Chapter 12
Preparing Students for the Twenty-First Century: A Snapshot of Singapore's Approach

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Abstract The teaching and learning of twenty-first century competencies in Singapore schools began with a vision in 1997. The Thinking Schools, Learning Nation (TSLN) vision initiated a series of educational reforms to strengthen thinking and inquiry among students, preparing them for learning and working in the twenty-first century. The momentum generated from the TSLN vision led to the development of the *Framework for 21st Century Competencies and Student Outcomes* which articulates the twenty-first century competencies that will be nurtured in schools – civic literacy, global awareness and cross-cultural skills, critical and inventive thinking, and communication, collaboration and information skills. This chapter narrates the policies and approaches that were central to TSLN, specifically on the structural and curricular changes, the re-perception of teaching and learning and a redefinition of the role of teachers. TSLN, which captures the central ideas of preparing students for the twenty-first century, was never conceived as a programmatic change in that it did not contain an explicit set of intervention strategies and targets. TSLN was an entire systemic effort encompassing the policy, cultural, curricular, assessment and professional learning arenas. TSLN recognised that Singapore can no longer depend on large structural fixes to transform the education system. Instead, any refinement has to be at the nexus of teaching and learning, be reflexive and responsive to students' needs and interests, and create new opportunities

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and learning experiences dynamically in and out of the classroom. Bringing about transformational change in teaching and learning requires honest recognition of issues of implementation in the classroom. Significant reductions of the national curricular content took place to make time and space for student inquiry approaches. The role of teachers was examined and rebalanced – while recognising the importance of the teachers' role to tell, instruct and demonstrate, there was also an imperative for teachers to teach less, so that students learn more. Teacher-preparation and in-service professional learning programmes were re-designed to build teachers' capacity to develop students' twenty-first century competencies and give a greater emphasis to teacher-initiated learning.

To understand the philosophy and approach Singapore took in the teaching and learning of twenty-first century skills, it would be pertinent to appreciate the country's geopolitical context. Singapore is a small country of just over 700 km^2, with no hinterland and no natural resources. There are only 365 schools in Singapore, with just under half a million students and 34,000 teachers (MOE, 2014a). Small, but strategically located at the tip of the South-east Asia archipelago, it sits at the geographical and cultural crossroads of the East and West. From the early days as a British Colony, to its independence in 1965 and until today, Singapore has almost always been a global hub, welcoming people of diverse ethnicities to take root here and building a thriving economy by being open to international trade and services. It also means, however, that Singaporeans are directly exposed to constant waves of intense competition and economic fluctuations, rapid advances in technologies and business models that impact how one makes a living, and shifting values that challenge the social norms.

Given that people are its only resource, education has always been a strategic plank of the Singapore government to meet new challenges ahead. It is not surprising then that as early as the 1990s, Singapore began thinking about preparing its students for the twenty-first century and starting a series of educational reforms that seek to equip its students with the dispositions, skills and competencies to seize opportunities and thrive in a much transformed world. These reforms involved structural and curricular changes, a redefinition of the role of teachers and schools, and a re-perception of teaching and learning.

This chapter provides a brief account of the policies and approaches that we felt were central to the educational reforms to equip students with twenty-first century competencies (21CC) in Singapore schools. We must qualify that we are narrating this account from the 'insider' lens. We were all participants of these educational changes from within the system, whether as teacher educators and researchers, curriculum developers in the Singapore Ministry of Education (MOE) or as teachers and school leaders contributing to the conception of the policies and approaches and implementing the changes. Our account therefore might lack some of the perspectives that would have been more obvious to an observer from outside the system. We hope that our narrative would, nevertheless, provide some insights to the journey that Singapore took in the teaching and learning of twenty-first century skills and we welcome other authors to provide their perspectives and critical review.

