of 2016. With both the network and associate schools, however, NYC Outward Bound is also developing services and programs that would support their own schools, but that could be shared with others as well. These include college preparation and mentoring programs (called "to and through" programs) to help increase its students' college admissions and completion. Another initiative involves school visits, in which network schools host leaders from other schools on a rotating monthly basis. As Former NYC Outward Bound Chief Schools Officer Anthony Conelli describes it, a driving force behind this work is a central question: "how do you create a context that allows people to share their practice, own their conversation, and how do you improve this kind of work?" From this perspective, NYC Outward Bounds goals moving forward include creating the "innovative atmosphere" that allows both new and existing schools to develop the key practices and structures that will enable them to sustain their commitment to their instructional approach.

17.4 Discussion and Implications

Times have changed in New York City, both in terms of the demands and supports for school improvement in general and for New Visions and for NYC Outward Bound. In particular, New York City has moved toward centralization, toward decentralization, and back toward centralization again. While both New Visions and NYC Outward Bound remain focused on some of the same ideas about improving student learning that helped to launch their new schools work in the 1990s, both organizations have changed as well. Both organizations began with an embrace of the comprehensive, whole-school reform movement taking hold in the 1990s, but their evolution since then suggests that both also may be "unbundling" these whole-school reform efforts to offer specific services and resources to conventional schools. In the process, there may be a shift or expansion from a theory of action that suggests that replicating new school models will eventually lead to system transformation to a theory of action that suggests that the way to influence the system is to develop tools, technologies, and strategies that can be spread through existing schools.

Notably, while these organizations have piloted, tested, and refined their ideas over time, their evolution reflects more than a cycle of implementation, feedback, and revision. Their experiences demonstrate how much their evolution is affected by the turbulent environment in which they are situated. In such a situation, organizations like these have to invest considerable time and effort in trying to manage the external environment (Hatch, 2009). They have had to figure out when to adapt to and take advantage of new policies; and they have had to determine when to avoid new policies and demands and when to create a "buffer" (Honig & Hatch, 2004) that protects their innovative efforts.

Throughout, they have had to seize opportunities they could not have planned for from the beginning. For example, at the turn of the century, New Visions was "ready" to help launch the high school transformation work pursued by the New York City Department of Education because New Visions' own efforts creating new small high schools helped inspire and shape that policy. Similarly, when the New York City DOE moved away from most of the networks after de Blasio and Farina took office, NYC Outward Bound was in a position to offer professional development and other services to schools that networks had previously provided. Crucially, however, these organizations managed these transitions in ways that have allowed them to gain new sources of revenue without getting overwhelmed by the capacity problems that so many organizations succumb to when they try to expand (Fullan, 2003; Hargreaves & Fink, 2004).

In other words, the evolution of these organizations suggests that the educational "ecosystem" is not a simple set of concentric circles. This ecosystem is more like a swamp of interacting sectors—economic, political, and educational—and the groups and organizations that make up those sectors. As a consequence, these groups and organizations cannot count on conditions remaining the same. They need to treat the turbulence of the environment and the unpredictability of the opportunities that may emerge as a given rather than hoping against hope that the environment will remain stable. Under these circumstances, systematic planning and sustained investment in the most innovative ideas remain subject to short-term shifts in policies, funding, and district organization and the changing requirements and expectations that come with them. That means that even as organizations like New Visions and NYC Outward Bound strive to create new kinds of schools and learning opportunities, they also have to find some ways to "fit" into the conventional system without abandoning key aspects of their missions and organizational identity.

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Chapter 18
Doing Things Differently in Order to Do Them Better: An Assessment of the Factors that Influence Innovation in Schools and School Systems

Toby Greany

Abstract This chapter explores the systemic factors that help and/or hinder change and innovation across school systems, with a focus on evidence and examples from England. It sets out an innovation framework, adapted from (Leadbeater, C. and Wong, A., Learning from the Extremes, Cisco, San Jose, CA, 2010), as a means of comparing examples of innovation and to analyse the factors that influence them. It finds that i) innovation is risky and demanding for schools, ii) school autonomy policies can support isolated examples of innovation, but will not lead to systemic change, and iii) system-wide change requires sustained capacity building within a values-based framework that allows for local agency and adaptation. These findings contradict the OECD's (2015a, b) view that top-down policy is 'impotent' to effect change and also challenges arguments that innovation requires school autonomy coupled with clear vertical accountability and minimal central co-ordination. The chapter concludes by reflecting on how best to balance structure and agency, so that innovation is encouraged and learning is spread. This requires a sophisticated set of capabilities from those overseeing public education systems: stretching traditional conceptions of public sector governance to include systems for vertical and lateral knowledge sharing and mechanisms which continuously engage teachers, parents and other stakeholder groups in processes of systemic innovation and change.

Keywords Educational innovation · School system reform · School leadership and change · School autonomy and accountability

18.1 Introduction

This chapter 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

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and explore these issues. It also sets out an innovation framework, adapted from Leadbeater and Wong's (2010) 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. This includes his experience as a former Senior Civil Servant based at England's National College for School Leadership, where he was responsible for the development and implementation of new policies that sought to generate and support innovative evidence-informed practices in schools.

A number of authors (Caldwell & Spinks, 2013; Hallgarten et al., 2015; Hargreaves, 2003; Leadbeater & Wong, 2010) have argued that schools and school systems need to become more innovative and adaptive if they are to meet the needs of twenty-first century societies and economies. Hallgarten et al. (2015: 22) state that, despite decades of reform in education, real change has been constrained by an unquestioning acceptance of narrowly defined criteria for success, as measured through tests and examinations:

> The structures that dictate the systems, processes and intended outcomes of the formal schooling system remain remarkably resilient. In the domain of organized tax-funded education, systems of schooling are for the most part in improvement mode: that is they take for granted the implicit parameters and metrics which maintain the industrial model of schooling.

In their view, this focus on 'improvement' has led to a crisis of legitimacy, resulting in issues such as learner dissatisfaction, disengagement and stress, growing costs, frustrated teachers, challenges with equity, and a mismatch with societies' real needs. The issue of legitimacy in relation to innovation, as well as improvement, is returned to in the conclusion of this chapter.

Hallgarten et al.'s assessment raises a fundamental question about whether and how school systems that have been premised on 'improvement' can move to become more responsive to the ever-changing needs of societies and economies? This chapter seeks to contribute towards a better understanding of this question. It adopts the definition of innovation used in the title—'doing things differently in order to do them better'—a definition which is consciously broad; which emphasises the need to evaluate changes in order to understand whether they are genuinely 'better'; and which implicitly suggests a definition for 'improvement' along the lines of 'doing the same thing harder and/or faster'.

The focus of the chapter is primarily on the conditions required for successful innovation across school systems, rather than within single schools. This is not to suggest that intra-institutional change and innovation are not relevant, simply that they have already been studied extensively from both organisational and leadership perspectives (Day et al. 2011; Hall & Hord, 2001; Kotter, 1996; Leithwood et al. 2006; Matthews et al. 2014; Ofsted, 2009a, b; Schein, 2010). A recent development in this area has been the study of evidence-informed practice, where the importance of trust and informal processes of influence between teachers have been highlighted as significant (Brown, 2015).

Over the past thirty years, quasi-market models premised on school autonomy, parental choice and competition between providers have been seen by policy makers around the world as the best way to secure flexible and innovative school systems (OECD, 2015b), but the evidence that such models are actually effective in fostering innovation remains thin (Glatter et al., 1997; Lubienski, 2009; Waslander et al., 2010). Partly in recognition of the flaws in classic quasi-market thinking, research and thinking on system change and innovation have developed rapidly in recent years. Michael Fullan (2002) argued that individual school leaders could and should consider their influence on other schools and the wider system as part of their moral purpose. In a similar vein, David Hargreaves (2003) argued that systemic transformation requires a move away from top-down imposition and the development of disciplined innovation networks. Recent work on innovation (Hallgarten et al., 2015; Suggett, 2015) suggests that traditional conceptualisations of top-down versus bottom-up change are largely inappropriate. Similarly, the OECD argues that traditional notions of top-down policy implementation are 'increasingly inadequate' because policy is 'notoriously impotent to change behaviour in teaching and learning' (2015a: 17). Instead we need to understand change and innovation as orchestrated through complex combinations of vertical and lateral knowledge mobilisation.

These ideas are now being explored from a number of angles, including: policy development, implementation science, regulation and governance (Mourshed et al., 2010; Sahlberg, 2011; Greany, 2014, 2015a, b, c; Barber, 2015; Ainscow, 2015; Burns and Koster, 2016); networks, partnerships, system leadership, school-to-school support and peer evaluation (Hargreaves, 2012; Kamp, 2013; Suggett, 2015; Greany, 2015d; Matthews & Headon, 2015; Muijs, 2015); and knowledge mobilisation (Bryk & Schneider, 2002; Daly, 2010; Greany, 2015c). Other research has looked at specific aspects of innovation, such as in the curriculum (Cheng & Greany, 2016; Kärkkäinen, 2012).

