THF Working Paper
Working Papers Series No.2 /2020

Leading Innovation in Complex Adaptive Systems, an Outside View on Singapore's Pursuit of 21st Century Education

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Singapore is recognised as a high-performing system on traditional measures of academic success, but, since the 1990s, the nation state has sought to re-orient its education system to combine 21st Century Competency development with strong academic performance (Gopinathan, 2015). This has placed a new onus on principals to re-imagine education, to lead organisational and process innovation, and enable teachers to adopt a broader range of pedagogies, which foster a 'joy of learning' (Ministry of Education, 2017a, 2017b). In this paper, I combine findings from my own primary research into the leadership of future-focused schools with a review of existing literature. I present two case studies, of fostering innovation at Crest Secondary School, and of principal development on the Leaders in Education Programme, to examine how Singaporean principals lead innovation in a complex school environment (Holling, 2001; Preiser et al., 2018). Using the framework of explanatory factors and control factors (Oates, 2017), I then identify how Singaporean policy-makers have leveraged a range of control factors to re-orient the system towards 21st Century Competency development, taking an iterative approach that is suited to the complex nature of the education system. Finally, I highlight the tension between these actions and the values which are deeply embedded in Singaporean culture and act as a 'system memory' that inhibits change. I conclude by asking whether incremental shifts will be enough to achieve the level of reform now sought in Singapore, or whether a critical event such as COVID-19 is necessary to trigger the type of 'creative destruction' that could lead to whole-scale system change.

1. Introduction

Building an entrepreneurial nation has been a growing priority for the Singaporean government since the late 1990s. Numerous initiatives have been designed to shift the education system from producing graduates who are not only knowledgeable and technically capable, but are also able to apply their knowledge to generate innovations that will support economic growth. Meanwhile, Singapore has maintained its status as a high-performing education system on internationally recognised assessments such as PISA and TIMSS (Gopinathan, 2015). It was with this context in mind that I chose to visit Singapore as part of my Winston Churchill Memorial Trust fellowship, investigating the leadership of future-focused schools. I hoped that Singapore would provide a case study of a jurisdiction that combined strong academic performance with a future-focused commitment to developing students' 21st Century Competencies (Ministry of Education, 2015a).

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Between November 2018 and May 2019, I travelled from England to Australia, New Zealand and Singapore, researching the leadership of future-focused schools. In the course of my research, I visited 20 schools and five professional development providers and interviewed over forty educators, sector experts and policy makers. Within a broad theme of future-focused education, I was interested in the role of school leaders because of the pivotal role they play mediating between system-level policies and local context. In England, many school leaders technically have the autonomy to determine their school's curriculum and whether value is placed on outcomes other than academic performance, such as creativity or entrepreneurship. However, accountability mechanisms are heavily weighted towards academic performance on national examinations and the view is often put forward that schools can either prioritise academic rigour or holistic development, but not both (e.g. Kelly, 2012).

It was the portrayal of this apparent dichotomy that led me to visit Singapore. Even though the state is not culturally comparable to England, the Singaporean system is often cited by the UK media and government as a system from which to learn, because of its high performance (e.g. Civinini, 2019; Moore, 2013; Stewart, 2013). Since 1997, Singapore has also been focused on building learners' 21st Century Competencies (Ministry of Education, 2015a). I wanted to see if Singapore offered a case study for the compatibility between high academic standards and a commitment to future-focused education.

In Singapore, I visited Crest Secondary School and the National Institute of Education and met with experienced educators who could provide context on the evolution of the Singaporean education system and the role of school leaders within it. I also analysed the speeches of Ministers of Education and reviewed existing research literature to provide context for my research.

In this paper, I summarise the historic system context for my research before presenting two case studies. Crest Secondary School acts as a case study of the implementation of the *Framework for 21st Century Competencies and Student Outcomes* and for the leadership of innovation in a Singaporean school, and the Leaders in Education Programme as a case study of developing the capacity of future principals to lead in complex systems. I then examine the role of Singaporean principals in educational innovation and how features of the Singaporean education system facilitate or inhibit their intentions, drawing on contrasts with Australia, New Zealand and England to place the notable features of the Singaporean education system in an international context. I employ the theory of Complex Adaptive Systems (Holling, 2001; Preiser et al., 2018) as a framework for understanding innovation and change across the Singaporean education system and use explanatory factors and control factors (Oates, 2017) as an architecture to articulate how successive policies have been leveraged to re-orient the Singaporean system towards 21st Century Competency development. I conclude by asking whether Singapore has indeed bridged two aims of education by combining strong academic performance with the development of students' 21st Century Competencies.

2. Context: Singapore's evolving education system

Many authors have written extensively on the initiatives that have been adopted since the late 1990s to ensure that the Singaporean education system remains future-focused (e.g. Deng & Gopinathan, 2016; Gopinathan, 2015; Natarajan et al., 2018; P. T. Ng, 2008; J. P.-L. Tan et al., 2017). I will therefore provide only a summary of these initiatives as a reminder of the context for my research.

When Singapore became fully self-governing in 1959, its education system was fragmented and many citizens had not even completed primary education. However, within forty years and through careful and reflective system-level planning, Singaporean students have become some of the highest achievers in the world (Gopinathan, 2015). Reforms started with a survival-driven phase (1965-1978) focused on increasing the number of citizens engaged in education, followed by an efficiency-driven phase (1979-1997) oriented towards reducing attrition and increasing the quality of education (Gopinathan, 2015). By 1995, Singapore reached a point where its young people were top performers in the international maths and science tests, TIMSS (Goh & Gopinathan, 2008).

The *Thinking Schools, Learning Nation* speech given by the then Prime Minister, Mr Goh Chok Tong, in 1997 was a milestone in the development of the Singaporean economy and education system (Goh & Gopinathan, 2008; Ministry of Education, 1997). The vision of *Thinking Schools, Learning Nation* was that schools should shift from being wholly outcome-oriented to being more process-centred learning environments, with opportunities for experimentation and uncertainty, and that Singapore should develop a culture of life-long learning amongst its citizens (Gopinathan, 2015). As Mr Goh asserted:

> *A nation's wealth in the 21st Century will depend on the capacity of its people to learn. Their imagination, their ability to seek out new technologies and ideas, and to apply them in everything they do will be the key source of economic growth.*
>
> (Ministry of Education, 1997)

There were four core tenets of *Thinking Schools, Learning Nation*:

- An emphasis on critical and creative thinking
- Increasing the use of information technology in education
- National Education (citizenship education); and
- Administrative Excellence (Ministry of Education, 1997)

The Singaporean system began re-orienting towards students' 21st Century Competency (21CC) development. The end-goal of this re-orientation was expressed through the *Desired Outcomes of Education*, which were publically specified in 1997 and refined in 2009 (J. P.-L. Tan et al., 2017). The *Desired Outcomes of Education* identify that by the end of their formal education every Singaporean should be a confident person, a self-directed learner, an active contributor and a concerned citizen (Ministry of Education, 2009).

Building on the *Desired Outcomes of Education*, in 2010, the *Framework for 21CC [21st Century Competencies] and Student Outcomes* was formalised (J. P.-L. Tan et al., 2017). This

Framework articulated the core values and social and emotional competencies that would underpin the development of young people's 21CC: Civic Literacy, Global Awareness and Cross-Cultural Skills; Critical and Inventive Thinking; Communication, Collaboration and Information Skills (Ministry of Education, 2015a). The Framework did not undermine the importance of academic success. As Deng et al (2013) explain, 21CC and similar initiatives are designed to enhance the academic content of the curriculum and "C2015 adopts a vision of 'Strong Fundamentals, Future Learning' signalling that academic subjects…continue to play an important part in the new curriculum" (Deng et al., 2013, p. 267). However, the Framework was another explicit statement that students needed more than academic outcomes to be fully prepared for their futures.