Beginning with the Thinking Schools, Learning Nation Vision

The teaching and learning of 21CC in Singapore schools began with a vision. The 1990s saw the world transit into a knowledge-based economy driven by innovation and proliferation of knowledge, and fuelled by advances in technology and communications platforms. As described in the preceding section, Singapore is particularly vulnerable and thus needs to be responsive to global changes. There was then a collective sense that a paradigmatic change in the education system was necessary to meet these challenges. An extensive review involving a wide spread of stakeholders was carried out by MOE in 1997 to garner views on the educational reforms that would be needed to better equip students with competencies to flourish in the twenty-first century (MOE, 1998). A major outcome of the review was the articulation of the *Thinking Schools, Learning Nation* (TSLN) vision to "provide the young with the capacity, core knowledge and skills, and the habits of learning that will enable them to learn continuously throughout their lives … in a future we cannot really predict" (Goh, 1997, para 7). TSLN envisions schools and the classrooms as "crucibles" where teaching and learning reflect a thinking culture, where inquiry is nurtured and where students develop a lifelong desire and capacity for learning. TSLN recognises that learning cannot be completed in schools, but that it is the responsibility of all schools to nurture and develop the capacity, dispositions and skills for thinking and continuous learning in all students.

The simplicity of the vision statement, Thinking Schools, Learning Nation, facilitated the communication of the vision of twenty-first century education among teachers and other stakeholders. The TSLN aspirations were shared with parents and other Singaporeans when the then Prime Minister of Singapore launched the TSLN vision in June 1997. All schools in Singapore dialogued the ways in which they could realise the educational aspirations embodied in TSLN. Starting with a shared vision became an important step forward in co-creating and implementing concrete strategies and approaches across schools. In the following sections, we describe some of these concrete strategies and approaches and their impact on teaching and learning.

Systems Approach to *Thinking Schools, Learning Nation*

TSLN, which captures the central ideas of preparing students for the twenty-first century, was never conceived as a programmatic change in that it did not contain an explicit set of intervention strategies and targets pertaining to a programme or project to be attained within a specific time frame. And it was much more than just a clarion call to raise the quality of teaching and learning. TSLN was an entire systemic effort encompassing the policy, cultural, curricular, assessment and professional learning arenas.
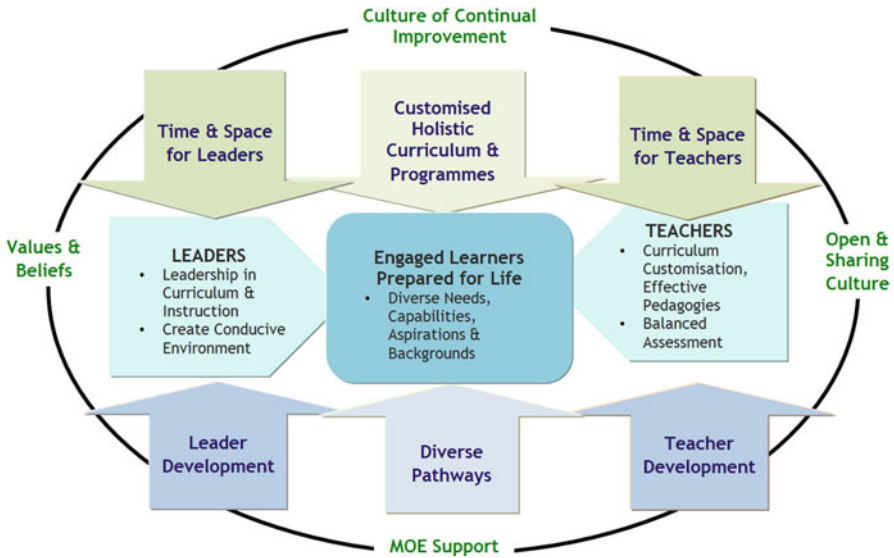
Fig. 12.1 A systems approach to realising thinking schools, learning nation

Working towards the realisation of the TSLN vision involved multiple stakeholders, and multi-pronged efforts and work-streams, which is captured in the framework shown in Fig. 12.1. At the heart of this framework is the students – TSLN seeks to help them be engaged learners, prepared for life, regardless of their different needs, capabilities, aspirations and backgrounds. TSLN took a systems approach, which recognises that an entire eco-system of shared values and beliefs, a culture of continual improvement, and an open and collaborative school environment would be essential to drive and change practices in schools to effect the spirit of TSLN. Policies and MOE provisions, such as freeing up curriculum space for more inquiry-based activities, and structuring time for teachers to collaborate on planning lessons and activities that better align with TSLN, facilitated the development of such an ecosystem in schools. But more critical than policies and top-down support from the MOE was the bottom-up initiatives that would have to be driven by school leaders and teachers. Hence, the systems approach also made provisions for school leaders and teachers to be prepared for these roles through professional learning and growth.

