

Design Thinking

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Abstract

Among the competencies that are widely regarded as vital for survival and success in the increasingly volatile, uncertain, complex, and ambiguous world that we live in today is design thinking. Traditionally the main driving force behind innovation in business and industry, design thinking is now also seen as key to creating better solutions to social, economic, technological, and political problems. Unsurprisingly, educators and educational researchers have also begun exploring the potential of design thinking in improving curriculum and pedagogy. In this chapter, we briefly explain the methods, processes, and dispositions that constitute design thinking and present two principals' attempts to introduce design thinking into their school. The case studies provide insights into the possible ways, benefits, and challenges of infusing design thinking into a school's curriculum and operations.

8.1 Introduction

We live in an increasingly volatile, uncertain, complex, and ambiguous world today. The skills and capabilities that brought success to individuals and organisations in the twentieth century can no longer be relied upon to produce the same results in the twenty-first century. Among the competencies that researchers and industry analysts have identified as vital for survival and success in the new world order is design thinking (Davies et al. 2011; Gardner 2008; Pink 2005). Traditionally the main driving force behind innovation in business and industry, design

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thinking is now also seen as a key to creating better solutions to social, economic, technological, and political problems (Brown 2009; Brown and Wyatt 2010; Edwards 2008; Kimbell 2011a, b; Martin 2007, 2009). A growing number of educational researchers and educators have also begun exploring the potential of design thinking in improving curriculum and pedagogy (Carroll 2014; Laurillard 2012; Noweski et al. 2012; Tsai et al. 2013; Wagner 2014).

In Singapore, tasked to develop new strategies to safeguard the country's economic future in the twenty-first century, the Economic Review Committee (2003) reached a similar conclusion when they identified the design cluster as one of three key drivers for economic growth. Since 2003, the Singapore government has deployed a substantial amount of resources to develop the design capabilities of workers and organisations, both within the traditional design sector and beyond. Structures that enable firms to leverage good design for competitive edge and environments supportive of innovation have also been established (DesignSingapore Council 2009; Economic Strategies Committee 2010). An important element among these strategies is the introduction of design thinking into schools (Ministry of Education 2010, 2013; Design Masterplan Committee 2016). This includes the nurturing of design competencies in students and the use of design tools and processes in the review and redesign of curriculum, pedagogy, administrative processes, and school leadership.

Of course, there are many strategies for generating innovation. Lean thinking and *kaizen* are currently two of the more well-known ones in business management and product development. Understood reductively to mean a specific model, process, or set of methods, design thinking appears to be yet another innovation strategy. The question naturally arises: why choose design thinking over other available strategies? However, that is not how 'design thinking' is understood in this chapter, nor is that the conception that those policymakers mentioned in the previous paragraph had in mind. Design is here understood as the intentional creation of new types of things that fulfil a practical function or address a real human need and emphasises the experiential quality of the design artefact (Cross 2011; Papanek 1984; Parsons 2016; Simon 1996). 'Design thinking' therefore refers to designers' cognition and values when they do this creative work. Design thinking is not a mere strategy for producing innovation. Rather, it is a way of seeing, thinking, and working that is consistent with and incorporates various strategies for identifying and understanding human issues and individuals' needs, generating and testing new ideas, and refining and implementing solutions. So, it would be a mistake to think that design thinking is here being put forward as a preferred strategy for generating innovation. Instead, design has been identified as the field or practice that has innovation as its chief concern, and the proposal is that the competencies and dispositions that form the core of this discipline should be part of the basic skillset of every individual in the workforce, and that the developmental process should begin in schools.

As an approach to tackling human issues, design thinking typically begins with an attempt to understand the issue at hand through the perspectives of the people affected. The needs and motivations of the different groups of stakeholders in the

issue provide the basis for identifying and defining the various problems that constitute the issue. Ideas and prototypes for possible solutions are generated, explored, and tested with the experiences of the target users firmly in mind to ensure that the eventual solution fully addresses people's needs and is a product or service that people would want to use.