Following *Thinking Schools, Learning Nation,* a strategic and systematic approach was taken to shift the Singaporean education system towards 21st Century Competency development including:

- Investments in the Centre for Research in Pedagogy and Practice and the Learning Sciences Lab, starting in the early 2000s, intended to support evidence-informed changes to practice that could support a 21st century education (J. P.-L. Tan et al., 2017).
- The launch of the *Teach Less Learn More* policy in 2005, which encouraged teachers to provide opportunities for students to engage in inquiry-based learning as a vehicle for developing 21st Century Competencies (J. P.-L. Tan et al., 2017) and an associated reduction in curriculum content to free up time for such learning (Poon et al., 2017).
- The National Institute of Education's development of V3SK in 2009; a new teacher education model within which teachers are educated to integrate inquiry-based, problem-based and experiential learning into their practice and to make full use of learning technologies (J. P.-L. Tan et al., 2017).
- The iterative implementation of four ICT in Education Master Plans from 1997-2002, 2003-2008, 2009-2014 and 2015 onward. These have involved building teacher capacity to use ICT, increasing the number of devices and tools available to students, enhancing system support structures and encouraging the integration of ICT into day-to-day teaching and learning (Natarajan et al., 2018).
- A reduction in the school-based assessment load for some year levels, announced by the then Minister for Education, Mr Ong Ye Kung, with the hope that reducing the time spent on assessments might free up time for inquiry-based learning and student-initiated investigation (Ministry of Education, 2018b).
- The development of Applied Learning programmes and Learning for Life programmes, from 2013, the former of which provided students with opportunities to learn in real-world settings and the latter of which exposed them to experiences that would instil life skills and socio-emotional competencies (J. Y. Ng, 2015). These programmes were an evolution of the Programme for School-Based Excellence and Niche Programmes, introduced in 2005, which were intended to build up an area of excellence in a school while also building students' values and soft skills (Ministry of

> Education, 2011). Whereas the Niche Programmes motivated schools to focus on accruing awards through building the excellence of a select group of students, the ALP and LLP helped create an environment where every student could try different activities and discover new aptitudes (J. Y. Ng, 2015).

Singapore is by no means the only education system to have adopted an orientation towards 21st century educational goals, or to have identified a set of competencies that students need to develop in tandem with academic growth in order to be effectively prepared for their futures. In Australia, general capabilities were a core element of the first national curriculum, which has been implemented through States and Territories since 2014 (ACARA, n.d.). Similarly, the New Zealand curriculum, published in 2007, contains a set of key competencies to be developed in a range of subjects and across multiple settings (MoE, 2007). In all cases, these competencies or capabilities do not replace academic content, but are presented as transversal outcomes that span academic curriculum areas and should be woven into subjects.

England stands apart from these countries, in that the National Curriculum makes no reference to competencies or capabilities and it has been left to individual school leaders to determine whether to place value on these broader aptitudes and what framework to adopt if they choose to do so[2].

General Capabilities **Australia** **(ACARA, 2019)**	**Key Competencies** **New Zealand** **(MoE, 2017)**	**21st Century Competencies** **Singapore** **(Ministry of Education, 2015a)**
Literacy Numeracy Information and communication technology Critical and creative thinking Personal and social capability Ethical understanding Intercultural understanding	Using language, symbols and texts Thinking Managing self Relating to others Participating and contributing	Communication, Collaboration and Information Skills Critical and Inventive Thinking Civic Literacy, Global Awareness and Cross-Cultural Skills

Table 1. A comparison of competency and capability frameworks from Australia, New Zealand and Singapore

3. Theoretical framework: innovation and change in complex adaptive systems

Shifting education systems from industrial, standardised and outcome-oriented models of education to 21st century, process-focused models which value the development of capabilities alongside academic knowledge, is a slow and challenging endeavour. It

[2] Since I completed my research, Character has been incorporated into the new Ofsted inspection framework, published in May 2019.

inherently involves process innovation – "the implementation of a new or significantly improved production or delivery method" (OECD, 2009, p. 2) – insofar as teachers have to adapt or develop new practices suited to the development of 21st Century Competencies as well as academic knowledge. It can also involve organisational innovation – "the implementation of a new organisational method in…workplace organisation" (OECD, 2009, p. 2) – if schools have to re-design traditional structures to enable change, for example to reduce segregation between academic subjects or to allow time for the collegiate collaboration. It also increases the complexity of policy makers' and school leaders' work, as they shift away from top-down, command and control modes of management suited to the delivery of standardised outcomes, towards enabling and empowering modes where individuals gain the autonomy necessary to foster innovation.

Education systems and the schools within them are fundamentally human organisations – their operation depends on the way individuals act and interact, not on mechanical processes – and they therefore function as complex adaptive systems (Holling, 2001; Preiser et al., 2018). Recognising this helps to explain why it is difficult to achieve system change: simple, linear causality does not apply in complex systems (Preiser et al., 2018), so it cannot be used to determine which policies, programmes or structural changes can be deployed to achieve a desired end state. Furthermore, Holling (2001) argues that complex adaptive systems move through adaptive cycles, during which they go from periods of slow accumulation and transformation of resources, where connectedness and capital within the system increases but the system can become fragile, to short periods of rapid re-organisation during which connectedness and capital is low but innovation can more readily occur. Depending on the state of an education system within this cycle, it may be more or less responsive to attempts to shift it towards a 21st century model of education.

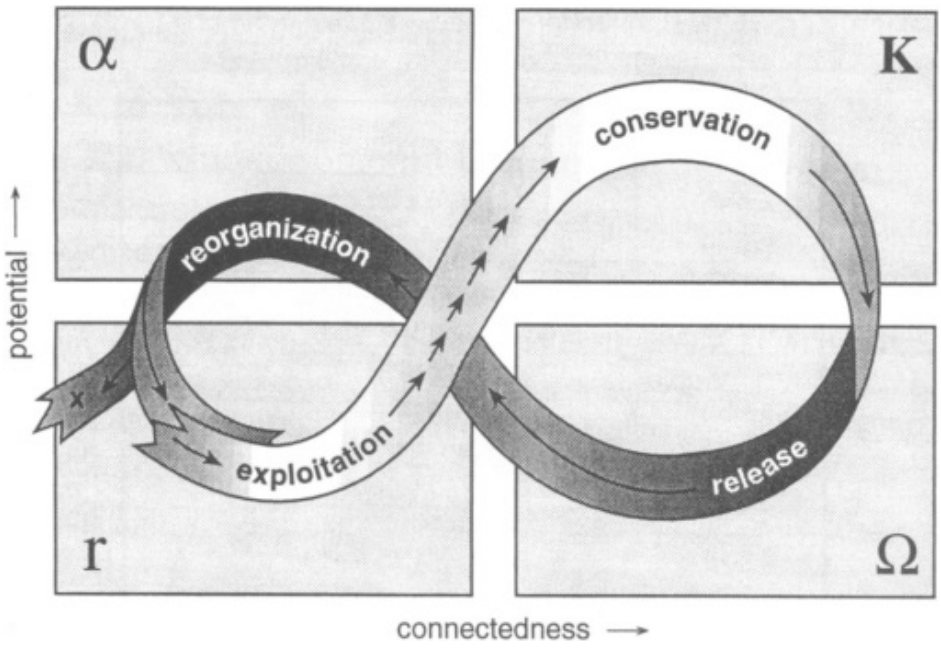

Figure 1. A stylised representation of the four ecosystem functions.

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A representation of the adaptive cycle, which "embraces two opposites: growth and stability on the one hand, change and variety on the other" (p.395).