Building a Culture of Continual Improvement

Since 1997, cultural, curricular and structural shifts were introduced into the education landscape. As a vision, TSLN is, first and foremost, contingent on a cultural shift in the mindsets of the different stakeholders – learners, teachers, and leaders.

TSLN recognises that Singapore can no longer depend on large structural fixes to transform the education system. Instead, any refinement has to be at the nexus of teaching and learning, reflexive and responsive to students' needs and interests, and creating new opportunities and learning experiences dynamically in and out of the classroom. Rather than top-down change which is much too slow and inflexible, in TSLN, there was to be "ideas bubbling up through the system" (Shanmugaratnam, 2005, para 5). In that spirit, the details of many changes resulting from TSLN were conceived through widespread consultation of teachers, school leaders and policy makers.

Examples of structural shifts were in the way schools were managed and where educational innovation took place. Moving away from a highly centralised system of management, schools were instead grouped into clusters, with cluster superintendents (who were former senior principals) mentoring principals and promoting innovation within each cluster and within each school. Schools were the centres of TSLN, with MOE providing top-down support for ground-up school-based curriculum innovations. This enabled schools to act autonomously to fine-tune their teaching and learning approaches in response to their school context, with resource and expertise support (e.g., funding, personnel support and teachers' skills enhancements) provided by MOE whenever necessary.

Aligned with the cultural shifts in education under TSLN, teachers were given time to reflect, professionally develop and stay relevant and updated. Changes in culture and practices, however, were not widespread across classrooms in the early years of TSLN. This is to be expected as cultural shifts take time (Hargreaves & Fullan, 2012; Lortie, 1975). Under TSLN, the seeds of continual improvement and innovation have been sown, as seen by the pockets of innovation in teaching and learning in schools. Sustained effort and continuous review of the effectiveness of the TSLN strategies would be needed to ensure a wider and deeper entrenchment of the spirit of TSLN.

Reforms in Curriculum, Pedagogy, and Assessment

TSLN sets the stage for Singapore to think about a total learning environment that will help prepare students for the future. The momentum generated from this vision enabled the ministry to develop the *Framework for 21st Century Competencies and Student Outcomes* (henceforth referred to as the "21CC framework") in 2010 (Fig. 12.2). This framework articulates the competencies and values that are critical to enable the young to thrive in the twenty-first century. Compared to the initial TSLN period which focused solely on thinking skills, the competencies in the framework are multi-faceted – encompassing values, social and emotional competencies and emerging 21CC.

Sitting at the core of the framework are the values of *Responsibility*, *Respect*, *Resilience, Integrity*, *Care* and *Harmony*. Stakeholders believe strongly that to be able to function effectively in a turbulent and fast-paced twenty-first century, stu-
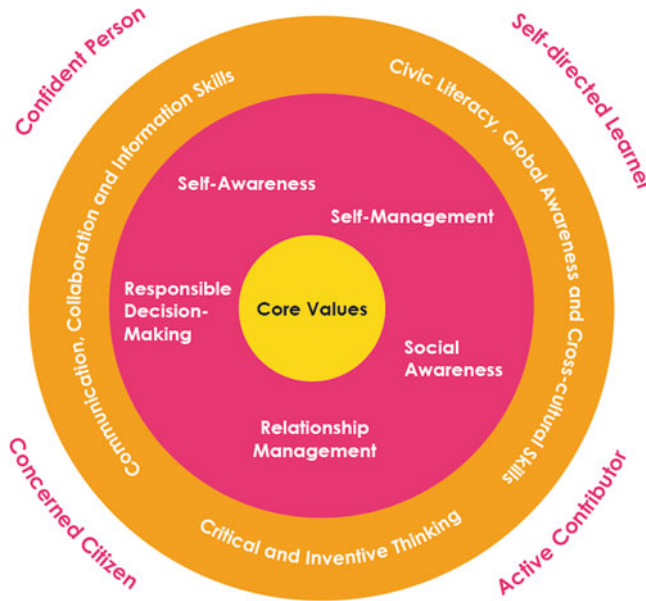
Fig. 12.2 Framework for 21st Century Competencies and Student Outcomes © Ministry of Education, Singapore (Reproduced with permission from the Singapore Ministry of Education; MOE, 2014b)