The chapter is structured in seven sections following this introduction. The first provides key definitions and frames the issues. The next two sections look separately at quasi-markets and the high-autonomy-high-accountability model. These models operate in tandem in England, but they are outlined separately as they have different intellectual antecedents and practical implications for innovation policy. The fourth section summarises recent developments in England's 'self-improving school-led system' since 2010. The fifth section introduces the five examples of innovation in the areas of pedagogy, curriculum and school improvement. The sixth section categorises and analyses the five examples using an adapted version of Leadbeater and Wong's innovation framework (2010) in order to allow for a comparison of the factors that have influenced their implementation. The final section discusses the implications of the examples in the context of wider thinking and research on innovation policy across school systems and sets out a series of conclusions.

Overall, the chapter highlights a number of implications and conclusions on the systemic factors that help and/or hinder change and innovation across school systems based on its cross-case analysis of the examples from England using the adapted innovation framework. Firstly, policymakers need to understand that innovation is risky and demanding for teachers and school leaders and need to find ways to mitigate these risks. Secondly, increasing school autonomy on its own might lead to isolated examples of innovation, but will not lead to systemic change without implementation support and capacity building. Thirdly, system-wide change and innovation is possible, but requires strong and sustained political support and capacity building within a values-based framework that allows for local agency and adaptation.

These findings provide an important challenge to those who argue that quasi-markets could still secure innovation, if only market incentives could be increased by extending school autonomy and reducing central co-ordination yet further. Rather, the findings suggest that we need a more nuanced definition of autonomy; one that distinguishes between 'structural' and 'professional' autonomy, with an emphasis on building professional autonomy. We also need a more nuanced understanding of accountability, since this can be central to improvement efforts, but can limit the scope for innovation in the eyes of practitioners and can narrow the perception of school quality (and therefore attitudes to innovation) among parents. All this suggests that the key challenge is around how to balance central control and local agency, so that innovation is encouraged and learning is spread. This requires a sophisticated set of capabilities from those overseeing public education systems: stretching traditional conceptions of public sector governance to include systems for vertical and lateral knowledge sharing and mechanisms which continuously engage teachers, parents and other stakeholder groups in the process of systemic innovation.

18.1.1 Quasi-Markets and Innovation

As Lubienski (2009) describes in detail, the economists such as Milton Friedman and Julian Le Grand who originally proposed quasi-markets in education saw choice and competition between schools as critical for driving enhanced innovation and quality. Similarly, the politicians championing autonomous charter schools in the USA, academies in England and free schools in Sweden have all seen innovation and increased choice as primary outcomes. The implicit assumption seems to be that innovation by autonomous schools will be a naturally occurring feature of such systems as schools compete to attract and retain parents, with minimal need for additional interventions or support from policy.

In practice, studies (Glatter et al., 1997; Waslander et al., 2010) indicate that local hierarchies of schools develop in competitive systems, from the most to the least popular. Schools at different ends of these hierarchies tend to respond differently to competitive pressures, but the dominant response is for schools to try to control their intake by attracting the most 'desirable' students. This might involve anything from increasing marketing spend to developing attractive new facilities. Clearly this presents a number of challenges, most importantly the potential for increased stratification by social class and socio-economic status between schools (Gorard, 2013). A recent summary of research for the OECD (Waslander et al., 2010: 7) concluded that 'the effects of market mechanisms in education are small, if they are found at all'.

Lubienski's review for the OECD (2009: 18) explores these issues specifically in relation to innovation, distinguishing between different types of innovation, for example in processes as well as products. He finds that competition does make schools 'more sensitive and responsive to the demands of stakeholders… leading to a more diverse range of programmatic options in many localities'. But he also finds that 'we are seeing fewer new product and process innovations than might be expected, especially of the disruptive, "second-order" type' (ibid: 27).

Thus, it seems that autonomous schools operating in quasi-markets may increase choice for parents, by transposing existing innovations from elsewhere into the new context, but will not necessarily increase the overall level of innovation in a system.

18.1.2 High-Autonomy–High-Accountability Systems and Innovation

England has arguably been one of the pioneers of quasi-market reform, introducing parental choice of school and funding-follows-the-learner mechanisms from 1988 onwards. But these reforms have formed part of a wider approach—characterised as high-autonomy–high-accountability—that is distinct from the market-based approach due to its strong reliance on central accountability.

Having lost faith in what Barber (2015) calls the post-war 'trust and altruism' model of public service delivery, in which local authorities ran schools with minimal central oversight, policymakers in England have devolved significant decision-making power and resources to schools. School leaders in England were already among the most autonomous in the world at the start of the current decade (OECD, 2011), and levels of autonomy have been extended further in recent years through the academies programme (see below). Evidence suggests that it is school autonomy over curriculum and pedagogical choices—as opposed to financial and human resources—that correlates most closely with improvements in outcomes (OECD, 2011). Importantly, though, such approaches do not appear to be appropriate in all contexts as they are related to levels of professional capacity (Bloom et al., 2014; Di Liberto et al., 2014; Hanushek et al., 2012).

In order to incentivise improved outcomes in England's autonomous schools, policymakers have put in place central regulation and control. Key features of the central accountability system in England include: a National Curriculum, national tests and examinations, the publication of school-level performance in these exams, floor targets and other metrics that schools are required to meet, regular inspections of schools with reports published grading schools on their quality, and a framework and system for intervening in schools that are deemed to be underperforming. This approach reflects the OECD's advice to system reformers that autonomy must be combined with accountability if it is to drive consistent improvement across school systems (2015b).

Well-designed accountability systems have the potential to mitigate some the pitfalls of pure quasi-markets, not least by providing transparent information to inform parental choice. Such systems can also provide clarity for schools on what success 'looks like' and can help government assess value for money (Ehren et al., 2014). The risk is that such systems quickly descend into an unhealthy 'performativity' regime (Ball, 2003), flattening the very freedom and autonomy that governments want to encourage while encouraging school leaders to narrow the curriculum (teaching to the test) and to focus their efforts on attracting the most desirable students (Cappon, 2015; Waldegrave & Simons, 2014).

18.1.3 England's 'Self-Improving School System' Reforms Since 2010

The education reforms under the Conservative-led coalition government elected in 2010 and the Conservative majority government elected in 2015 have been radical and widespread, affecting almost every aspect of school life. They build on the previous two decades of quasi-market high-autonomy–high-accountability reforms but also take these to a different level, particularly in terms of school autonomy, while also introducing a much stronger focus on developing lateral networks as the basis for a 'self-improving school-led system' (2015a; b, d; Greany, 2014). A key tenet of the approach is that 'the attempt to secure automatic compliance with central government initiatives reduces the capacity of the school system to improve itself' (DfE, 2010: 13).

Greany (2014) suggests that there are four principles underpinning the government's approach to the self-improving system:

I. Teachers and schools are responsible for their own improvement.
II. Teachers and schools learn from each other and from research so that effective practice spreads.
III. The best schools and leaders extend their reach across other schools so that all schools improve.
IV. Government support and intervention is minimised.

Changes since 2010 have included: a new National Curriculum and framework for national tests and examinations; a more demanding accountability model for schools; significant changes to how teachers are recruited, trained, performance managed and rewarded; a move towards a national funding system and the introduction of additional funding for each child in receipt of Free School Meals (Lupton and Thomson 2015).

Structural change has been a major feature of the reforms, increasing school autonomy through the academies programme. Academies are companies and charities that are funded directly by central government, rather than their Local Authority (LA). Academies have greater autonomy than LA maintained schools: for example they can operate their own admissions within a broad framework and are not required to follow the National Curriculum or employ qualified teachers. By early 2016 there were 5500 academies in total, representing almost one in four schools (Morgan, 2016). Multi-Academy Trusts (MAT—federations or chains of schools operating under one governance board) have become a central feature of the system: around 58 per cent of all academies and free schools are now in a formal chain (HoC Education Select Committee, 2015). Another plank of the Coalition's structural reform approach has been to support the development of new 'free schools', Studio Schools, University Technical Colleges and University Training Schools (discussed below). By September 2016, there were over 400 free schools open.

A further innovation has been the expansion of 'system leadership' and school-to-school support, through which successful leaders are encouraged to work across two or more schools (Greany, 2016). School-to-school support is arguably now the primary mechanism for school improvement in England (Earley et al., 2012; HoC Education Select Committee, 2013; Sandals & Bryant, 2014).