- *The x axis reflects the degree of connectedness and y axis the potential accrued within the system. Short, closely spaced arrows reflect a slower pace of change.*
- *r to K – "long periods of slow accumulation and transformation of resources" (p.394). At point K the system is highly connected and holds a lot of potential but is also increasingly rigid.*
- *Ω to α – "a period of rapid reorganisation during which novel recombinations can unexpectedly seed experiments that lead to innovations in the next cycle" (p.395).*

This paper focuses on the way in which the structural features of the Singaporean education system, and factors beyond the education system such as the culture and economy, affect the capacity of principals to foster innovation in their schools. Holling's (2001) model positions adaptive cycles within panarchies: "a cross-scale, nested set of adaptive cycles" (p. 397) which are connected in such a way that events at one level of the panarchy may trigger or inhibit changes at other levels. This is a particularly helpful model for considering how broader cultural and economic contexts may affect capacity for innovation within the education system and how this, in turn, may affect capacity for innovation within an individual school, because each can be conceptualised as a complex adaptive system, moving through an adaptive cycle and interlinked with others in a hierarchy.

Six Features of Complex Adaptive Systems (Preiser et al., 2018)

1. **CAS are constituted relationally**

The nature of relations and interactions between the parts in the system and with their wider environment define the system more than the parts themselves. These interactions allow CAS to self-organise and produce emergent patterns.

2. **CAS have adaptive capacities**

As interactions occur, links between parts of the system change and CAS adapt. However, the history of this adaptation is stored in the system's memory and affects its future trajectory.

3. **CAS behaviour comes about as a result of dynamic processes**

The interactions are dynamic and non-linear, so there is no simple cause and effect relation between action and reaction. Perturbations can be amplified or dampened by non-linear feedback loops.

4. **CAS are radically open**

There is an exchange between the CAS and its wider environment so the two naturally affect one another.

5. **CAS are determined contextually**

As system elements interact with the wider environment, the wider environment helps determine the system's structure and that structure and the behaviour and function of elements within it will change as the wider environmental context changes.

6. **Novel qualities emerge through complex causality**

As the interactions between elements are non-linear, system behaviours cannot be predicted from component parts and interventions can cause unexpectedly large or small effects. Component parts that were previously unrelated can become related and outputs from one interaction can become inputs to another.

Table 2. Six features of Complex Adaptive Systems.

In order to aid in identifying the contextual features and system factors influencing within and between each level of the panarchy, I utilise the framework of control factors and explanatory factors (Oates, 2017). This framework is useful for identifying how factors that are intrinsic or extrinsic to the education system affect the way in which principals can act within their school and how others react to their intentions. Within this framework, control factors such as curriculum coherence or accountability are those which are "most amenable to policy action" (Oates, 2017, p. 19) while explanatory factors such as the domestic economy or culture are "those which condition the context of that policy but which are distinctly resistant to direct action in educational policy" (Oates, 2017, p. 19). Relating this back to the notion of panarchy, it is evident that control factors are typically components

within the education system, whereas explanatory factors originate at other levels of the panarchy.

3.i. Leadership, culture and innovation

The role of leaders in fostering conditions for innovation is well-recognised in literature covering private and public sector organisations. Reviews of empirical research conducted in a wide range of organisations identify overlapping sets of cultural characteristics conducive to innovation. These include: freedom or autonomy to engage in self-initiated activity; risk-taking; commitment to and identification with the organisation; mental flexibility or openness to new ideas and change; constructive management of confrontation or disagreements; acceptance of diversity; curiosity; association between apparently disconnected ideas; respect and trust; open flow of communication (Andriopoulos, 2001; Moussa et al., 2018; Naranjo-Valencia & Calderon-Hernández, 2018). These cultural features are supported by management competencies of: effective communication; teamwork; tolerance for error; constructive management of conflict; participative decision-making; simplicity and agility in organisational processes; recognition and rigour; prioritisation (Naranjo-Valencia & Calderon-Hernández, 2018).

I identified a similar set of cultural features in the innovative schools that I visited for my fellowship. Their cultures were defined by collaboration, a developmental orientation, strong relationships, agency and experimentation. The leaders I interviewed modelled collaborative behaviours; adopted the role of lead learner; focused on building relationships; remained open to ideas; responded positively to risks; and, used a range of evidence to inform and evaluate changes (Theobald, 2019b).

In the next section of this paper, I draw on two case studies - of leading innovation at Crest Secondary School and of developing leadership capacity for innovation through the Leaders in Education Programme – to examine the evolving role of principals in leading innovation in Singaporean schools.

4. The role of the principal in Singapore's system change

In the early phases of the Singaporean education system's development, principals held a largely administrative role. Their responsibility was to implement centrally developed policies within their school and ensure, for example, that school finances were managed well (Ho & Koh, 2017). However, as the system has shifted to support an innovation driven economy, it has become important for teachers to adopt new practices, for schools to become more diverse and for principals to tailor school programmes to meet their communities' needs (Ho & Koh, 2017). Such innovative and contextually-responsive practice cannot be achieved via top-down mandates; rather, school leaders have to be given the autonomy to navigate and respond to the novel qualities that emerge from interventions in complex systems.

This does not mean that principals have free rein. The system has shifted to a model of centralised-decentralisation (P. T. Ng, 2007, 2010). The Ministry of Education still plays a central role in affirming the purpose of education, providing guidelines to principals and setting expectations around the most valued aspects of the educational experience. Principals then interpret this centralised guidance with respect to their community's needs and determine how their school's programme will be differentiated from others (P. T. Ng, 2007, 2010).

Co-curricular activities (CCAs) offer one example of such centralised-decentralisation in practice. The Ministry of Education has clearly communicated the importance of CCAs and, through the LEAPS2.0 framework, has provided some specificity around the nature of activities in which students should engage and how their involvement will be recognised. However, each school can then develop its own CCA programme and this becomes one of the differentiating features for parents and students when choosing a school.

Similarly, the creation of the *Framework for 21st Century Competencies and Student Outcomes* by the Ministry of Education (Ministry of Education, 2015a) sets a clear expectation that schools' focus should go beyond their students' performance in examinations, to ensure that students develop as well-rounded, critical and inventive thinkers and as globally aware citizens. Enhancing these Competencies is considered to be as important for the sustained economic success of Singaporean citizens and, therefore, their nation state, as pure academic capability. School leaders can interpret and apply the Framework to suit their school.

4.i. A case study of leading innovation: Crest Secondary School

While in Singapore, I visited Crest Secondary School to see how the principles of Singapore's recent reforms and the *Framework for 21st Century Competencies and Student Outcomes* were being put into practice.

Crest Secondary School, opened in 2013, was the first of the Specialised Schools for Normal Technical Students. It has an innovative combined vocational and academic programme tailored to students who are less academically inclined. In many ways, Crest Secondary School exemplifies the intent of Singapore's recent education reforms. Perhaps more than most students, those at Crest Secondary School rely on their secondary school experience to ensure they achieve the *Desired Outcomes of Education*. Having not been strong academic performers at primary school, Crest Secondary School students often need their confidence as learners rebuilt. They also need their secondary school education to help them find their place as active contributors to society. In an interview in 2014, Mr Adrian Tay who was then the school's Head of Department of Math and Science explained "our mission is to provide a caring and creative learning environment that customizes authentic learning experiences, and equips them for academic progression and employment" (SingTeach, 2014).

The type of curriculum innovation that occurs at Crest Secondary School is reflective of a broader intention within the Singaporean system to ensure that all students are catered for. The intent of recent reforms, including Curriculum 2015, has been to "[build] upon existing strengths while seeking to accommodate a wider definition of talent and ensuring that

weaker students can access a relevant and meaningful curriculum within the system" (Deng et al., 2013, p. 15).

