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


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

## 1.1 Introduction

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

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

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

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

## 1.2 Literature Review

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

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

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

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

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

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

## 1.3 Research Context

### *1.3.1 Use of ICT in Singapore's Educational Landscape*

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

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

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

### *1.3.2 The School*

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

## 1.4 Data Collection

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

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

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

### *1.4.1 Data Analysis*

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

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

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

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

### *1.4.2 Findings*

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

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

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

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

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

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

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

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

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

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 worldwide 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<br>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 |

(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 |
| 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 |

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(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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