The corollary of these shifts has been a wholesale reshaping of England's middle tier, with Local Authorities largely hollowed out but still nominally responsible for maintained schools (around three in four of the total) and the emergence of a mixed economy of academy chains and Department for Education-appointed Regional Schools Commissioners overseeing the 5500 academies (Greany & Higham, 2018; Greany, 2015d). Assessing the impact of the self-improving system so far is challenging given the rapid pace and scale of change and the limited time for the reforms to bed in. On the one hand, reports suggest that private fee paying schools are struggling to recruit students because the perception of state-funded schools has improved so dramatically among parents,[1] while on the other there is some evidence that a 'two-tier' system is developing in which strong state schools thrive but weaker ones are left struggling (Coldron et al., 2014; Earley et al., 2012) as well as significant concerns around teacher recruitment, workload and regional disparities in performance (Ofsted, 2015; DfE, 2015). The PISA and TIMSS 2015 results suggest that England's performance against international comparators has continued to remain relatively static (Greany, 2016).

18.2 Examples of Innovation: Pedagogy, Curriculum and School Improvement

This section presents examples of change and innovation in three areas: pedagogy, curriculum and school improvement. The focus on these three areas is justified because they are all core to the current operation of schools and school systems. Many innovations seek to introduce additional practices into schools which can be layered

[1] Headline in The Guardian 'Massively' improved state schools threaten private sector: Better behaviour and results are attracting families who can afford private school fees, says Good Schools Guide editor', 5.2.16 http://www.theguardian.com/education/2016/feb/05/massively-improved-state-schools-threaten-private-sector accessed 24.2.16.

on to existing core practices, for example using social media to enhance communication with parents. By contrast, changes to pedagogy, curriculum and approaches to school improvement all require innovations in existing practices and so allow for an exploration of the question at the heart of this article: how can school systems that have traditionally focussed on 'improvement' make the move to become more 'innovative'? The examples themselves have been selected based on two criteria:

- The original aim of the intervention or project must fit the article's definition of innovation (doing things differently in order to do them better), even if this aim has not been fulfilled.
- The project or intervention must have been assessed through at least one independent evaluation.

Neither the innovation examples selected nor the evaluations that have assessed their impact adopt a standard methodology. This is justified because the rationale for selecting them is not to assess whether one innovation was 'better' or more 'impactful' than another. Rather, a range of very different examples has been selected quite deliberately, based on the review of literature undertaken for this article as well as the author's own direct experience, as a way of illuminating the different aspects of systemic innovation that are discussed in the final sections. While it could be argued that a more cautious approach would be to compare only innovations that have adopted similar methods and evaluation metrics, or that address a single aspect of practice, this approach would not have served the aim of this article, which is to explore the systemic factors that help and/or hinder change and innovation across school systems. Such a systemic analysis requires an understanding of the differences and trade-offs involved when innovating across different areas of a school system.

18.2.1 Pedagogy Example 1: Piloting a 360° Classroom in One School

This vignette is not a system-level innovation, but is included because it highlights some of the challenges involved in innovation efforts at school level. These challenges clearly need to be recognised and understood by policymakers and system leaders if they are to develop innovation across school systems.

The vignette describes an ambitious innovation in one secondary school that proved challenging in many ways. The author was directly involved in the work as the leader of the national project of which it formed part.[2] The data for the vignette

[2] The Design Council Learning Environments Campaign ran from 2003–2006 and comprised several strands, all aimed at enhancing the quality of school design. One strand involved working with 12 secondary schools to design and test innovative environments through a collaborative design process. The author was the Campaign Leader from 2004–05 with responsibility for the overall programme of work.

is drawn from the project documentation and an external evaluation undertaken by academics at the University of Newcastle (Hall & Wall, 2005).

The boys' secondary school in a deprived urban area was one of twelve secondary schools that applied to work with a team of designers and educational experts to shape and implement an innovation in their physical environment. The school identified 'boys' underachievement' as the theme that they wanted to explore via the project. The work started with a two-day design workshop run by the project team and involving senior leaders, teachers and other staff as well as pupils from the school. Drawing on research suggesting that boys prefer a more hands-on approach to learning, the school representatives developed a brief for a 360° classroom. Three design teams were then commissioned to respond to this brief, with the school staff and students selecting their preferred option. The selected option was then designed and built as a prototype in a temporary classroom at the school site and used for teaching by volunteer staff from across the school. An image of the prototype classroom is included below.

The description of the classroom from the project prospectus (Design Council, 2005) is as follows (Fig. 18.1):

> The concept centres on the 'heart', a secure and mobile multimedia projection module at the centre of the room. The combined table/chair reduces the footprint of a traditional desk and chair, leaving space for the teacher to circulate around the 'racetrack' and so access each student individually. The flexibility of the table/chair means it can also be moved by the students to support individual, paired and group work, while the whiteboards around

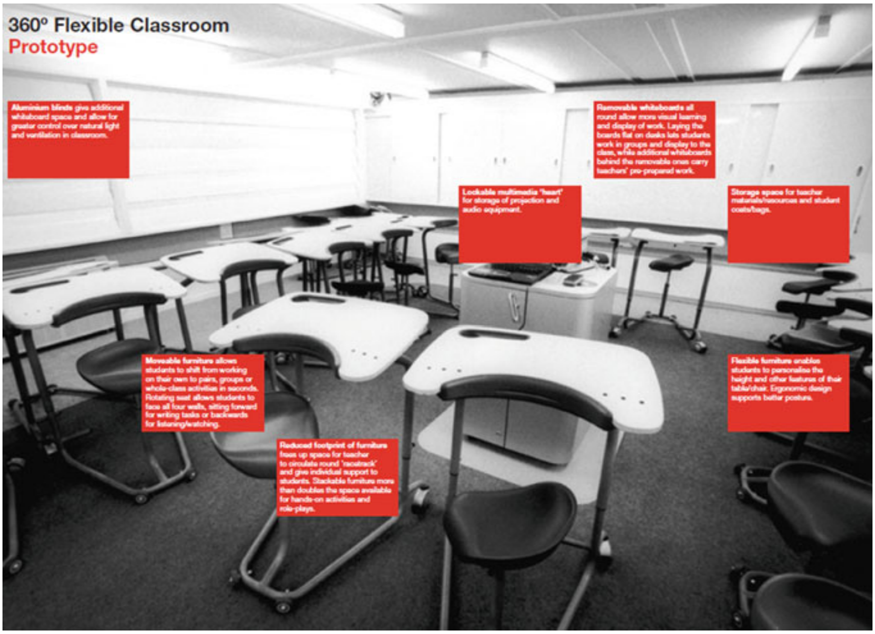

Fig. 18.1 360° classroom. Reproduced from Design Council (2005)

> the walls can be removed (to reveal additional display space) and placed onto the tables to facilitate group work. The aluminium window blinds move individually to control light and air flow and can also be used as whiteboards to provide additional display and projection space, meaning that in the final plenary session of a lesson the teacher can refer to a vivid learning ‘trail’ that has been built up around the four walls.

Any teacher reading this will immediately appreciate that the design required fundamental changes to standard classroom pedagogies: for example the removal of the teacher’s desk, the potential for reconfiguring the classroom multiple times in the course of a lesson, the potential different uses of space and the option of additional technology. The challenge of adapting to these changes was compounded by the fact that the classroom was built as a prototype. This meant that it was not fit for purpose in many respects, for example: it was built in a temporary classroom that was too small to allow for the anticipated movement of teachers and pupils; there was no heating, making it too cold in winter; and the chair height could be ‘dropped’ by a student to make a loud noise in the middle of a class.

In practice, all these changes proved too great to withstand. Despite significant commitment and effort, the volunteer staff refused to use the classroom after the first two terms of the pilot year. They argued that it was not fair on the students to risk their learning by putting them in a prototype environment.

The example highlights how difficult it is to attempt disruptive innovation in a ‘live’ environment, even with structured support and involvement from the school staff in defining the original concept and brief.

18.2.2 Pedagogy Example 2: Changes in Pedagogy in Primary Schools

The second example is taken from Webster’s (2015) analysis of six separate systematic observation studies conducted in English primary classrooms between 1976 and 2012. The findings are shown in Table 18.1. They show the time that pupils observed spent interacting in class with either: a teacher or teaching assistant (whether as part of a whole class, part of a group or individually); with their peers, or with no one. The findings are separated between children with and without special educational needs (SEN).

The table shows that for non-SEN children, interactions with the teacher increase from 16% of the time in 1976 to 40% in 2011–2012. This is due to an increase in whole class teaching, rather than teachers working with small groups or individuals. Peer interaction increases from 19 to 32% over the same period, while ‘no interaction’ decreases from 66% of the time to 26%. Although not all the studies looked at children with SEN, those that do show marked increases in time spent with a teaching assistant, with much smaller increases in the amount of time spent interacting with their teachers than their non-SEN peers. The trends over time are relatively consistent, although the 2005 study has some exceptions in this respect.