When Crest Secondary School was established, the teachers were expected to create an innovative curriculum and adopt new pedagogical practices that not only served their students well but could act as a point of learning for the rest of the system. In 2015, the then Minister for Education, Mr Heng Swee Keat, explained how "We learn from the good ideas that are working well at Crest and at the same time we draw lessons that will be useful to every school in Singapore" (Ministry of Education, 2015b).

One of the goals of *Thinking Schools, Learning Nation* was to provide opportunities for students to engage in applied and inquiry-based learning (Poon et al., 2017). All secondary schools offer such opportunities through their Applied Learning Programmes and Learning for Life Programmes, and, by 2023, so will all primary schools (Ministry of Education, 2018a; P. T. Ng, 2017), but at Crest this type of authentic learning was core to the teaching and learning approach from the outset. In 2013, Mr Christopher Go, a PE teacher, described "Students do not merely learn how to assemble and fix a bicycle; they explore the mechanism of how bicycles work. Learning can even be extended to how different muscle groups and energy systems work when they ride a bicycle" (SchoolBag, 2013).

During my visit to Crest Secondary School, I asked Principal Mr Seet Tiat Hee (who succeeded founding Principal Mr Frederick Yeo), to describe how he enabled innovation amongst his teachers. He began by noting how important it was for his staff to innovate, because the teaching methods his staff had learned in other schools were not always appropriate for the students at Crest Secondary School and alternative strategies were needed to support student achievement. It is a reflection of schools as complex adaptive systems that Principal Tiat Hee's staff had to get to know their students and then develop teaching methods and curriculum content to meet their needs. Complex adaptive systems are defined by the interactions between their parts rather than the parts themselves (Preiser et al., 2018). In this case, the students' previous experiences of education had shaped their readiness to learn at Crest. Furthermore, the teachers could not guarantee how students would respond to the innovative curriculum and pedagogy, rather they had to test out ideas and iterate them based on the way in which students reacted, a reflection of the non-linear and complex nature of the learning process. The curriculum and pedagogy at Crest could not be developed and imposed by a central team at the Ministry of Education, its development had to be a contextualised process.

In order to enable this innovation, Principal Tiat Hee explained how he would try to be supportive of all his teachers' ideas and would be understanding if things did not go to plan. This reflects research by Hung et al (2016) on the scaling and diffusion of educational innovation in Singapore; they also emphasise the need for leaders to trust in teachers throughout the process of innovation, even if results may dip during the early stages.

This need for trust and understanding was not unique to the principal-teacher relationship. Principal Tiat Hee explained how his behaviour towards teachers mirrored the behaviour he expected them to exhibit towards students. Just as he was understanding if a teacher's idea

did not go to plan, he looked for his teachers to be compassionate when students made mistakes. He also created an emotionally supportive environment for his teachers and he similarly expected them to consider the wellbeing of students. Principal Tiat Hee's behaviours echoed a broader pattern I observed in my research. I found that across the schools I visited, the principals reflected on the behaviours they needed their staff to adopt if they were going to innovate successfully and then actively role-modelled those behaviours themselves (Theobald, 2019a).

Other competencies that Principal Tiat Hee mentioned drawing upon would be recognisable within any effective leader (Leithwood et al., 2008): strategic thinking, the ability to look outward and set direction, and effective people skills. What differentiated his leadership at Crest was the need to ensure his teachers experienced an emotionally and professionally supportive environment that led them to feel safe to take the risks that are necessary to develop truly innovative practice. This reflects the broader literature specifying leadership behaviours and culture that support innovation: leaders who exhibit openness to ideas and tolerance for error, and who build trusting relationships, create a culture in which staff are empowered to innovate (Andriopoulos, 2001; Naranjo-Valencia & Calderon-Hernández, 2018; Theobald, 2019b).

In the next section, I explain how Singaporean principals' professional development is tailored to prepare them to lead innovation in complex environments.

4.ii. Developing Singaporean school leaders for future-focused schools

Aspirant principals in Singapore are supported to develop the knowledge and competencies needed to drive innovation in their schools as part of the Leaders in Education Programme (NIE, 2013). The design of the LEP is tailored to preparing principals to lead through complexity: rather than specifying the precise knowledge, skills or competencies the participants should develop, the programme scaffolds a process of emergent, self-organising and non-linear learning, based on the broad range of information and experiences to which the participants are exposed, and the problem-solving they have to navigate (D. Ng, 2015). Participants are also encouraged to adopt a cycle of action and reflection, which equips them to lead in a complex environment (Wong & Ng, 2020) where problems may have multiple solutions and each action may have multiple consequences.

Participants in the programme undertake a placement in a host school – the Creative Action Project - where they must implement an innovation, leveraging their influencing skills to do so without a formal leadership role in the school. The CAP acts as a vehicle for action-learning in a complex environment. Participants can draw on the knowledge gained through other programme elements – lectures, reading, organisation visits and international visits – as they develop hypotheses for an innovative solution to the problem they have identified in the school. Through discussions with their syndicate group (a group of five to six peers, led by a faculty facilitator) and through self-reflection, they can make sense of this knowledge, relate it to the problem at hand and reflect on the impact their actions have had in school

(which are not readily predictable, given the non-linearity of outcomes in complex organisations such as schools) (D. Ng, 2015).

Participants are encouraged to utilise their training in design thinking and futuring as they develop their ideas:

> *Using the principles of Futuring and Design Thinking, each participant has to envisage what the school will be like in 10-15 years' time and implement a component of this future school that is currently feasible and desirable.*
>
> (NIE, 2013, p. 4)

The leadership development providers I visited in Australia and New Zealand – Bastow Institute of Educational Leadership in Victoria, Association of Independent Schools of New South Wales, Education Changemakers across Australia, The Mind Lab in New Zealand - all incorporated the principles of design thinking into their development programmes, along with other design features such as organisational visits, peer learning and discussion through syndicates. It is therefore striking to contrast the structure of the Creative Action Project with the analogous aspects of England's National Professional Qualification for Headship (NPQH). Within the NPQH, prospective headteachers (prospective principals) are required, in their home school, to "Lead [a] change programme at whole-school level, lasting at least 2 terms, to improve pupil progress and attainment" (DfE, 2019, p. 46). In a placement school they are required to "Research the placement school's current and/or projected resource and capability challenges, and design an action plan to address these" (DfE, 2019, p. 47).

Design thinking and innovation do not feature in any of the National Professional Qualifications for leaders offered by England's Department for Education. Aspirant headteachers are encouraged to learn about principles of change management, but with the aim of driving improvement in students' headline academic outcomes, as defined by the Department for Education's accountability framework, rather than exploring broader priorities or examining how effectively the educational practices in their school equip students to be active citizens or adaptable in their careers.

A common thread between the Singaporean model of principal development and the provision I observed in other jurisdictions was a focus on encouraging critical inquiry and a re-imagining of education. By building aspirant principals' skills in design thinking, these jurisdictions equip them to understand constraints in the current system and actively re-imagine schooling to better suit their students' needs. However, unlike in Australia and New Zealand, through the process of centralised-decentralisation, principals in Singapore have a narrower field of vision through which to re-imagine education, since the purpose of education and valued outcomes are set at the system level. In that sense, while the principles of principal development in Singapore seemed more aligned to those I observed in Australia and New Zealand, it is possible that Singaporean principals' experience of system boundaries is closer to that of school leaders in England.

5. System factors affecting principals' capacity for innovation

The role of the principal in fostering school-level innovation cannot be examined in isolation. Instead one has to consider the influences acting upon them and their school from the broader education system, economy and societal culture. These higher levels in the panarchy act as cultural determinants for innovation within schools.