Different design schools and companies characterise the design process differently. For example, the Rotman School of Management at the University of Toronto presents the design process as the interactions among the three gears of (business) design: Empathy and Need-finding, Prototyping and Experimentation, and the creation and implementation of a solution (Business Strategy). On the other hand, the design firm IDEO and Stanford University's Hasso Plattner Institute of Design (popularly called the d.school) describe the design process as a flexible and iterative movement through the stages of empathy, define, ideate, prototype, and test. These different characterisations are simply a matter of naming convention and branding. In practice, design thinkers generally employ a similar suite of tools and methods in an iterative and non-linear process that they strive to keep human-centred and multi-perspectival. This observation is corroborated by numerous academic investigations into how designers think and work (for an introduction to these studies, see the following review articles on design theory and research: Cross 1999, 2001; Johansson-Sköldberg et al. 2013; Kimbell 2011b; Razzouk and Shute 2012).

A human-centred and multi-perspectival approach to dealing with human issues promises to deliver innovative solutions that better meet people's needs, thereby bringing about improvements in the quality of life. Human issues are complex, with the needs of different groups of people intricately interconnected and often pulling in opposing directions. For example, in some Third World countries, poor rural families that have little or no access to modern hospital facilities need a safe, effective, and affordable way to keep their premature babies alive. The absence of such means puts pressure on these families to have more babies in anticipation of the death of some of their children. But this tends to raise the population growth rate in areas that are already struggling to feed the existing people living there. Seeing issues through the perspectives of different groups of people draws attention to frequently overlooked or neglected needs and increases the likelihood that tensions among the different needs are revealed. Design thinkers' commitment to being human-centred and to improving lives motivates them to select these needs and tensions for 'solutioning'. Ideas that can address these needs and resolve these tensions effectively are game-changers that have far-reaching positive social impacts: consider, for instance, the impact of a solution that allows major drug companies to reap significant profits from the drugs they have developed and yet make the drugs affordable and available to the impoverished people who need them the most.

In commercial endeavours, such solutions usually translate into huge profits for companies; in politics, they mean greater popularity and more votes; and in humanitarian efforts, they may attract more funding for future projects. It is

therefore easy to understand why many businesses, governments as well as social and humanitarian enterprises are beginning to find design thinking attractive.

In Singapore education, many Ministry of Education (MOE) officers, school leaders, and teachers find design thinking useful for generating better policies, management strategies, administrative processes, and curricular programmes as they seek to improve the experiences of staff and students in schools. Furthermore, design thinking promises immense educational value when introduced into school curricula. Wong (2011) has explored the different skills and competencies that constitute design capabilities (see also Noweski et al. 2012). Here, we wish to draw attention to the few that seem to resonate most strongly with educators.

The human-centred and multi-perspectival nature of design thinking make design thinking projects a natural vehicle for developing in young students basic socio-emotional skills, such as self-awareness and awareness of others, communication skills, collaboration skills, and the ability to empathise with others. In older students, these skills form the foundation for developing ethical reasoning and decision-making skills. When students can empathise with the experiences of other people, exposing them (through design thinking projects) to the needs and motivations of people who live in situations unfamiliar to them enables them to not only acquire an acute awareness and deep understanding of different social issues, but also ignite in them a passion for social endeavours and advocacy. Students participating in design thinking projects also gain insights into how the knowledge and skills they are learning in the various subjects may be useful in understanding and solving real-world problems, thus giving meaning and purpose to their learning (Carroll 2014).

Participating in design thinking projects also allows students to hone their critical and inventive thinking skills by providing them with opportunities to use these skills to analyse complex data and generate innovative solutions to intricately interconnected problems. Recent reports place Singapore students among the top performers in the first OECD PISA problem-solving test (MOE 2014; OECD 2014). In this test, students were required to respond creatively to ill-structured problems in unfamiliar contexts. Although it is encouraging to know that Singapore students can perform well when given such problems, we recognise that our students still have some way to go before they can be said to be truly innovative. Being able to creatively solve problems that have already been identified is one thing; being innovative by identifying new problems to solve through seeing issues from multiple perspectives is quite another. We saw above that the ability to identify problems and define them in new ways is a fundamental skill in design thinking. Therefore, design thinking may just be the key to unlocking the innovative potential of the next generation of Singaporeans.