Table 18.1 Evidence from six systematic observation studies undertaken in primary school classrooms over a 35-year period (Webster, 2015)

		Pupils without SEN						Pupils with SEN		
		Oracle 1976/1977	One in five 1981/1982	PACE 1993–1996	Oracle 2 1995/1996	DISS 2005/2006	MAST 2011/2012	One in five 1981/1982	DISS 2005/2006	MAST 2011/2012
Teacher and pupil	Part of class (%)	12	23	24	21	44	35	21	36	30
	Part of group (%)	2	3	2	4	3	2	2	3	2
	One-to-one (%)	2	2	4	3	4	3	3	7	4
	Teacher total (%)	16	28	30	28	51	40	26	46	36
Teaching Assistant and Student	Part of class (%)	–	–	<1	–	0	1	–	<1	3
	Part of group (%)	–	–	<1	–	2	1	–	5	5
	One-to-one (%)	–	–	<1	–	2	1	–	9	13
	Teacher total (%)	–	–	<1	–	4	2	–	15	20
Peer interaction (%)		19	19	22	27	20	32	18	16	18
No interaction (%)		66	53	46	45	25	26	56	23	26
Total interaction (%)		100	100	100	100	100	100	100	100	100

Webster is rightly cautious about speculating too much as to why the classroom experience of children observed in these studies changes over the period. He does note that for non-SEN children the authors of some of original observation studies linked these changes to the introduction of the National Curriculum from 1988 onwards. However, this assumption can be challenged since the results are relatively static between 1981–1982 and 1995–1996, suggesting that the National Curriculum itself did not make a difference in its first seven years. The big increase in whole class teaching comes between 1995–1996 and 2005–2006, a period that arguably saw the strongest ever state intervention in pedagogy in England through the national literacy and numeracy strategies. These strategies were explicit in requiring all primary schools to allocate specific amounts of time to literacy and numeracy teaching each day, using standardised whole class teaching methods (Alexander, 2011). Whole class teaching then dipped between 2005–2006 and 2011–2012, perhaps reflecting the fact that the National Strategies became less prescriptive over time and were then closed down in 2010.

18.2.3 Curriculum Example 1: Innovation in Free Schools and Academies

Free schools have been explicitly set up since 2010 to challenge existing providers and to provide innovative curricula and pedagogical models (DfE, 2010). Like all academies free schools are not required to follow the National Curriculum or to employ qualified teachers. The government's original vision was that parents and voluntary groups might set up the schools, reflecting their own priorities and needs, but in practice the challenges involved in establishing a new school have meant that nearly half are now actually set up by established academy chains (Ofsted, 2015).

There are examples of free schools that have sought to offer a distinctive curriculum, reflecting both traditionalist and 21st Century ends of spectrum. For example, the West London Free School offers a 'a classical—knowledge-based-curriculum, including compulsory Latin up to the age of 14',[3] perhaps as a way to attract parents that might otherwise prefer a private education and reflecting Lubienski's comment about the traditional nature of parental expectations. By contrast, School21[4] has set out to offer 'new ways of teaching for the twenty-first century' aimed at developing a set of six attributes: eloquence, grit, professionalism, spark, craftsmanship and expertise. Both schools have proved popular with parents and have been judged positively by Ofsted, the school's inspectorate. By contrast, a small number of the other early free schools have been less successful, with two high profile examples where the school was closed after being judged Inadequate by Ofsted.

[3] See http://wlfs.org/ accessed 10.3.16.

[4] See http://school21.org.uk/ accessed 10.3.16.

As yet there is relatively little research on free schools, but one study of the first two cohorts opened after 2010 indicated that curriculum innovation had been limited, with a mixture of government bureaucracy and accountability requirements as the main cause (Dunford et al., 2013). Some have argued that the need to conform to the existing national accountability requirements has meant that free schools have been constrained in their ability to innovate (Taylor, 2012).

Turning to the much larger group of over 5000 schools that have either converted or been forced to become academies since 2010, they are also not required to follow the National Curriculum. As with charter schools in the USA, the expectation was that the academies would use their additional freedoms to innovate their curricula (Greany & Waterhouse, 2016). Thus far, however, the evidence indicates that this ambition has not been realised, or at least only in part. For example, a survey of academy leaders in 2014 (Finch et al., 2014) found that only 35% had, or planned to develop, a curriculum that varied from the National Curriculum. The authors concluded that 'academies are not fully capitalising on the freedoms they have over the curriculum' (ibid: 18).

18.2.4 Curriculum Example 2: Developing the Capacity to Teach Chinese

The teaching of mandarin Chinese has emerged as a policy priority in the UK in recent years. Addressing the challenge from a standing start is beyond the resources of a single school or even academy chain to address given that it requires action on multiple fronts, such as recruiting and training Chinese-speaking teachers to work in English schools, creating appropriate curriculum resources and formal examinations, finding space in an already crowded curriculum and persuading parents and teachers that it is a suitable subject for academic study.

Tinsley and Board (2014) researched the development of Chinese teaching in schools across the UK. They identified just ninety-five primary schools in England that are teaching Chinese—which equates to around 1 in 160—while in Scotland they identified 119 such primary schools—equating to around 1 in 16. The researchers are clear that Scotland's strategic plan for addressing issues such as teacher training and its support for implementation in schools through Local Authority hubs is part of that country's apparent success. By contrast, England's 'self-improving' system has very few capacity building levers to pull. For example, teachers are increasingly trained by schools rather than universities in England and the lack of scale and capacity in their operations makes it challenging to take on a new area. Similarly, the Local Authorities have all but disappeared from England and while the new academy chains and school networks are beginning to provide an alternative 'middle tier' infrastructure, their coverage is far from comprehensive across all schools and the quality of their work is variable (Hutchings et al., 2014; Gu et al., 2015).

18.2.5 School Improvement Example: School-to-School Support

Researchers in the 1990s characterised England's school system as highly competitive (Higham et al., 2009). In the mid-2000s, if a school was deemed to be failing then the response was invariably to send in teams of consultants to help turn it round. Less than 10 years later it was arguable that school-to-school support had become the predominant model for school improvement (HoC Education Select Committee, 2013). This shift from competition between schools to structured collaboration and support arguably represents a significant innovation in a system of 24,000 schools.

School-to-school support was pioneered through the London Challenge programme, which ran from 2004 to the end of the decade (Baars et al., 2014). Faced by the need to address systemic underperformance in the capital's schools, the London Schools Commissioner, Sir Tim Brighouse, persuaded some of the capital's most successful headteachers to support the 'keys to success' schools that had been identified as needing most improvement. The rationale for this approach was that support from credible, serving leaders and teachers would be more effective than that from external consultants (Mathews & Hill, 2010). This 'consultant head' model was then scaled up nationally by the National College for School Leadership through the National Leaders of Education/National Support Schools (NLE) and Local Leaders of Education (LLE) initiative. These headteachers and their teams are designated against a clear set of criteria and then brokered to support schools deemed to be underperforming. Evidence to date does indicate that outcomes improve faster in NLE-supported schools than in a matched sample (NCTL, 2013; Muijs, 2015) and that NLEs increase the rate of improvement for children on free school meals (FSM) (Rea et al., 2013).

Meanwhile, more structured forms of partnership through federations and Multi-Academy Trusts (MATs) in England have also adopted the school-to-school support approach. Whereas the NLE/NSS model involves temporary support from one school to another, federations and MATs both involve the school being subsumed into a larger group that is overseen by a single governing body or board, with schools within the group commonly supporting each other to improve. Chapman et al.'s (2011) research for the National College indicated a positive federation effect on pupil outcomes over time, most significantly in the case of 'performance federations' (i.e. strong and weak schools together) and where an Executive Head was in place. Analysis by Hutchings et al., (2014) has shown that while academy chains do appear to be improving outcomes for the most disadvantaged schools, performance between chains is highly variable.

Teaching School Alliances represent another model for school-to-school support, both because the partnership remains voluntary for alliance members and because the alliance remit is broader than just addressing underperformance. Launched by the 2010 White Paper (DfE, 2010) Teaching Schools are Outstanding schools that designated by the government to play a leading role in co-ordinating initial and continuing professional development, school-to-school support and research and development across an alliance of partner schools. By October 2015, 692 Teaching Schools had been designated, while by October 2014 at least 7,144 schools were linked with a Teaching School, representing 32% of all maintained schools in England. The evaluation (Gu et al., 2015) reflects considerable progress overall and indicates the sheer diversity of organisational forms and approaches emerging, but also highlights the challenges for these informal partnerships where resources are scarce and schools are constantly pre-occupied by their own performance due to the high stakes nature of the accountability framework.

18.3 Towards an Innovation Framework: Categorising and Analysing the Examples

This section seeks to categorise the brief examples set out in the previous section in a suitable, overarching framework. The aim of this categorisation is to enable cross-case comparison of the different types of innovation in order to assess their relative significance and to analyse the factors that have influenced their development. The framework used for this is drawn from Leadbeater and Wong (2010), but with significant developments, described below, in order to allow for a more in-depth exploration of systemic change factors involved.