The Singaporean education system has long been recognised as a vehicle to promote social cohesion and economic sustainability (Gopinathan, 2015) and it has been strategically managed to meet Singapore's broader social and economic needs (D. Ng, 2008). The education system sits as a sub-system within a panarchy, with higher levels being Singapore's economy and society, which in turn are sub-systems to the South-East Asian and global economy. For example, recessions in 1985, 1997 and 2001 triggered Singapore to seek out new competitive advantages, resulting in shifts in the desired make-up of the economy and new requirements for the knowledge and skills that the education system needed to deliver (D. Ng, 2008). The 1997 Asian financial crisis in particular catalysed efforts to re-orient the education system towards 21st century competency development (Gopinathan, 2015).

Singapore is recognised internationally for achieving high levels of coherence between education policy and other areas of government, and coherence within aspects of education policy (Oates, 2017; OECD, 2011). Coherence within the education system reflects Singaporean policy makers' recognition of the complexity of the education system and of the way in which different control and explanatory factors may interact and affect the success of reforms. The range of reforms listed at the start of this paper exemplify how, under the broad umbrella of an initiative such as *Thinking Schools, Learning Nation*, policy makers leverage multiple control factors, observe interactions between them and adjust further to facilitate reform.

In this section I highlight some of the control factors I observed being actively leveraged in Singapore to promote innovation along with others that can inhibit the adoption of innovative practice in schools. I discuss how societal culture acts as a critical explanatory factor, moderating the impact of these control factors on the state of the system. I draw contrasts with other jurisdictions in order to illustrate how specific control factors and explanatory factors may affect principals' capacity for innovation in Singapore.

5.i. Consistency of policy and the steady pace of change

Since Singapore gained independence and the foundations of its current education system were laid, there has been an ongoing commitment to evolving the education system in the name of improvement. This reflects an early and ongoing acknowledgement that, given Singapore's lack of natural resources, investment in human capital through a high quality education system would be essential to the nation state's sustainability (Gopinathan, 2015). In this sense, the entire Singaporean state could be viewed as having an entrepreneurial orientation (Naranjo-Valencia & Calderon-Hernández, 2018) insofar as policy makers have

recognised that Singapore is in competition with other nations and have pursued ongoing change in order to create and then sustain a competitive advantage.

The Singaporean education system is certainly not static. As recently appointed Minister for Education, Mr Lawrence Wong, has stated: "we are constantly looking to fine-tune and improve the system" (Ministry of Education, 2020a). However, as the word 'fine-tuning' implies, educational change in Singapore rarely involves drastic or sudden shifts; it is carefully planned and steadily implemented, often in partnership with other agencies such as the Ministry of Manpower and Economic Development Board (Gopinathan & Naidu, 2020). These agencies act to connect the education system with the economy, so that structural change in the economy triggers adaptation in the education system; re-organisation and change at one level of the panarchy triggers a change in conditions for another.

The current, future-focused educational orientation has been pursued in some form since 1997 and builds upon existing system structures. As described earlier, successive policies have been designed to incrementally shift the system away from being exam-oriented and towards a more holistic and life-long view of success. This incremental approach is suited to the complex nature of education systems, because the same reform can trigger multiple outcomes depending on the prior state of the system (Holling, 2001). Therefore the impact of previous changes has to be assessed before further changes can be planned. Furthermore, the consistent messages from multiple government Ministers around the direction of reforms can be analogised to organisational leaders clearly communicating their strategy. If employees understand their organisation's mission, vision and objectives they can be inspired by them and prioritise and focus their innovation (Naranjo-Valencia & Calderon-Hernández, 2018). The more that school leaders understand and embrace the intent of educational reforms, the more capable they are of fostering innovation in their schools.

To place the pace and stability of Singaporean reform in perspective, since 1997 in England schools have experienced Labour, Coalition and Conservative policy agendas. Leaders have been told to value personalised learning (Department for Children, Schools and Families, 2008a; NCSL, 2005), social and emotional learning (Department for Children, Schools and Families, 2008b), core academic subjects (Department for Education, 2010), character development (Department for Education, 2016), and a knowledge-rich curriculum (Department for Education, 2017). In some schools this has translated into continuous, fast-paced and exhausting change. In other schools, it has translated into continual resistance or the selective adoption of initiatives that already align with the school's priorities (Bates, 2013; Lynch et al., 2017).

Some academics do describe Singaporean teachers' perceptions of transformation at the school level as "incessant and seemingly endless" (Reyes & Chua, 2014, p. 1). As an outside observer on the Singaporean system, it is indeed evident that reform is "seemingly endless" insofar as there are continued efforts to reflect on and improve the adequacy of the current system for meeting Singapore's future economic needs. However, it is also evident that the system experiences unusually high levels of stability and coherence in the *direction* of

reforms and the values underpinning them, aided by the way in which educational reforms are aligned to economic reforms by inter-ministerial committees (D. Ng, 2008). In other words, to relate back to Holling's model of an adaptive cycle (Holling, 2001), reform in the Singaporean system seems more analogous to the "slow accumulation and transformation of resources" (p.394) associated with incremental system change, whereas in England reform can feel more analogous to the short, disruptive periods of rapid reorganisation which are associated with reinvention, but are also comparatively unproductive.

In this sense, Singapore benefits from the continuity of values and policies that arises from having had the same party – the People's Action Party – in power since 1959 (Gopinathan, 2015). The consistent direction of reform in the Singaporean education system means there is time to trial, test and grow relevant practice. For example, there have been successive ICT Masterplans in Education since 1997. Each plan has built on the previous one, starting with deploying technology in more schools, then building teachers' capability, then building students' capacity to use technology collaboratively and become responsible digital learners (J. P.-L. Tan et al., 2017). The Singaporean government has also leveraged funding as a control factor that can encourage and target innovation. Forerunner schools, namely the incubator schools, LEAD schools and then FutureSchools, have been given additional resources so that they can experiment with technology and develop innovative practices (Reyes & Chua, 2014). The intention is that these schools then lead professional development for teachers in other schools and support the diffusion of practice across the system (Hung et al., 2016).

Overall, coherence and stability at the over-arching system level creates a foundation for localised innovation in schools, insofar as it helps make the strategic intent of policy makers clear. Clarity of strategy helps actors within an organisation to focus their innovation efforts towards valued outcomes (Naranjo-Valencia & Calderon-Hernández, 2018). In the case of the Singaporean education system, it helps leaders focus their staff towards future-focused innovation that contributes to building students' 21st century competencies and realising the *Desired Outcomes of Education*.

5.ii. Collaboration and networking

Having set a clear vision for the system's direction, Singaporean policy makers no longer rely on centralised development of practice, nor on top-down mandates to implement it across the system. Innovation is more prevalent in an organisational culture where people have the autonomy to pursue self-initiated activity (Naranjo-Valencia & Calderon-Hernández, 2018). As early as 1997, then-Minister for Education Mr Teo Chee Hean acknowledged that "To be creative and responsive, schools can no longer be managed by a centralized top-down approach in problem-solving and in implementing change" (Teo, 1997). The Minister recognised that the desired level of innovation could not be mandated by the Ministry of Education but had to arise from "local initiative with collaborative local decision making" (Teo, 1997). A school cluster system was introduced to decentralise administration and increase school autonomy (Gopinathan, 2015). This led to the increased role for principals in leading school-level innovation described in section four.

