Chapter 14
Capacity Building as a Driver for Innovation and Change: Different Contexts, Different Pathways

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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).

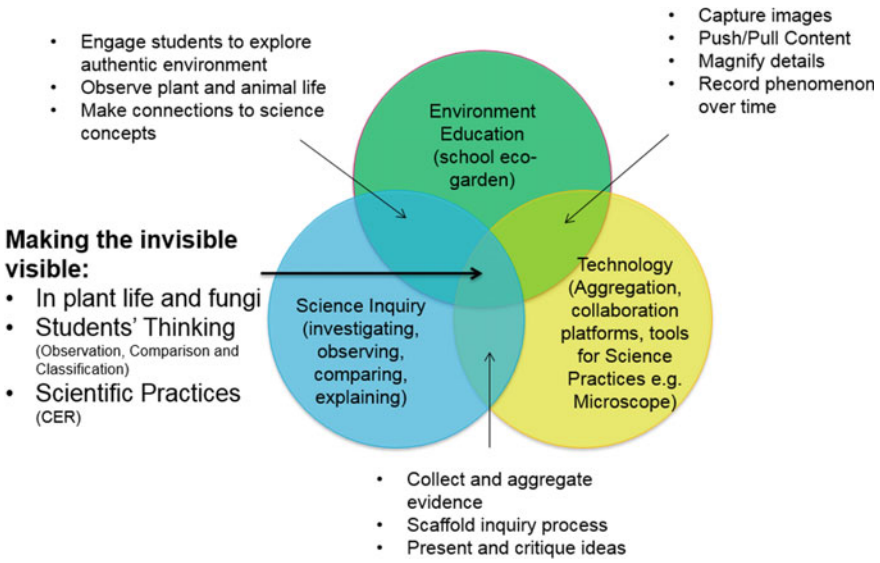

Fig. 14.1 Core innovation principles

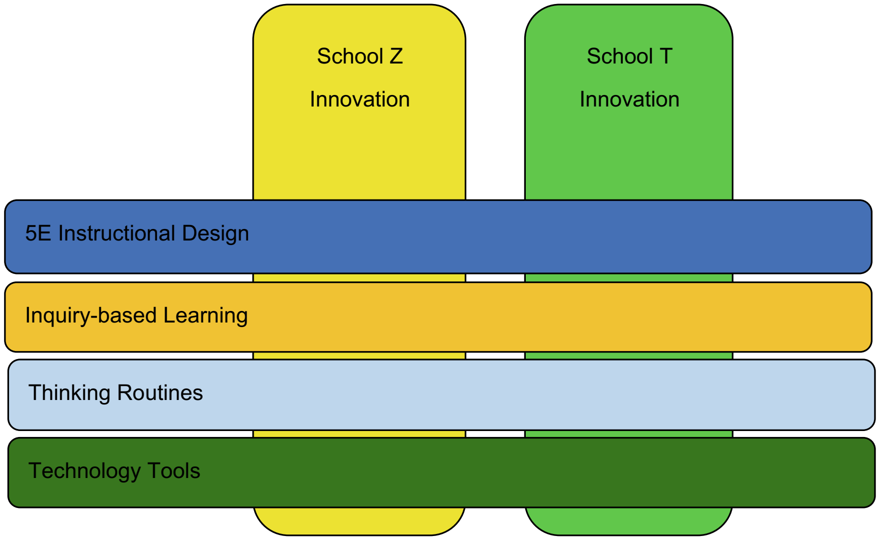

Fig. 14.2 Core principles for lesson design

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

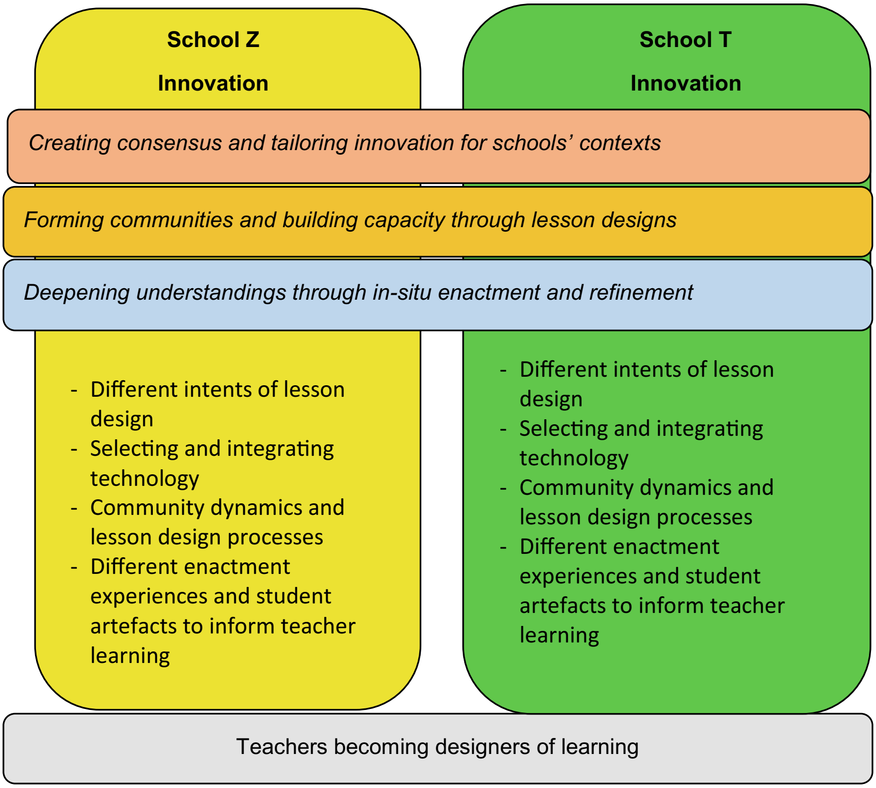

Fig. 14.3 Tight-loose couplings for capacity building within and between schools

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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