Leadbeater and Wong (2010) utilise a simple four-box framework for categorising the innovations that they study. The dimensions are: formal versus informal learning and sustaining versus disruptive innovation. Formal learning here indicates school or institution-based, while informal implies online as well as family and community-based. Sustaining innovation here implies an incremental enhancement in existing learning products, systems or processes, while a disruptive innovation implies a more transformational approach involving paradigmatic changes in the way that learning is provided or experienced. This gives four possible combinations:

- Sustaining innovation in formal learning—Improve
- Sustaining innovation in informal learning—Supplement
- Disruptive innovation in formal learning—Reinvent
- Disruptive innovation in informal learning—Transform

This framework is then developed by the author in two ways. Firstly, an assessment is made of the length, depth and breadth of each innovation.[5] Length here indicates the duration of the change, depth indicates how embedded it is, and breadth indicates how widespread it is. Secondly, the framework categorises the level of external support for change, and the level of internal ownership of change. The former of these—external support—is categorised in three areas: the level of prescription in the policy or design framework (e.g. via legislation or accountability requirements); the extent to which change is actively facilitated (e.g. through a team of dedicated advisers); and the level of funding provided to enable change. The latter–internal

[5] These headings are drawn from current work by the author with Professor Louise Stoll.

ownership—is categorised according to whether the innovation has been initiated by learning provider/s themselves, or adapted (i.e. copied/transferred) from elsewhere. More detailed descriptors for each category are shown in Table 18.2.

Table 18.3 then shows the five vignettes categorised using this revised innovation framework. Most of these categorisations can be made securely, because the definitions are clear cut and there is sufficient data available to allow for an assessment. However, in some areas there is inevitably a degree of subjectivity in making an assessment; for example over whether the depth of a particular change is shallow or deep. These definitional issues are discussed below.

The formal and informal learning boxes are all marked ‘Yes’ for formal learning and ‘No’ for informal learning except teaching Chinese, where some schools are offering Chinese as a voluntary activity in after school clubs. All five examples are marked ‘Yes’ for sustaining innovation, since all are aimed at improving children’s learning within the terms of England’s existing assessment and accountability framework. However, some can also be classed as disruptive, either because they represent a change to an existing paradigm (e.g. the 360 classroom in relation to pedagogy, or School 21 in relation to curriculum/outcomes) or a fundamental change to existing processes in the case of school-to-school support via NLEs, MATs and TSAs.

Turning to the length, depth and breadth categories, the picture is more varied. The 360 classroom took place in a single school over a short period of time and with limited success in embedding the approach. By contrast, the primary pedagogy changes appear to have been sustained between the 2005–2006 and 2010–2011 assessments (length–medium) and certainly achieves wide (i.e. national) breadth, although the drop in whole class teaching by the time of the 2010–2011 study may indicate that the approach had not become fully embedded (depth–medium). The examples of significant innovation in free schools and academies appear to be exceptions rather than the rule, so the breadth box is marked ‘narrow’. The length box is marked ‘medium’ (the initiative has only been operating since 2010) while depth is also marked ‘medium’ on the basis that the changes in the more innovative examples are still being established. Teaching Chinese is categorised as length–medium, depth–shallow and breadth–narrow, on the basis that the initiative remains relatively recent, most schools involved see Chinese as an add-on to their core curriculum and proportionately few schools have engaged. School-to-school support is categorised as length–medium, depth–deep and breadth–wide, on the basis that the changes now extend over more than a decade, most schools and alliances will have a range of staff involved for at least some of their time and the approach is now in place nationally.

Turning to the external support column, the 360 classroom framework is categorised as ‘loose’ because although the design process was clearly defined, it was consciously aimed at generating user-driven creative ideas. The design process was actively facilitated by the Design Council, but the evaluation is clear that the lack of funding—for example for a prototype classroom big enough to enable the desired flexibility—was a hindrance to success. The primary pedagogy example is categorised as having a ‘tight’ framework, because the literacy and numeracy strategies were explicit in prescribing whole class teaching approaches. Facilitation was active, with consultants based on each Local Authority supporting implementation, while

Table 18.2 Innovation framework: categories and definitions for aspects of innovation in education

Formal learning	**Informal learning**	**Sustaining innovation**	**Disruptive innovation**	
e.g school or institution-based learning	e.g. Family and community-based learning	Incremental enhancement in existing learning products, systems or processes	Paradigmatic change in the way that learning is provided or experienced	
Length	**Depth**	**Breadth**	**External support**	**Internal ownership**
Duration of change: • Short - >5 years • Medium - 6–15 years • Long - 16 years+	Extent to which change is embedded into mainstream practice: • Shallow - remains an add-on • Medium - some change to mainstream practice • Deep - mainstream practice transformed	Spread/coverage of change: • Narrow - few isolated example/s) • Medium - significant number of examples, but still a minority • Wide - majority of schools/providers involved	• Framework: the policy/legislative (including accountability) or design requirements imposed on providers: tight-medium-loose • Facilitation: extent to which innovations are supported through external expertise/capacity: active-medium-passive • Funding: extent to which additional funding is provided to providers: limited-sufficient-generous	Categorised as either: • Initiate: innovation has been developed by one or more provider in response to identified needs • Adapt: innovation has been applied by provider, having been pioneered elsewhere

Adapted from Leadbeater and Wong (2010)

Table 18.3 Five English examples categorised using the innovation framework

	Formal learning	Informal learning	Sustaining innovation	Disruptive innovation	Length	Depth	Breadth	External support	Internal ownership
Pedagogy 1: 360 classroom	Y	N	Y	Y	Short	Shallow	Narrow	Framework—loose Facilitation—active Funding— limited	Initiate
Pedagogy 2: Primary pedagogy	Y	N	Y	N	Medium	Medium	Wide	Framework—tight Facilitation—active Funding—sufficient	Adapt
Curriculum 1: Free schools and academies	Y	N	Y	Y	Medium	Medium	Narrow	Framework—medium Facilitation—passive Funding—significant	Initiate
Curriculum 2: Teaching Chinese	Y	Some	Y	N	Medium	Shallow	Narrow	Framework—loose Facilitation—passive Funding—limited	Initiate
School improvement: school-to-school support	Y	N	Y	Y (processes)	Medium	Deep	Wide	Framework—medium Facilitation—medium Funding—medium	Initiate (supporting school)/adapt (supported school)

funding was sufficient, possibly generous. Free schools and academies are categorised as having a 'medium' framework, because Dunford et al. (2013) note that the originally loose policy framework for free schools was tightened up over time, while Greany and Scott (2014) note the same for the wider group of academies. Facilitation of free schools and academies is categorised as 'passive', since the government's philosophy was clearly that the role of government should be minimised, while funding is categorised as 'generous' since several billion pounds of extra funding was provided to incentivise the original wave of academies after 2010 (Finch et al., 2014). The Teaching Chinese framework is 'loose' because England's approach has lacked significant policy direction, perhaps inevitably meaning that facilitation was 'passive' and funding was 'limited'. The school-to-school support framework is categorised as 'medium', because there are clear national criteria and processes for the designation and de-designation of NLEs and teaching schools, but this prescription does not extend to where and how the schools then work. The facilitation of school-to-school support is also classed as 'medium', since the National College for Teaching and Leadership has had some limited responsibility for brokering support between schools, while funding for NLEs to support other schools has been 'medium'.

Finally, turning to the 'internal ownership' heading, the volunteer schools involved in the 360 classroom, teaching Chinese, and free schools and academies examples all initiated their involvement and therefore can be assumed to have a reasonable level of ownership over the innovation. By contrast, the primary pedagogy schools were required to 'adapt' the literacy and numeracy strategies to their contexts. For school-to-school support, there is a clear difference between those that volunteered to be designated as NLEs, teaching schools or academy sponsors (initiate) and those that are required to accept such support due to weak performance (adapt).

18.4 Discussion and Implications: Conceptualising System-Wide Innovation Issues

This chapter started by asking whether and how school systems that have been premised on 'improvement' can move to become more responsive to the ever changing needs of societies and economies? It offered a brief review of the literature relating to school and system improvement and innovation, where the assumption of policymakers in many systems has been that quasi-markets will secure innovation as autonomous schools compete for pupils and resources. In practice, the parallel focus on high stakes accountability based on student test scores and school inspections has limited innovation and enforced a narrow improvement focus. England's recent focus on developing a 'self-improving' school system offers a potential way through this impasse, by increasing school autonomy further while also incentivising school networks led by the best leaders and schools as a means of ensuring the spread of effective practice and expertise. However, the fact that England's high stakes accountability framework has been retained makes significant innovation less likely (Greany & Waterhouse, 2016).