The Ministry of Education seeks to enable collaboration within schools through Professional Learning Communities, consisting of several professional learning teams (Hung et al., 2016; Hung, Lee, & Teh, 2015). Such networks facilitate the open flow of communication and capacity to make connections between apparently unrelated things that are characteristic of innovative organisational cultures (Naranjo-Valencia & Calderon-Hernández, 2018). Recognising the self-organising and contextually-determined nature of complex systems, the Ministry of Education has tried to avoid being overly prescriptive about how Professional Learning Communities should be implemented. In principle, this should enable members of the Community to align it to their context and needs. There may, however, be a tension in the implementation of Professional Learning Communities between the top-down requirement for teachers to engage in them and the absence of prescriptive direction around what that engagement should involve. While intended to give teachers the professional freedom and agency to tailor Professional Learning Communities to their context, it can result in confusion and concern amongst teachers that they are not implementing them as intended (Hairon & Tan, 2017).

While a principal can foster collaborative innovation amongst their own staff, support is needed to facilitate the cross-school collaboration and networking that enables localised innovations to spread across the education system (Hung, Lee, & Teh, 2015). Such spread may not involve replication of a practice with perfect fidelity. The priority may be to encourage the acceptance of a general principle, such as integrating digital devices into teaching, rather than the precise replication of a teaching practice, as exemplified in Hung et al's (2016) description of the 'designed wide' model of innovation spread. This focus on acceptance of general principles aligns with the nature of schools as complex adaptive systems. These systems are defined more by the relation between parts than the parts themselves (Preiser et al., 2018), so the same practice or technology may have a different impact when adopted in a new school, due to its interaction with other pre-existing practices. It may therefore be more relevant to build a shared understanding of the core design principles of an innovation than the exact methods, technology or behaviours previously deployed (Hung, Lee, & Wu, 2015).

Structurally, the school cluster model facilitates closer working between schools within a cluster and part of the cluster superintendent's role is to facilitate communication and ensure resources and practices are shared between their schools (Ministry of Education, 2020b). The Ministry of Education also enables collaboration between schools via Networked Learning Communities, through which teachers can observe, refine and share practices (Hung et al., 2016). Specific system actors also support the spread of innovation. Education Officers from the Ministry of Education can identify teachers who have developed promising practices and actively support them to share them more widely. National Institute of Education researchers can also facilitate access to resources, broker partnerships and provide professional development to aid the refinement and spread of practices (Hung et al., 2016).

Effective communication, flow of information and the capacity to connect unrelated ideas are all cultural features that facilitate innovation (Naranjo-Valencia & Calderon-Hernández, 2018). The learning communities established within and across schools provide an

architecture with the potential to enable the emergence and diffusion of innovative, future-focused practices. However, this is also dependent on teachers prioritising these practices as the end goal for their collaboration.

5.iii. High stakes exams and parental expectations

Since *Thinking Schools, Learning Nation* was introduced in 1997 by the then Prime Minister Mr Goh Chok Tong, successive Ministers of Education have emphasised how the outcomes of Singaporean education must go beyond strong examination performance, to develop young people who are critical and creative thinkers, who can compete at the upper end of the global economy. In 2017, the then Minister of Education, Mr Ng Chee Meng, introduced the notion of 'joy of learning' (Ministry of Education, 2017a, 2017b) explaining that "School should not just be about doing well in exams. It should be an exciting place to acquire knowledge and skills" and that applied learning should mean students "do not just learn theories, but get to apply learning to real world contexts" (Ministry of Education, 2017b).

Ministers have not been blind to the way in which the design of the education system affects principals' capacity to respond to this mission. As detailed in the introduction to this paper, structural changes and system reforms have been progressively implemented, leveraging control factors such as curriculum content to try to enable principals to re-orient teaching and learning towards future-focused aims. However, metrics and rewards "communicate the … values more clearly than any written declaration" (Naranjo-Valencia & Calderon-Hernández, 2018, p. 20) and are a central force for aligning behaviours to organisational objectives. In Singapore, for many community members and students, the predominant metric of educational success remains exam results.

Despite efforts to reduce fine-grained differentiation between students, for example through moving from giving primary students one of 29 banded scores rather than one of over 200 t-scores (Ministry of Education, 2020c), exams such as the PSLE continue to be a central determinant of students' future educational opportunities (Ministry of Education, 2020d; Teng, 2018). PSLE results still determine whether students can go to a 'high status' school, as perceived by parents, and hence parents remain willing to invest considerable sums in tutoring to ensure their children master content in preparation for exams (Gopinathan & Naidu, 2020; P. T. Ng, 2017). Singaporean secondary school students continue to be stressed about their examination performance, even in the midst of a pandemic (Ang, 2020)

Consequently, despite ongoing reform efforts, day-to-day practice and mind-sets have not been easy to shift. In the early 2010s, more than a decade after the then Prime Minister, Goh Chok Tong's *Thinking Schools, Learning Nation* speech, it was reported that many teachers still held views that:

> *"teaching is talking and learning is listening", authority is "hierarchical and bureaucratic", assessment is "summative", knowledge is "factual and procedural," and classroom talk is teacher-dominated and "performative"*

(Hogan, 2014)

My more recent experience in Singapore suggested that teachers' mindsets may have evolved since these observations were made. However, even with mindsets shifting and the system being carefully and intentionally reformed to facilitate pursuit of a 21st century vision of teaching and learning, teachers can still feel constrained by remaining system structures and by culture.

In January 2019, I attended a seminar held for teachers, schools leaders and Ministry of Education staff at the National Institute of Education. During the seminar, educators shared their reflections on the notion of 'joy of learning' via a digital portal. Their posts articulated some of the key constraints acting upon them, each of which compounded one another, making it hard for the teachers to adopt the constructivist methods they considered to be 'good teaching'.