Although it is not immediately obvious, the appeal of design thinking to educators goes far beyond the reasons mentioned above. Bronowski (2011) points out that of all the creatures on earth, human beings are the only ones that consciously and deliberately shape and reshape their environment to suit their needs and purposes. We do not adapt to our environment the way other creatures do; instead, we adapt our environment to us. This is the source of our evolutionary edge. But the

shaping and reshaping of environments is no more than an expression of design instincts and capabilities. In addition, we have a natural drive to be better at whatever we do well in (Bronowski 2011, p. 93). So, we seek to perfect and extend our design capabilities by constantly challenging and pushing at our limitations. This has not always worked out well for us. Design thinking's human-centredness and commitment to improving lives suggest that it may just be what is required to curb our excesses when we exercise our design instincts. Design thinking, so considered, is that which allows us to become human, thus making it an necessary component of education (Wong 2011).

In this chapter, we present two Singapore principals' attempts to introduce design thinking into their respective school. We hope to learn from a study of these two cases some insights into the following questions:

1. What are some possible ways of infusing design thinking into a school's curriculum and operations?
2. What potential benefits might we gain from infusing design thinking into a school's curriculum and operations?
3. How should attempts to infuse design thinking into a school's curriculum and operations be managed so that the chance of success is improved?

The two principals were purposively selected on two criteria. First, they are directly involved in the introduction of design thinking into their school. From the conception of the new strategic direction for the school, the development of the implementation strategy (which included the introduction of design thinking programmes), and the necessary professional training of teachers through to the evaluation of the implemented initiatives and programmes and the steps taken thereafter to improve the initiatives and programmes implemented, the two principals in our study take personal responsibility for both processes and outcomes. We were interested to learn about school leaders' perspectives on the issues and challenges that are likely to arise from an attempt to introduce design thinking, as well as some possible ways of resolving those issues and challenges. It was therefore important to us that the subjects of our study were school leaders who were directly involved in every stage of the implementation process (as opposed to those who simply delegated the task to another member of the school).

Second, the two principals selected for our study are leaders of two different types of schools. The first school is a mainstream government co-ed school that catered to students from diverse backgrounds. There are significant variations in the students' academic abilities and interests, as well as their socio-economic backgrounds. The school offers the standard academic curricula for secondary education in Singapore: Express, Normal (Academic), and Normal (Technical). It does not offer any specialised academic programmes. The second school is an established single-sex school. Most of the students are academically inclined and come from middle- or high-income families. These two types of schools have different needs and face different challenges. We wanted to find out the extent to which these differences matter in any school-based implementation of design thinking.

The data for the two case studies were largely based on interviews with the two principals. Where necessary, some teachers and students who played key roles in the implementation of design thinking programmes at the two schools were also interviewed. The subjects were interviewed separately, 1 to 2 years after the schools had introduced design thinking into their curricula and their teachers' curriculum development and lesson design processes. Data collected from the interviews were systematically analysed with the three research questions in mind. The case reports presented here use pseudonyms for the names of the subjects and their schools. Information pointing to distinctive features of the schools was also modified to ensure that the identity of the schools remains masked. This part of the ethics procedures was given particular attention due to the relatively small population of Singapore schools.

8.2 Case 1: Design Thinking as Change Strategy

Mr. Goh is a seasoned principal at an established high school. He has led the school for several years now. He introduced design thinking to the school as part of a broad strategy to help teachers explore new pedagogical practices. He hopes to make the school more distinctive by fostering a design culture among teachers and students. Mr. Goh first encountered design thinking when he was working at the Ministry of Education. There he met consultants from an international research institute who espouses the educational potential of design thinking. Later, he became acquainted with the deputy principal of a local polytechnic, whose teachers were undergoing training in design thinking. The deputy principal offered to train a team of teachers for Mr. Goh.