The chapter then summarised five recent examples of innovation in England and categorised these using an innovation framework derived from Leadbeater and Wong's and developed to reflect existing research and theory on school system reform. The framework allows for cross-case comparison of the different types of innovation in order to assess their relative significance and for an analysis of the factors that have influenced their development. In making this analysis, it is recognised that some of the categorisations are to some extent subjective, and that this is a limitation of the design, but this is not regarded as a substantial limitation since the aim is not to provide a precise categorisation, but rather to highlight patterns and systemic implications for innovation theory and policy, which are discussed below.

Assessing the categorisations in Table 18.3 raises several interesting patterns and questions.

Some patterns are unsurprising, for example that none of the examples seriously engage with Informal Learning. Others might be seen as more intriguing: for example, the 360 classroom and the free schools have some similar elements—a disruptive approach to pedagogy and/or the curriculum (School 21) and a model that is initiated by the schools themselves—yet the former is weaker on length and depth, despite having more active facilitation. Equally, how might we understand the differences between the free schools and academies programme and the school-to-school support approach? Both involve a level of disruptive innovation and are national in scope; both operate within a 'medium' policy framework (although the facilitation of school-to-school support is less 'passive' and the funding for free schools and academies is more generous); and both give participating lead schools the chance to initiate their approach. Yet, while the impact of school-to-school support, measured in terms of length, depth and breadth, is 'medium, deep and wide', the impact of free schools and academies is, as yet, 'medium, medium and narrow'. This leads to the following implications:

Firstly, asking teachers to change their practice in significant ways is risky and demanding. Even with a significant support infrastructure and a carefully designed process, the 360 classroom was not successful in conventional terms. This is not to imply that disruptive innovation in education is not possible: the School 21 example illustrates this and there are other examples in the literature (Leadbeater & Wong, 2010; OECD, 2015a). Nevertheless, the challenges and risks involved in innovation need to be carefully addressed by policymakers as well as practitioners and it may not always be possible to mitigate these. To recast the words of Thomas Edison, highly innovative schools and school systems will inevitably encounter high levels of failure.

Secondly, increasing school autonomy on its own, without implementation support and capacity building, might lead to isolated examples of innovation, but will not lead to systemic change. The free schools and academies represent a wide range of practice and so are hard to categorise, but the overall assessment of the independent Academies Commission (2013) was that academies have not used their increased freedoms to innovate. School 21 and the West London Free School provide examples of innovation, but these appear to be outliers that are dependent on a few visionary leaders. At best, the wider group of academies and free schools might come to reflect Lubienski's (2009) finding that US charter schools are effective at translating existing innovations to new contexts and at process innovations around marketing and governance. The teaching Chinese example suggests that where there is too much reliance on local leadership agency, with insufficient investment and a weak implementation architecture, then the impact will be limited.

Thirdly, system-wide change and innovation is possible, but requires strong and sustained political support and capacity building within a values-based framework that allows for local agency and adaptation. The primary pedagogy and school-to-school support examples both illustrate the ability of England's school system to change. The primary pedagogy example appears to have been the result of a strong top-down implementation effort with relatively little scope for local adaptation and agency. This was successful in securing change across multiple schools, but the drop in whole class pedagogy by the time of the 2010–2011 evaluation may indicate that these changes were not sufficiently embedded to become sustainable, perhaps because schools were required to adapt existing approaches, with limited local agency and ownership of change. School-to-school support also required strong political leadership and some financial investment, but it differed from the primary pedagogy example in several respects. Firstly, it emerged as a tried and tested model from the London Challenge where it was pioneered by some of the leading schools, so it had a basis in practice and a set of credible champions (Ainscow, 2015). Secondly, it was based on a clear set of values: successful schools saw it as part of their moral purpose to support other schools, so while the funding incentives were important it seems unlikely that they would have been sufficient on their own. Thirdly, it was taken to scale by a national agency (NCSL) that operated a transparent designation framework but left significant scope for local agency and adaptation within the approach (Matthews and Hill, 2010).

18.5 Conclusion

The three implications identified in the previous section—innovation is risky and demanding, school autonomy on its own will not lead to systemic innovation, and system-wide change requires sustained capacity building within a values-based framework that allows for local agency and adaptation—appear significant, not least since the third one seems to contradict the OECD's (2015a) view that top-down policy is 'impotent' to effect change, while the second one provides an important counterpoint to those who argue for ever greater school autonomy with minimal central co-ordination. Rather, the challenge is to balance central control (structure) and local agency, so that innovation is encouraged and learning is spread (Wermke & Hostfalt, 2014). Neither can succeed without the other because, as Kärkkäinen (2012: 49) argues in relation to curriculum innovation, 'neither pure centralisation nor pure decentralisation is an ideal universal solution'. What is clear though is that this requires a sophisticated set of capabilities from those overseeing public education systems. These capabilities stretch traditional conceptions of public sector governance, as Suggett (2015: 17) implies:

> School autonomy works in tandem with system capability – and it is not older style bureaucracy that is needed, but new systems that can articulate and respond to evidence-based improvement practices, and understand change management.

Building such capability requires both effective governance and systems for vertical knowledge sharing so that policy and practice inform each other. The OECD (2015a: 75) argues that knowledge management is the key to success in these contexts in order to enable systemic learning:

> Knowledge is crucial for governance and governance is indispensable for knowledge creation and dissemination. As complexity in education systems continues to increase, governance systems' capacity to learn becomes more and more crucial.

What has been less recognised in these discussions is the need for these governance models to continuously engage teachers, parents and other stakeholder groups so that they understand and subscribe to the aims of systemic innovations. Without the legitimacy that such support brings the innovations might not only fail in themselves, they might precipitate wider challenges to quasi-market education systems. New institutional theory defines legitimacy here as the acceptance of an organisation by its external environment (DiMaggio and Powell, 1983, quoted in Gibton, 2016). Governments have traditionally provided the legitimacy required for public education systems through their democratic mandate, but the development of autonomous schools overseen by 'closed managerialist networks' (Hatcher, 2014) and corporate-style chains, federations, and commissioners (Gibton, 2016) risks breaking that link, with few opportunities for electors, parents or other community groups to influence the direction of travel. Waslander (2010) provides an instructive example from the Netherlands in this respect, where pedagogic innovations initiated by school boards led to a sustained media and public backlash, driven by a concern that the traditional role of 'knowledge' was being disregarded. As a result, the government has passed new legislation which limits the autonomy of publicly funded schools—a status that had been enshrined in the constitution a century before. Waslander concludes that this was a result of the school boards losing their legitimacy, among teachers as well as parents, through a lack of good governance and stakeholder engagement; a view endorsed by the Dutch chief inspector of schools (Dutch Ministry of Education, Media and Culture, 2014: 41–42). This leads to three final conclusions:

The first is that we need a more nuanced definition of autonomy which distinguishes between 'structural' and 'professional' autonomy. Structural autonomy here denotes the extent to which the legal and policy framework formally delegates decision-making powers to school boards and/or leaders in two areas: resources (e.g. budgets/staffing) and curriculum/pedagogy. By contrast, 'professional autonomy' reflects a view that autonomy is as much about the confidence, capacity and effectiveness of school leaders and teachers and the trust placed in them by district and national officials as it is about formal delegated powers (Bryk & Schneider, 2002). Strengthening 'professional autonomy' needs to become a higher priority than extending structural autonomy further. This could happen through the strengthening of existing lateral networks and the establishment of governance structures and agencies that can support knowledge mobilisation.

The second is that the vertical accountability framework not only prescribes the parameters for innovation in many systems, it may also condition how parents perceive and value innovation. Vertical accountability to government appears to have both a coercive and normative power over school leaders, in that it requires them to act in certain ways (backed by rewards and sanctions) and also ingrains a sense that this is the 'only way to do things'. But that same vertical accountability may also have a normative impact on parents, telling them that only the qualifications that government deems important are worthy of consideration and that only the schools that the inspectorate deems high quality are worth of choosing for their children. Thus, vertical accountability may actually condition market accountability to parents so that they require one and the same thing from schools—high test scores and good inspection judgements. Innovation appears to be a casualty of this process.

The third is the need to enhance the legitimacy of innovation in the eyes of education's key stakeholders: in particular teachers, parents and employers. Proponents of quasi-markets may see choice as conferring legitimacy on innovation: parents can choose between Latin at West London Free School, 21st Century skills at School 21, or the standard GCSE offer at most other English schools. If they are not happy they can go elsewhere. But if it is the case that these remain isolated examples and that quasi-markets are not successful at fostering significant innovation (Lubienski, 2009), then the question is not only how might change and innovation be developed systematically, but also how can any such change avoid the public backlash described by Waslander in the Netherlands (2010). Any such effort must originate with governments, since legitimacy must stem from their democratic mandate even if, in practice, they are not always best placed to champion change. This point is clearly linked to the two above: in developing the 'professional autonomy' of school leaders, it will be important to equip them with the skills needed and a fit for purpose governance framework that can secure stakeholder engagement. Equally, if the accountability framework conditions parental expectations of schools, then it stands to reason that innovations must be given some level of legitimacy by that same framework if parents are to perceive them positively.