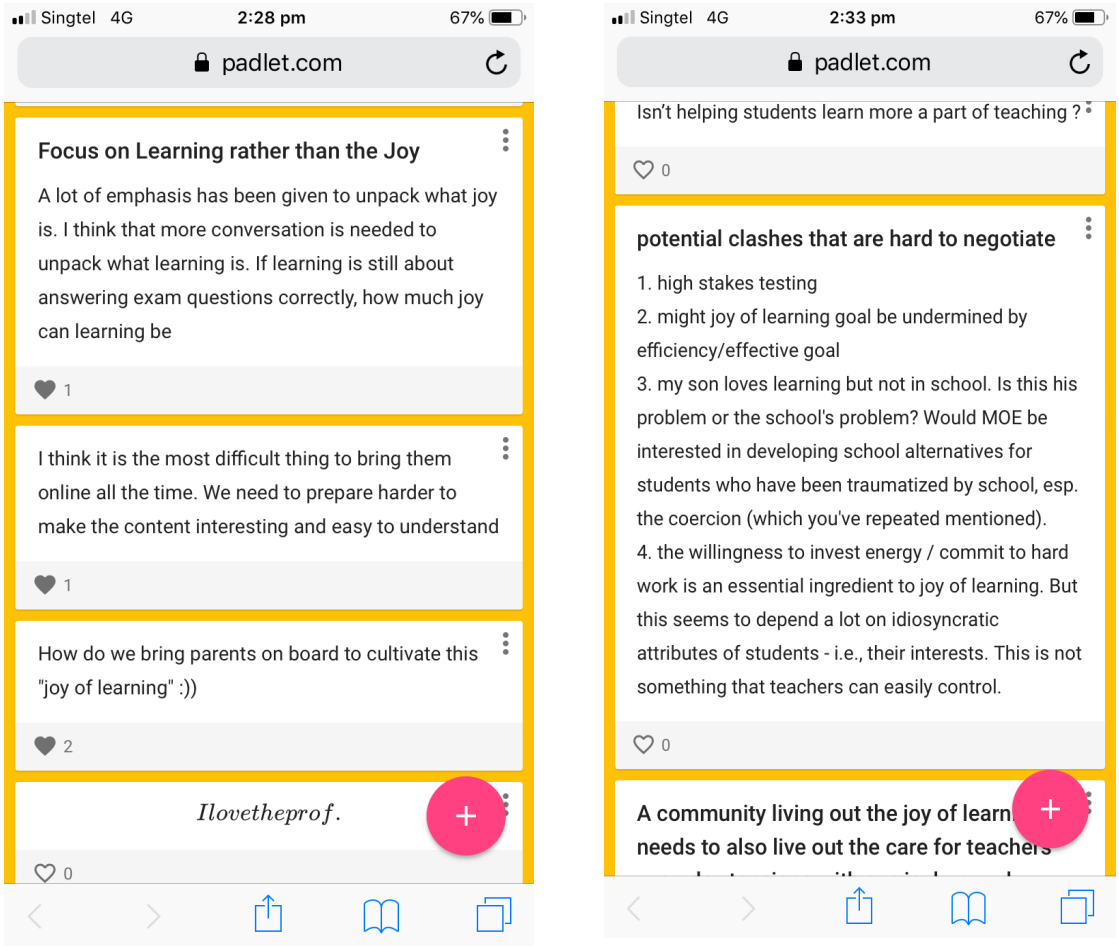

Figure 2. Screenshots of comments from Singaporean educators at an education seminar, taken January 2019

The posts asked "How do we bring parents on board to cultivate this 'joy of learning'" and "If learning is still about answering exam questions correctly, how much joy can learning be". They highlighted how parental expectation around the content students should cover and the high stakes nature of examinations put continued pressure on teachers to focus on teaching to the test. This constrained the teachers' perceived ability to adopt constructivist methods and nourish a 'joy of learning'.

Similar themes arise from other research. For example, in a case study examining the adoption of ICT innovations, one teacher explains:

> *There is a great fear of loss because all this drilling actually has produced excellent results and we obtained so many awards. There is a fear among us of letting go. The challenge is to see whether abandoning "drill and kill" and shifting to learner-centred approaches through ICT would necessarily mean that the results go down.*
>
> (Reyes & Chua, 2014, p. 10)

This aligns with the seminar comment "might joy of learning by undermined by efficiency/effective goal". In other words, can a shift to a wider range of teaching methods be reconciled with the need to cover content efficiently and ensure students are ready for exams? Deng, Gopinathan and Lee (2013) describe how a 'hybrid pedagogy' has emerged amongst Singaporean teachers where teachers combine direct instruction with constructivist learning principles but where "high stakes examinations…limit teacher efforts in pedagogical innovations" (p.268).

I observed similar tensions between maintaining academic performance and trialling innovations in each country I visited and recognised them from my experience in England. However, I observed how the wider system context affected the level of risk perceived to be associated with innovation and therefore how leaders responded.

In England, students' public exam results are one of the main ways by which school performance is judged and school leaders are held to account. Consequently, school leaders can be concerned about doing anything that risks exam performance and some argue that they are only safe to innovate once their students are performing well on these public measures (Bates, 2013; SASPA, 2020). In contrast, the school leaders I interviewed in Australia and New Zealand who were working with communities experiencing socio-economic disadvantage argued that low academic performance was a justification for change. While change presented a risk, for their students the opportunity to achieve better life outcomes than they were within the current system outweighed the possible short-term costs:

> *It's not the norm and it's not the safe option. But when you look at the rationale behind this, this demographic of child is not succeeding in the current system, the current ways. You need a circuit breaker.*
>
> *School Leader, New Zealand*

Conversely, educators in New Zealand and Australia who worked with schools in more advantaged areas explained how it could be hard to convince those communities that change was warranted.

> *There will be some, one comes to mind, a very prestigious boys' school in the city, always gotten great results, they don't want innovation because they have good results and that's why people send their boys to that school.*
>
> *Educator working with more advantaged communities*

This observation holds parallels with the experiences of Singaporean principals as they respond to the central vision of innovation: "Why change a strategy when it brings so much examination success?" (C. Tan & Ng, 2006).

These cross-jurisdiction comparisons show how the challenges facing the Singaporean system are neither unique nor easy to overcome. The Ministry of Education recognises how control factors including curriculum content and assessment and qualifications influence the system and has sought to reduce curriculum content and lower the stakes of exams to make space for teachers to adopt a broader range of pedagogies. However, as I elaborate on in the next section, culturally many parents continue to value exam performance and results remain a key metric of success for teachers, so they continue to perceive a drop in exam performance a major risk if implementing innovations. The Ministry also faces the challenge that explanatory factors such as culture are "not something amenable to policy" (Oates, 2017, p. 21) and entrenched practices, cultural constraints and the unintended consequences of high stakes examinations are hard to alter.

5.iv. Reflection: Understanding system factors influencing innovation through the lens of complex adaptive systems

The Singaporean approach to system change – looking holistically at the system, taking change at a steady pace, monitoring the impact of policies and then 'fine-tuning' those policies in light of foreseen and unforeseen consequences – is well-suited to achieving incremental change within a complex system. Historically, this steady approach has served Singapore well; in forty years the state has transformed from having a predominantly low-skilled and partially literate citizenry in the 1960s to having a highly educated workforce and school students who are some of the highest academic performers in the world (Data.gov.sg, 2020; Goh & Gopinathan, 2008).

However, the latest tranche of reforms appear to pose a particular challenge. Having honed a system that enables high academic performance, the aspiration now is to step back, or at least sideways, to prioritise 21st Century Competencies and develop students' critical and creative faculties alongside their academic prowess. Teachers are being asked to modify efficient practices which "produced excellent results" (Reyes & Chua, 2014, p. 10) and to focus time on applied and inquiry based learning. However, they struggle to do so and businesses in Singapore continue to bemoan graduates who have straight A grades but lack resilience or cannot think outside the box (Lim-Lange, 2020; Zaharia & Ungku, 2017).

One of the challenges as complex adaptive systems are honed in their current state is that they become increasingly rigid (Holling, 2001). In the case of the Singaporean education system, it seems the careful refinement of the system that has enabled it to perform so well to date now makes it less responsive as the goals of the system change.

The teachers and leaders within Singapore's education system have, by and large, been educated within it. They have therefore absorbed the values that were present in the system over previous decades; a system historically premised on mastering content and knowing the correct answers in order to perform well in key examinations. Their experiences help to create a system memory, which affects the system's future trajectory (Preiser et al., 2018). This helps explain why, despite a shift towards centralised-decentralisation and an intent for educators to interpret and implement policy locally, educators remain concerned about interpreting central policy 'correctly' (Hairon & Tan, 2017), a sentiment which acts in tension with the willingness to take risks and potentially fail that underpins the process of innovation. It also explains why it can be challenging for those adults now responsible for implementing the new policy intent to achieve the necessary mind-set shift. As Associate Professor Suzaina Kadir, of Lee Kuan Yew School of Public Policy, articulated in a recent panel discussion:

> *It is in my view quite a substantial mind-set shift actually. It's extremely extremely difficult for those of us that have emerged out of a system that's, in the current context, just rather old and traditional. I'm a product of that, I'm also a parent.*
>
> (Kadir, 2020)

Not only have most parents experienced the education system that the government is now seeking to shift, they also hold cultural values that emphasise the importance of examination success. As acknowledged by the then Minister for Education, Mr Ong Ye Kung:

> *I know that 'coming in first or second', in class or level, has traditionally been a proud recognition of a student's achievement. It is even a greeting used in certain festivities like Chinese New Year – "**恭喜**发财，祝你的孩子每年考第一。" In English, it is "Gongxi Facai. I hope your child will always come in first." Such a mind-set is very deeply rooted in our culture.*
>
> (Ministry of Education, 2018b)

As Holling (2001) notes, larger, slower cycles in a panarchy – such as culture - can act to slow change at lower levels by placing constraints around renewal. The slow-changing cultural values that have historically contributed to the success and high performance of the Singaporean system have now become a barrier to change. While the Ministry of Education has made some effort to reduce the emphasis on examination results by, for example, placing PSLE results in bands (Ministry of Education, 2017b), the PSLE itself remains strongly defended (Teng, 2018), the national syllabus and school curricula remain closely aligned to the content of high stakes examinations (Hogan, 2014) and parents remain heavily focused on their child's exam success. Teachers then face the challenge of bringing "parents on board to cultivate this 'joy of learning'".