dents need to be anchored on values that will help them develop social and emotional competencies. The middle ring articulates the social and emotional skills that are necessary for students to recognise and manage their emotions, develop care and concern for others, make responsible decisions, establish positive relationships, as well as handle challenging situations effectively. The outer ring of the framework articulates the emerging 21CC: *Civic Literacy, Global Awareness and Cross-Cultural Skills*; *Critical and Inventive Thinking*; and *Communication, Collaboration and Information Skills.* Together, these values and competencies nurture the twenty-first century citizen as a *confident person*, *self-directed learner*, *concerned citizen* and *active contributor*.

Since its introduction, the 21CC framework has been used to guide curriculum planners in developing and revising the national curriculum to ensure that the development of these competencies is effectively integrated into subject syllabuses, as well as the instructional materials. The framework also guides schools as they adapt and modify the national curriculum to meet the needs and aspirations of students.

Bringing about transformational change in teaching and learning requires honest recognition of issues of implementation in the classroom. For student-centric inquiry-based approaches to even start taking root, teachers needed curricular time to carry out higher-order thinking activities. Something would need to be taken out of the curriculum to create space and time for students to learn the new skills. Therefore, as part of the TSLN efforts in 1997, a fundamental review of the entire

national curriculum was conducted, resulting in significant reductions of curricular content across all subject syllabuses to make time and space for student inquiry. Other systems that have embarked on curriculum reduction would appreciate that it involved a lot of debate, persuasion (almost every piece of content seems too fundamentally important to be removed!) and careful deliberations. The challenge was to achieve a judicious reduction of curricular content, without eroding the strong foundation in literacy and numeracy skills that will enable students to access further knowledge and skills throughout their lives.

To strengthen the teaching and learning of higher-order thinking skills, a deliberate decision was made to build the learning of these skills into all the subject syllabuses as previous efforts to do so via a standalone thinking programme were deemed as less successful both in Singapore and elsewhere (Bransford, Brown, & Cocking, 2000; Chang, 2001). Cognisant that the development of dispositions and competencies reflected in the 21CC framework required a different approach to teaching, pedagogical approaches that better supported the development of these competencies were also introduced into the various disciplines such as science and the humanities. For example, in Social Studies, which is a compulsory subject for all primary and secondary school students, inquiry approaches are used to help students construct new knowledge actively as they engage in the processes of critical questioning, evidence-based reasoning and metacognition. Through these processes, students acquire higher-order thinking skills such as drawing inferences, evaluation and synthesis. To complement efforts to develop such skills in each subject, Project Work was also introduced into the curriculum in 2000 to expand opportunities for students to synthesise knowledge from various areas of learning, and to critically and creatively apply their knowledge and skills to a longer and more authentic learning experience.

Citizenship and Character Education (CCE) was also strengthened to develop a stronger sense of national identity and rootedness to the country. This was and still remains an important emphasis given the need to ensure a strong core of citizens to contribute to nation-building–important attributes to enable the young to stay local while developing a global mindset. Alongside curricular changes, a national Information and Communications Technology (ICT) masterplan was also drawn up to equip schools with the technology to harness ICT for teaching and learning.