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Part V
Conclusion

Chapter 19
Building a Cohesive Twenty-First Century Learning-Orientated Community in Singapore—Summary and Conclusion

Longkai Wu, David Hung, Sin Yee Lau, and Sujin He

Abstract Singapore's education system is internationally acclaimed; however, the driving force behind the success might not always be focused on the intrinsic purpose of learning vis-à-vis academic performance in schools. Students are required to sit for examinations that would determine their prospective development pathways even at a young age, and this may not always work well for all kinds of student needs and profiles. Multiple initiatives were announced by the Ministry of Education (MOE) to address these issues with increasing customization of learner needs. Yet, true change remains elusive as Singaporeans' excessive fixation on grades is deeply rooted and hence would require more time to change cultures. In this concluding chapter, we will be using the SCAEL model (Chap. 3) to examine how the discussed education innovations, system reform and case studies meet the diverse needs of Singapore's ever-changing education system. The intents for change and reform are built on substantial and sustainable school innovations, with the view towards more diverse measures of merit that is more adaptable to change and globalization.

19.1 Introduction

The Singapore education system is built upon a strong foundation, and it is ready to make quantum leaps for enhancements in national capacity (Info-communications Development Authority of Singapore, 2015). The key thrust of education reform is the spread of innovative ideas and practices oriented towards school improvement

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and advancements in student's deep learning and teacher's professional development (Hung et al., 2016). Schools must prepare students to be future-ready and to possess dispositions such as motivation, self-direction, resilience and lifelong learning capabilities. All of these attributes, together with taking joy in learning, can empower students with the 21CC skills of effective communication, creativity, problem solving and critical thinking (Hung et al., 2016).

Since the post-independence survival-driven phase, the Singapore Education System, at the systemic level, has undergone reforms to provide directives and structures that balance high academic achievements through teacher-centred (centralized) practices, with the developing of twenty-first century skills through inquiry-based, student-centred (decentralized) pedagogies to level up lower achieving students (Lee et al., 2016). These are reflected throughout the chapters with reform strategies such as the experimentations of future schools and initiatives developing teacher capacity. As the meso-layer is the interface between the macro- and the micro-levels, more emphasis is placed on this middle layer, as the stakeholders involved are instrumental in mediating the realization of strategic goals with system needs. There has been more autonomy for innovations, changes and adaption of different pedagogies on the school level while remaining aligned to the system's intended goals. Schools and teachers are also expected to hybridize student-centred pedagogies with teacher-centred approaches to deliver foundational knowledge and maintain academic performances (Lee et al., 2016). Hence, we see that the tenets of change are effective from the meso-level, in a centralized–decentralized system of Singapore, where such forces and balances can be attained by system monitoring and capacity upskilling of stakeholders involved in the change process.

19.2 Initiating Reforms Using the SCAEL Model

The SCAEL model, as discussed in Chap. 3, is a context-sensitive translational and scaling framework that can translate theories to practice for sustained educational changes. Policymakers should question our education system constantly with the four "Cs", namely *community*, *conditions*, *culture* and the *carryovers* for subsequent reforms. There are mainly three layers of change, namely the macro, meso and micro. These three layers of change are observed in our centralized–decentralized system as well as the education system from overseas, described in the next section.

19.2.1 Local Perspective

At the meso-cluster, social networks of teachers and groups of core school personnel create the socio-technical infrastructure for apprenticeship learning. As discussed in Chap. 9, leadership from the middle (LftM) is a key leverage to be situated within the levels of the system with teacher leadership working in tandem with school leaders. The unique proposition of the Singapore's school system is that it has a tight relationship with policy from the MOE, thus enabling a research–practice–policy nexus to be actualized. Therefore, the implementation of a school-based teacher professional development (PD) approach as described in Chap. 13 on the micro-layer has the potential to change teachers' "indigenous" beliefs and mindsets that allow them the bandwidth to experiment with new pedagogies and achieve the desired student outcomes.

Furthermore, Chaps. 4 and 11 bring to the fore the indispensable role of leadership across all levels of the organization that encompasses a diverse set of leadership models supporting curriculum development. Due to power distance cultures, intentional brokering is needed for trust building laterally. The emphasis on distributed leadership further depicts the importance placed on role specializations to secure the production of an "educative curriculum" to support the "school-based curriculum enactment". This important stance can cultivate more social and positional capital to achieve traction between school leaders and teachers towards the same agenda, operationally wise and between teacher/school leaders with policymakers. Chapter 14 demonstrates implementation tenets for teacher capacity building focusing on lesson design, enactment and refinement as a key to understand how to infuse and adapt inquiry practices for their classrooms. Some issues teachers face are present in the implementation tenets, such as shared problems, common lesson design principles. The authors argue for collaboration and partnerships as effective ways to build teacher capacity. This can build an effective socio-infrastructure that enables teachers to undergo the epistemic change process. Teachers can gain peer support from their fellow nLC members, with the encouragement of school leaders (Chap. 12). Consequently, teachers can then see their roles as designers of learning, by using student artefacts to inform design and facilitating of the conditions for successful trajectories of development at both teacher and classroom level.

On the macro-layer, Chap. 9 investigates a transformative pedagogy that leverages ecosystem carryover effects in sustaining Singapore educational innovations, moving towards achieving lifelong, life-wide, life-deep and life-wise learning in schools. It also examined the partnerships involved in a research-practice "It Takes a Village" project. The collaboration acknowledged and respected each other's expertise and knowledge, contributing equally and collaboratively, to influence the services provided for students, by studying the demographics and contextual factors of the schools. Consequently, working towards a longer term for the purpose of scaling and sustaining educational innovations helps to benefit the wider community of the education sector. Chapter 10 then looked further into the conceptualization of a 4-lives framework to address the skill gap between what schools develop in students and the high value workforce skills needed for innovation and enterprise. Finally, we conclude the section with Chap. 15, in discussing how Singapore schools can fill the skills gap.

Following that, our discussion takes us further into the iterative process of growth in people capacity, alongside the multiple artefacts and products/resources that accompany an innovation and change process.

In the first and second sections, we looked at how schools have adopted diversified approaches of education reforms and have enabled innovations with appropriate resources and processes. Chapter 1 outlined the four phases of ICT integrations for sustainable change, and Chap. 2 explored the maker culture with immersive environment built upon the six learning curriculum design framework. Both chapters showed the innovative and effective integration of technologies that enabled a transformation to the teaching and learning experience. The implementation of technologies looked into leveraging ecosystem carryover effects.

Chapters 2 and 5 studied the maker movement in education. The implementation and enabling of making-centred learning spaces involve changes at the teacher- and school-level. Chapters 6 and 7 highlighted the importance of niche programmes, such as co-curricular activities (CCAs). This is an initiative that recognizes different talents, apart from academic talents. This is particularly salient in sparking the interests of students to learn, by providing distributed expertise in the form of designed opportunities, bringing alongside a community to support the students' activities as well as encouraging healthy competition amongst the students.

While the school is conventionally seen as an institution of learning and not of play, Chaps. 5–7 explore how students' interest and learning can be integrated, to encourage collaboration, facilitate self-initiated learning and intrinsic motivation. They provide students with learning opportunities and experiences to work towards lifelong, life-wide, life-deep and life-wise learning. Educators can level the playing field by preparing students with the skills and dispositions that are relevant for the twenty-first century workforce. It acknowledges the importance of levelling up lower achieving students and to enable greater resource savings in the longer term.

Chapter 8 looked into knowledge building (KB) in Singapore. KB is grounded on teacher communities, through teachers' discourse and community-building. Within each participating school's community, a senior teacher facilitates the continual deepening and sharing of knowledge building practices as well as the sharing of students' artefacts. KB scaling efforts have been successful at nurturing innovation champions who exhibit strong epistemic agency in leading the spread of the innovation and creating new knowledge about their practices. KB has exhibited carryover effects from the micro-teacher and meso-school levels. However, likely due to the lack of a consistent movement support at the macro-layer, the scaling of KB is relatively slow(er).

19.2.2 International Perspectives

Section 19.4 provided us international perspectives on how these schools promoted diversity in their education systems on an international level. The three chapters in this section further affirmed the importance of apprenticing and ecological leadership. In order to make sustainable change to the education ecosystem, policymakers should understand historical patterns in the system. This should include knowledge of current realities, early information about what other key organizations are doing and planning, and what kinds of funding and policy decisions are likely to be made. A practical understanding of these can help an organization anticipate the conditions that may change and ultimately, to devise productive responses. Chapter 16 discussed how Joetsu city leveraged the carryover effects in sustaining educational innovations that had helped them move towards achieving the 4-lives (lifelong; life-wide; life-deep and life-wise). Chapter 17 discussed how New York City's economic, political and educational sectors caused tensions to their socio-technological infrastructure and had brought challenges to construct sustainable ecosystem. Finally, Chap. 18 concluded the section with the examination of what refrained the real change to England's decades of education reform.