There are some schools that realise the full aspiration of the *Framework for 21st Century Competencies and Student Outcomes*. The leaders and teachers at Crest Secondary School have achieved the level of innovation that is aspired to across the system. Why has this innovation been possible at Crest when teachers in some other schools still struggle to shift their practice? In my mind, the answer comes from the comment made by the New Zealand educator who argued "this demographic of child is not succeeding in the current system…you need a circuit breaker". The students who come to Crest are there because they have not attained strong academic results in the more typical primary system. For them, the innovative curriculum at Crest acts as a circuit breaker by offering them a different way to engage in learning. The mainstream system was not optimal for these students, and hence their families do not apply the same pressure for them to perform against mainstream metrics. I would argue their connectedness with that system was therefore weaker, making it easier to engage in something new.

6. Discussion and conclusion

In visiting Singapore as part of my Churchill Fellowship, my intention was to understand how future-focused education was implemented in an education system identified as 'high-performing' according to internationally recognised measures.

My review of the design and content of the Leaders in Education Programme demonstrated a commitment to equipping principals with the skills to re-imagine aspects of education through techniques such as futuring and design thinking. I also learned how principals' re-imagining was carefully focused through the system lenses of the *Desired Outcomes of Education* and the *Framework for 21st Century Competencies and Student Outcomes*. Visiting Crest Secondary School, I saw an example of how these *Desired Outcomes of Education* could be realised through an innovative curriculum, delivered using practices such as inquiry-based and applied learning, which have been encouraged across the system (see Ministry of Education, 2018b).

However, the teacher comments I observed at a National Institute of Education seminar illustrated an ongoing tension between the intent of recent reforms and the metrics and cultural values that teachers experience. At the system level, this is evident as a complex interplay between different control factors and explanatory factors (Oates, 2017), some of which could facilitate innovation and others which could inhibit it.

On the one hand, the Singaporean system is set up with a policy orientation and many structural features that should support future-focused innovation. Since 1997, through initiatives such as *Thinking Schools, Learning Nation* and *Teach Less, Learn More,* successive Ministers of Education have emphasised a need for schools to prepare students to engage in an entrepreneurial and increasingly digital economy. Ministers have acknowledged this requires teachers to adopt new pedagogical practices and have adjusted the curriculum and assessment load with the intent of freeing up more time for project-based and inquiry-based learning.

With regards to pedagogical innovation, the establishment of Professional Learning Communities and Networked Learning Communities creates the foundations for collaboration that are necessary to nurture and spread new ideas and practices. Furthermore, the government has actively invested in innovation through initiatives such as the ICT Masterplans, where selected schools focus on experimenting with technology and developing practices that can be shared across the system. The government has leveraged multiple control factors – curriculum content, assessment and qualifications, funding, institutional development, institutional forms and structures, professional development – to steer the system towards adopting future-focused frameworks and educational practices. Overall, there is an unusually high level of coherence underpinning the various system reforms undertaken in Singapore to support a shift towards an education system that prepares students holistically for the 21st century.

Despite these efforts, however, practice in the classroom has been slow to change. In the early 2010s, some teachers still reportedly believed that "teaching is talking and learning is listening" (Hogan, 2014) and the existence of high stakes examinations has continued to inhibit pedagogical innovation (Deng et al., 2013). Although successive ICT Masterplans have introduced technology into schools, Hung and Huang (2016) reported that: "we have observed that despite the provision of innovations on technology-enhanced, inquiry-based learning, teachers do not necessarily use innovation sustainably and pervasively" (p.28). Some teachers were therefore challenged when forced to master remote learning technologies when students began learning from home during the circuit breaker phase of the COVID-19 response (Robert, 2020; J. Tan, 2020).

Several cultural and systemic factors which act as a 'system memory' may explain why practice has been slow to shift in response to policy intent. Teachers educated within a system that focused on academic performance and equipped them to give a 'correct' answer are now being asked to contribute to the creation of a system with different values. Despite aspiring to a form of 'centralised-decentralisation' where schools are empowered to respond in a localised manner to the broad vision set by the Ministry of Education, some researchers still report that teachers are concerned about interpreting central policy 'correctly' (Hairon & Tan, 2017). A substantial shift in mind-set is needed for teachers to innovate freely.

Even more significantly, despite all the efforts made by Ministers of Education to lower the stakes of assessments and discourage an excessive focus on exam performance, high exam scores are still seen as the mark of success for students and, perhaps more importantly, their parents. Culture is a strong explanatory factor that can shape behaviours in an education system without being readily open to influence through policy. As a larger and slower system, its influence acts to slow the pace of educational change. My experience at the NIE seminar suggested that while parental pressure remains strong and exams remain high stakes, teachers will continue to struggle to focus on engendering a 'joy of learning' rather than on delivering good exam results.

In his model of complex adaptive systems, Holling (2001) argues that systems go through different phases. During "long periods of slow accumulation and transformation of

resources" (p.394) the capital of the system increases and it also becomes increasingly connected and stable. Arguably, this was the position of the Singaporean system in the early 2000s – high performing on traditional academic measures and highly coherent in the way control factors had been leveraged to achieve this performance – as leaders embarked on pursuing the intent of the *Framework for 21st Century Competencies and Student Outcomes*. My own experience and broader literature (Deng et al., 2013; Hogan, 2014; Reyes & Chua, 2014) indicate that practices in many schools remain similar to those evident in the early 2000s. Despite concerted reform efforts since 1997, businesses still find that high achieving graduates lack 21st century capabilities such as inventive thinking (Lim-Lange, 2020; Zaharia & Ungku, 2017). These employers are doing their best to complement or circumvent traditional measures of academic success in order to identify the young people who will bring entrepreneurial value to their companies (Davie, 2019; Lim-Lange, 2020).

While complex systems can change incrementally within a long period of relative stability, as connectedness increases – as the different control factors in the system are aligned and become mutually reinforcing – the system becomes more rigid and less flexible or adaptable (Holling, 2001). Complex systems will resist shifting to a new state unless the perturbation they experience is large enough, at which point a more fundamental change can be achieved (Scheffer et al., 2001; Sugiarto et al., 2015). Drastic innovation and restructuring occurs in a distinct phase of rapid reorganisation (Holling, 2001) which can reset the system into a 'new normal'.

Leaving Singapore, I realised the system is still working towards a balance between academic performance and 21st Century Competency development. The question in my mind was whether, with further persistence and incremental reform, the system will shift track and see teachers adopting different teaching methods and students becoming more entrepreneurial. Alternatively, it may be that the careful, intentional and incremental planning that has brought the system to this point has also created a system too interconnected to make this type of change. If this is the case, a critical event may be needed to instigate 'creative destruction' and more whole-scale system change. Few events have been more disruptive than COVID-19, so perhaps now is the moment of change.

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8. Acknowledgements

My research was generously funded by the Winston Churchill Memorial Trust. I would like to extend my thanks to Prof Saravanan Gopinathan, Assoc Prof David Ng, Dr Neil Gilbride and Dr Charleen Chiong who offered feedback on earlier versions of this paper and to all of the participants who gave freely of their time to contribute to my research. Responsibility for any errors or inaccuracies is mine alone.