Understanding that teachers and parents regard national examinations as an important influence on how students learn, changes were made to the format and modes of the national examinations at Grades 6, 10 and 12 for greater alignment with the objectives of TSLN (Tan, Chow, & Goh, 2008). Given the emphasis on developing higher-order thinking skills, assessment modes and item formats that were more aligned to the learning outcomes of the different subject disciplines were introduced. In the humanities subjects such as Geography and History, for instance, source-based questions required students to draw inferences, analyse and evaluate evidence, draw conclusions based on reasoned consideration of evidence and arguments, and recognise values and biases. In Science, students have to identify the problem, design and plan investigations, evaluate methods and techniques, and support their arguments and claims using experimental evidence. Such changes meant

that the national examinations moved away from the ubiquitous multiple-choice and short response questions to more open-ended items requiring students to produce more thoughtful and considered responses.

Under TSLN, equipping students with 21CC went beyond the academic curriculum. A distinctive feature of Singapore's education system is the emphasis placed on Co-Curricular Activities (CCAs) and CCE. These areas of learning provide unique opportunities for students to develop important values and competencies. For example, through CCAs and CCE, students plan projects that address problems in their schools or communities. Through these experiences, students not only pick up important life values; they also have a platform to practise problem solving skills that have greater connection with the real world.

In summary, the TSLN effort was focused on the nerve centre of students' school experiences – curriculum, pedagogy, assessment and co-curricular activities.

Teaching Practices and Professional Learning Under TSLN

TSLN recognises that teachers are important agents of instructional change (Cohen, 1990) and education policies only become a reality if they are implemented well in schools and classrooms (Fullan, 2007; Fullan & Pomfret, 1977). Teachers play an instrumental role in realising the TSLN vision of creating a vibrant learning environment to develop 21CC. This required a re-conceptualisation of not only *what* teachers taught, but also a re-thinking of *how* they taught. The TSLN vision called for a rebalancing of the role of teachers, one in which teachers will not only tell and instruct, but also guide and facilitate independent thinking as well as collaborative learning. To this end, the policies related to teacher-preparation and in-service professional learning programmes were re-designed.

A unique feature of teacher development policy in Singapore is that each teacher is entitled to 100 h of sponsored training annually and has access to a range of professional development opportunities offered by MOE, the National Institute of Education (NIE) and other sources to ensure that they receive the types of training they need to hone their craft. Aligned to the TSLN movement, teacher professional development is underpinned by five principles, namely, (i) the shift from deficit to growth model, (ii) greater teacher autonomy and ownership, (iii) application of learning to close the theory-practice gap, (iv) mentoring and teacher collaboration, and (v) global understanding grounded in local perspectives and contexts (Heng, 2012b).

Professional development under TSLN emphasised teacher ownership of the teaching and learning process through teacher-initiated learning and the formation of learning communities (Heng, 2012a; Teo, 1998). To engender greater teacher ownership of professional development, the Teachers' Network was set up in 1998 for teachers to come together as members of a larger professional fraternity to reflect on issues of classroom practice (Teo, 1998), a major thrust to help teachers form learning communities. By 2010, the Teachers' Network evolved into the Academy of Singapore Teachers to facilitate a greater push toward a teacher-led culture of

professional excellence (Ng, 2010). The Academy, together with other discipline-based academies and subject chapters, spawned networks of teacher learning communities.

In line with the TSLN spirit, schools also initiated professional learning communities (PLCs) which became the drivers of practitioner-oriented professional growth that engendered a culture of collaborative professionalism at the school level. These communities provided the platforms for teachers to gather in interest groups to dialogue, share, embark and reflect on teaching and learning initiatives to address student learning issues (Heng, 2012b). Time (one hour of 'timetabled' time weekly)[1] and space was built into teachers' weekly timetable to give them time to reflect and share with and learn from one other. Teachers were using a variety of methods such as Lesson Study and Action Research to capture data so that they can use it to improve their classroom pedagogy (Rajah, 2012).