In the first chapter of the section, we saw Joetsu city advocating the implementation of career education that aimed to move students out of the classroom to real workplace experience learning and practice. Their belief in "The First Principle" has led to strong cultural support, and as a result, it received positive responses on a national level. This chapter described a sustainable system-wide approach towards systemic change in the schools from the micro-, meso- and macro-layer. It also demonstrated a model of ecological leadership that aligned the macro- and micro-layers of the ecology through alignment in the meso-layer such as with the Challenge Shop "Rikka" interschool cooperative shop management project.

On the other hand, Chap. 8 highlighted a turbulent time of education reforms in New York City. NYC has moved towards centralization, then decentralization, and returns towards centralization again. Therefore, groups and organizations in NYC could not anticipate conditions to remain the same. Under these circumstances, there were constant changes to the *community*, *conditions*, and *culture* conditions. Systematic planning and sustained investment remain subject to short-term shifts in policies, funding and district organization and the changing requirements and expectations that come with them. Similarly, in Chap. 9, Greany recognized that the increase of school autonomy in England on its own will not lead to systemic innovation. Perhaps due to the culture differences between the west and east, "The First Principle" has established a common ground for the Joetsu's policymakers and citizens. As a result, it may create a more stable learning ecosystem as well. In principle, a sustainable system-wide change and innovation is more likely to happen when strong and sustained political support is involved with the capacity building within a values-based framework that allows for local agency and adaptation.

In addition, both Chaps. 16 and 17 demonstrated a top-down implementation. However, it was stressed by Greany that top-down policy is "impotent" to effect change. It is evidently the case when we examine the success of Joetsu city, in their collaboration of the different stakeholders for its community-based career education. A centralized–decentralized system can also be observed. The executive committee discussed concrete project plans and activities, while the schools took a leading role, explaining the goals of the project to other cooperating schools and determined how they could support the project. Neither pure centralization nor pure decentralization is a sustainable solution, rather, a balanced central control coupled with local agency should then be able to scale change in an education system. This way, a rigorous design model can be developed to facilitate generation of credible evidence for future decision-making.

19.3 Implications

Academic results as a narrow way of judging success East-Asian values are implicit in Singapore's local context, and in addition to the "decades of an excessive fixation on grades and educational streaming, they have left a seemingly indelible mark on the Singapore psyche" (Jagdish, Commentary: Are we still missing the point of education?, 2017). To eradicate the culture of judgement that academic results are used to predict a person's future, there is a need to shift the emphasis to the individual's strengths and to facilitate a love for learning. Eradicating such a culture is a challenge (Jagdish, Commentary: Are we still missing the point of education?, 2017), and it can only be achieved if there is enough support and engagement across different community makers. On the macro-level, policymakers can actively promote the values of LIFE by providing evidence-based practical resources to nurture a cohesive community that shares the same vision of education and learning for the twenty-first century. Schools and other stakeholders (meso-level) should continue to provide socio-technical infrastructure for apprenticing leadership and welcome new pedagogical innovations while sharing with other networks. On the micro-level, teachers should focus on providing a meaningful learning experience for students. Therefore, these experiences will provide students with the skills for dealing with authentic, non-routine and complex real-world problems.

19.3.1 Changing Perspectives with Community Cohesion

Policymakers in Singapore have shifted towards more student-centred inquiry-based learning pedagogies, but the process of reform is still hindered by society as they struggle to redefine the purpose of learning and what constitutes success (Jagdish, 2018). There is a need to refocus the schooling experiences for students so that the non-academic aspects of schooling assume greater prominence (Mokhtar, 2018). Building this cohesive community, where teachers, students and the community understand that grades are not as crucial as the cultivation of intrinsic motivation to learn, is essential for radical changes to happen. Nevertheless, there should be a safe space and a white space for exploration and experimenting, as little innovation can occur without encouraging experimentation. More active collaboration should be made between schools and collaborating agencies that can provide learning experiences that are without any emphasis on national high stakes examinations. Educators can consider integrating non-formal and informal learning experiences such as museums and learning trails, as these collaborations can provide opportunities for students to engage in activities that can boost their interests and passions. It is necessary to nurture a pedagogical culture that can change the prevailing mindset of the community, that it is safe for students to explore and discover their own interests and abilities. Moreover, autonomy ought to be given to students to pursue purposeful learning and at the same time build their motivation to do so. On top of recognition for innovative endeavours, resources should also be allocated for teacher capacity building. A safe community of partners can be forged.

19.3.2 Developing a Joy and Interest for Learning

MOE has made laudable efforts to create multiple pathways and informal learning opportunities. Education analysts have realized the importance of having a robust education system that enables students to discover their interests and passions, as pursuing one's interest and passion is more sustainable, self-directed and motivated than learning without such factors. Sections 19.1 and 19.2 demonstrated the different approaches to leverage opportunities for assessing and facilitating learning trajectories in the context of Singapore. Educators can refer to the development trajectory (Chap. 1) of integrating ICT into classroom so that more research and development can be done to further explore how we can harness our ICT program that pairs learning analytics with AI, augmented and virtual reality and the Internet of Things to prepare students with the right skills to build a digital economy, in support of a smart city. Fostering learner interests and the intrinsic motivations to pursue goals that would be useful to society is needed, going forward.

19.3.3 Teachers' Capacity Building

At the heart of pedagogical innovations and educational change are the teachers who implement the curricula. Chapters 11–14 looked into complementary policies that aim to build teachers' capacities to enact more student-centeredness while maintaining some teacher-centred pedagogies used to teach foundational/disciplinary knowledge (Lee et al., 2016). Teacher-centred pedagogies are still needed to regulate educational goals set by policymakers (Lee et al., 2016). Teachers are expected to be able to draw links from informal learning settings to classroom learning and provide distributed expertise to the students and to encourage healthy competition in class. They may face a dilemma of choosing which to emphasize in their teaching practice with limited resources. Hence, teachers should be empowered with the capacity and flexibility to adapt instruction according to learning needs and profiles (Hung et al., 2012).

Additionally, innovations designed by teachers have the greatest leverage in activating skill acquisition, as teachers' work on the ground can actualize policies into teaching practices. We should encourage the teachers to build their design competencies in their practice, by partaking in PLCs to discuss how best to implement pedagogical innovations for student learning. At the same time, they get to discuss and learn through each other's mistakes. This also reduces the time and resources for trial and error and will help to build community confidence.

To generate more comprehensive insights in recognizing diversified practices that encourage change towards twenty-first century learning orientations, future studies might be devoted to include discussions on balancing student-centred pedagogies with teacher-centred pedagogies and integrating informal learning programmes into formal learning curricula. Further investigation is needed to explore how learning experiences can be developed through technology, pedagogy and innovative school design, without compromising the spontaneity and freedom of expression laid by the policymakers.

19.4 Conclusion

We hope that this book has provided more insights into the nature of schools in Singapore and internationally, provided insights into the nuances underpinning change reforms and the challenges that would confront any system and highlighted where the priorities where change matters most. Policies and resourcing should ideally be placed or channelled to where change matters most, and investments made to evidenced-based practices for such efforts both as a documentation process and also as formative advising of the process. On the macro-level, the policymakers have recognized the importance of providing multiple and complementary pathways that recognize diverse students and encourage change towards twenty-first century learning orientations. The set-up of the future schools and specialized schools encouraged and provided opportunities for innovations and facilitated meaningful and engaging experiences for students through technology, pedagogy and innovative school design. On top of that, other initiatives are also carried out to decrease the emphasis on examination to school-based excellence programmes, such as ALP and CCA. The aim of rebalancing of teacher-centred and student-centred learning is to help students discover their interests and talents while developing values and competencies that will prepare them for a rapidly changing world. With these ranges of different initiatives, schools can develop innovative practices to accommodate learning opportunities for all students. However, the push for such shifts is hindered by the community obsession towards getting prefect grades.

Viewed through the lens of the SCALE model, Singapore has established the conditions (C2) to enable change. Ongoing efforts and supports are given to increase teachers' capabilities and collaborations between schools and organizations (C1). The next phase would be looking at changing its people's mindset towards education (C3). There is a need to redefine what is learning and to also eradicate the culture of judgement towards grades in order to make the mindset shift. Nonetheless, we recognized that this culture change cannot be changed overnight, and more works need to be done to reassure the people that it is safe to make the shift. Therefore, the reforms require efforts from all over level. Policymakers, schools, teachers, parents and students have to work hand in hand for it to happen. Schools matter to learners, but the relationship between schools and the community can be elaborated and further explored. The desired outcomes of education should remain current to the times and also rooted on values which are evergreen.

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