The deepening of teacher's professional growth in more fundamental pedagogical skills gained momentum in the *Teach Less, Learn More* (TLLM) movement introduced in 2005 (Shanmugaratnam, 2005). TLLM encouraged and supported teachers to use engaging pedagogies that would promote inquiry, develop deep understanding, and create authentic learning experiences in order to develop students' critical thinking skills and dispositions – to enable them to apply their learning to new contexts. Further, a Research Activist scheme was set up in 2006 to equip teachers with the skills to conduct and use research to improve teaching and learning practices (Shanmugaratnam, 2006).

Nearly two decades since the implementation of TSLN, we turned to two sources – the results of the 2013 Teaching and Learning International Survey (TALIS) conducted by the Organisation for Economic Cooperation and Development (OECD) and insights gleaned from a large scale study conducted in Singapore on teachers' classroom practices by NIE – to examine the extent to which teachers have understood and assimilated their redefined teaching roles in their classroom practices.

The 2013 TALIS survey administered by OECD indicated that the majority of Singapore teachers held constructivist beliefs about teaching – that teaching should be done in a way that enables students to learn actively through 'doing'. In particular, TALIS 2013 data showed that 95 % of the ISCED 2 (lower secondary) teachers and 96 % of ISCED 3 (upper secondary) teachers in Singapore surveyed believed that their role as a teacher was to facilitate students' own inquiry (OECD, 2014a). About 95 % of the teachers (compared to the TALIS average of 84 %) believed that thinking and reasoning processes were more important than specific curriculum content. While we do not have the benefit of comparable data on teacher beliefs prior to TSLN, these findings on teachers' wide subscription to constructivist beliefs are aligned to the desired shifts in the role of the teacher envisioned by TSLN.

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[1] This one hour for professional planning and collaboration is worked within each teachers' total timetabled time so as not to add to their existing teaching load. Providing more time and space for teachers to engage in professional development was supported by an 8-year recruitment effort to increase the size of the teaching force (Straits Times, 2015).

Underlying these teachers' constructivist beliefs, however, is a more complex conception of how their beliefs are translated in the reality of the classroom. In this respect, about a third of the ISCED 2 Singapore teachers in the same TALIS 2013 survey reported that they employed what OECD termed as "active" teaching practices (including getting students to work in small groups to come up with a joint solution to a problem or task, students using ICT for projects or class work, and students working on projects that require at least 1 week to complete) frequently or in nearly all lessons. While this was encouraging, we wondered what this implied of the other two-thirds of the fraternity – Do they seldom or not translate their constructivist beliefs into classroom practices? To make sense of this, we referenced a large scale, classroom observational study conducted in Singapore by NIE on the classroom practices of English Language and Mathematics teachers[2] (see Hogan et al., 2013, 2011 for details).

This study found that Singapore teachers used a blend of 'performative pedagogy'[3] and 'knowledge-building pedagogy'[4] that co-existed in a hybridic and pragmatic form that defies the traditional-constructivist pedagogical binary. Relying on survey results and classroom observational data, the study showed that teachers drew from, and combined, "ensembles of practices grouped by broad instructional categories" which included traditional instruction, direct instruction, teaching for understanding and co-regulated learning strategies (Hogan et al., 2013, p. 94). These ensembles cohered around two institutional purposes of Singapore schooling – to perform well in examinations (performative) and to co-construct disciplinary knowledge (knowledge-building).

In classrooms where knowledge-building pedagogy was dominant, lessons had clear and explicit learning objectives that focussed on conceptual understanding, deeper learning, metacognitive self-regulation, knowledge transfer, and the development of expertise. The use of the knowledge-building pedagogy was strongly framed by instructional tasks that encouraged and required students to participate in

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[2] The Singapore Core 2 study is a large-scale study carried out by NIE from 2010 to 2014 that examined pedagogical and assessment practices in Singapore classrooms. Employing a mixed methods approach, the quantitative component of the study utilised a multi-stage sampling design that involved students and teachers in over 200 classes and across 62 primary and secondary schools (see Hogan et al. (2011, 2013) for details of the research design).

[3] Performative pedagogy pays attention to ensuring that curriculum content and concepts are taught in the classroom, and to ways that help students master both factual and procedural knowledge.

[4] 'Knowledge-building pedagogy', a theory that is derived from research into the disciplinary nature of knowledge (e.g., Christie & Maton, 2011; Ford & Forman 2008), Visible Learning theory (Hattie, 2009, 2012), dialogic teaching (Alexander, 2008), exploratory talk (Barnes, 2008), academic work (Doyle, 1983; Stein, Grover, & Henningsen, 1996), authentic pedagogy (Newmann & Associates, 1996) and productive pedagogy (Hayes, Linguard, & Mills, 2002) is evident when students have access to powerful conceptual, epistemic, disciplinary and metacognitive knowledge.

knowledge-building practices including generating, representing, communicating, deliberating, validating, and justifying knowledge claims against given epistemic norms. Importantly, participation in such tasks provided students with opportunities for collaboration, ICT use, open-ended questioning, extended student responses and classroom talk that focused on meaning making, understanding and interactional exchanges that were dialogic in nature – supportive, collective, cumulative, reciprocal, and purposeful (Alexander, 2008; Lefstein & Snell, 2014). See Box 12.1 for an illustration of a lesson using knowledge building pedagogy in a Singapore Secondary English classroom.

Box 12.1: Knowledge-Building Pedagogy in a Secondary English Classroom

In a unit on Secondary English, the teacher focused on narrative writing and structured well-designed instructional activities in a cumulative fashion to systematically enhance students' repertoire of skills for writing narratives. Across the unit, activities show a steady progression in cognitive demands – from those that entail recall, practice, application and interpretation to those requiring students to extensively draw on language resources to express meaning. The teacher uses learning materials that focuses on the disciplinary nature of English (Christie & Maton, 2011), as well as uses a range of representations for meaning making. Lessons commence with a story or song for tuning-in students to engage in activities that equip them with a range of understandings such as the use of narrative structure, essay introduction techniques and characterisation in stories. Furthermore, students have opportunities to apply and practice their understandings through group activities. The teacher weaves between factual and procedural knowledge which provides the foundation students need, and conceptual and hermeneutical knowledge which involves the deconstruction of texts. Exploratory talk is present and teacher and students engage in interactions that are reflexive in nature, explanatory and serve to make teaching and learning more visible. Students have ample space to express their opinions, debate, deliberate, present and justify alternative perspectives in a favourable learning environment even while the teacher maintained her epistemic authority in the classroom. In the post-unit interview, the teacher expressed clear understandings of the need for coherent development of conceptual understanding throughout the lessons and explicit explication of learning objectives to the students so that they understand why they are learning the unit and what comes next so that learning becomes purposeful (Hattie, 2012).

Source: Hogan et al. (2013, 2011)

The blended pedagogy observed in the Singapore study supports the assertion that the constant provision of 'rich classroom discussions' alone is insufficient in bringing about richer student thought and expression. Teachers need to design rich learning opportunities in order for students to attain higher-order skills (Gallimore, Hiebert, & Ermeling, 2014), a call made by TSLN. This can be illustrated by observations of Mathematics teaching in the Singapore study, where even though students typically worked on numerous problems, they are, in fact, able to discern different and important aspects of mathematical concepts, problem solving heuristics and disciplinary understanding. This is because teachers skilfully selected and deployed problems for their students by weaving between repetitions and simple chains, then moving the problems to procedurally and conceptually complex ones (see Box 12.2 on Insights into a Singapore Secondary Mathematics Classroom).

Box 12.2: Insights into a Singapore Secondary Mathematics Classroom

In secondary Mathematics classrooms in Singapore, teachers use problems to help students understand mathematical concepts and practise on problem solving skills. Students typically encounter an average of 30–40 problems in a topical unit of work. On surface, this might suggest a form of traditional, rote-learning pedagogical model. However, on examining the relationships between problems in a typical unit, a significantly different understanding emerged. The mathematical problem relationships can be classified into four types – (i) repetition (a problem is a repetition of a previous problem and are similar in nature), (ii) simple chain (a problem is related to another when it tests different aspects of the same concept), (iii) procedurally complex chain (a problem is related to another when it requires a more complex procedure to solve it), and (iv) conceptually complex chain (a problem is conceptually more complex to another). The Mathematics teachers skilfully selected and deployed problems for their students by weaving between repetitions and simple chains, then moving the problems to procedurally and conceptually complex ones, and finally, cycling through repetitions and simple chains of such complex problems, before cycling in more procedurally and conceptually complex problems again. Through this constant weaving (Kwek, 2012) between problems and their relationships, teachers were engaged in both performative and knowledge-building pedagogies (Hogan et al., 2013). It is through this rapid variation of problems and making numerous connections between them that students were able to discern different important aspects of mathematical concepts, problem solving heuristics and disciplinary understanding. Importantly, Marton and Tsui (2004) pointed out that through variation, students come to be able to discern and solve problems simultaneously, as if on reflex, as well as be cognitively aware of, and focus on, how problems can be solved efficiently and effectively.

Source: Hogan et al. (2013, 2011); Rahim, Hogan & Chan (2012)

Conclusion

The endeavour to equip Singapore students with twenty-first century competencies and dispositions has been a sustained and coordinated systematic effort since 1997. Working to realise TSLN involved coherent and comprehensive structural, cultural and curricular changes. Structurally, schools were given more autonomy. Culturally, a new approach to teaching and learning was being adopted; and professionally, teachers were encouraged to learn continuously and to take ownership of their learning so that they can transit into new pedagogies that are more engaging and supportive of the development of 21CC. Curricular reviews were made to provide more time for the use of inquiry-based and constructivist approaches to develop critical and creative thinking.

But reaching the goals of TSLN is far from complete. Uneven implementation of pedagogical approaches that engender thinking and inquiry across classrooms is a threat (see for example, Poon & Lim, 2014). Lee (2014), who spent time in a school to observe a school-based innovation under the umbrella of the TSLN movement, observed that students' efforts in investigative projects and the teachers' emphasis on the learning of process skills did not generate adequate "rich experiences in developing epistemic agency, which are the higher-order and critical reasoning skills" (p. 185). Lee attributed this to the lack of curriculum space for students to exercise a more sustained and deeper sense of inquiry. Teachers have also pointed to an examination culture that made it harder for them to effect changes in teaching and learning (Ratnam-Lim & Tan, 2015). Gopinathan (2015) also pointed out that as the TSLN movement matures, the realisation of the TSLN vision would be closer with fewer directives from the top and greater school and teacher ownership of the changes that are required.

There are some indications, however, that students are benefiting from the TSLN efforts. The Trends in International Mathematics and Science Study (TIMSS) reports three dimensions of student ability in mathematics and science: *Knowing*, *Applying* and *Reasoning*, with "reasoning" regarded as a higher-order thinking dimension. Between TIMSS 2007 and TIMSS 2011, there was a significant increase in the reasoning scores for Singapore's Grade 8 Mathematics and Science and Grade 4 Science (see, Martin, Mullis, Foy, & Stanco, 2012; Mullis, Martin, Foy, & Arora, 2012). In Grade 4 Science, for instance, it was observed that the "knowing" score decreased in TIMSS 2011 (from 599 in TIMSS 2007 to 570 in TIMSS 2011), arguably as a result of the syllabus reduction to free up time to support engaging pedagogies and development of thinking skills in TSLN. However, this was compensated by a significant gain in score in the "reasoning" domain (from 576 to 597), possibly reflecting the shift towards a more inquiry-based curriculum and pedagogy. In April 2014, when OECD published the results of the PISA 2012 study on Creative Problem Solving, Singapore students performed well. The OECD report (OECD, 2014b) described Singapore's 15-year-olds as having displayed good problem-solving skills – able to think flexibly and creatively to solve complex and unfamiliar problems, able to handle uncertainty, and daring to experiment with alternative

solutions. These are indeed some of the 21CC that Singapore schools have been working towards, and the results provided some encouragement and assurance to educators here that while they have yet tofully achieve the TSLN vision, they have made a small headway towards their goals. Singapore will continue building on its efforts under TSLN to prepare its students to live and thrive in the twenty-first century.

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