8.2.1 The Strategy for Change

The dominant concern of Singapore teachers is to prepare students for the national examinations. Teachers will do all they can to ensure that students perform well in these examinations. Remedial classes are often conducted for students who struggle in a subject. However, Singapore educators increasingly recognise that an examination-focused approach is not particularly useful in preparing students for the more complex and dynamic work conditions of the future. What is needed is a more holistic, student-centred approach, one that gives students room to pursue self-directed learning and encourages them to explore and experiment with new ideas and to experience and learn from failures.

Although Mr. Goh recognises the need to move away from traditional pedagogical practices, he is also aware that this would require a fundamental mindset change among teachers. Being familiar with the research literature on change management, Mr. Goh knows that it was going to be difficult to change settled teaching practices. The challenge is even greater in Singapore because its school

system continues to be successful. The importance placed on high-stakes national examinations means that teachers tend to rely on tried-and-tested approaches. Mr. Goh understands that teachers would be unwilling to risk departing from their settled teaching methods. Moreover, it is one thing to change mindsets, and quite another to gain the expertise needed successfully implement new pedagogies. So, although change was desirable, Mr. Goh knows that it has to happen slowly and gently. The teachers must be given time to adapt and develop.

Mr. Goh firmly believes that the intended changes could be reconciled with the emphasis on high-stakes examinations. The school offered a typical 4-year secondary-school programme that culminates in the Singapore-Cambridge GCE 'O' Level Examinations for students between the ages of 13 and 16. The reality is that it did not require 4 years of uninterrupted and sustained instruction to prepare students for this examination. A well-managed curriculum would give teachers enough time to cover the required syllabus and leave sufficient space for experimentation.

Mr. Goh's strategy is to start the lower secondary students and their teachers on design thinking activities and other alternative pedagogies. If the new pedagogies were effective, teachers would be bought over. Meanwhile, students who were exposed to the new pedagogical practices would not only gain new learning experiences but also come to have different expectations about teaching. They would expect teaching and learning at the upper levels to be just as meaningful and innovative as what they had experienced at the lower levels. Students' expectations would nudge teachers at the upper levels towards pedagogical experimentations. Over time, a new culture of teaching and learning would emerge in the school. However, it bears repeating that this process cannot be rushed.

8.2.2 Why Design Thinking?

A pragmatic person by nature, Mr. Goh, is willing to experiment with any new pedagogical approach so long as it delivered the desired results. In Singapore, teachers and school leaders are constantly exposed to new ideas about teaching and learning. For Mr. Goh, design thinking stood out. What struck him about design thinking when he first encountered the approach is its emphasis on empathy with others. At a basic level, acquiring empathy requires one simply to observe and listen to people. This fundamental attitude is especially relevant in the Singapore context, because teachers tend to talk more than they listen, and students are given few opportunities to express themselves. At the pedagogical level, the emphasis on empathy would require teachers to listen more to the students, learn about their needs, and take them into consideration when designing lessons.

All design thinking models maintain that products and services should be designed to meet users' needs. This means getting to know the users well. Close interaction with users may even reveal needs that the users themselves are unaware of. In such cases, the designers would engage even more deeply with users, first to identify and articulate the users' needs, and then to collaborate with the users to create the desired products or services. In this sense, design thinking is not so much

about enacting a specific pedagogical practice than fostering a way of thinking that is focused on finding practical solutions to problems. Mr. Goh hopes that as teachers grow accustomed to this way of thinking, they would become more open to reviewing their pedagogical practices and be more willing to experiment with new approaches to teaching and learning.

Mr. Goh believes that students make a crucial transition when they move from primary to secondary school. What students generally remember of their final year in primary school is the intense preparation for the national Primary School Leaving Examinations (PSLE). Like their teachers, students also have settled beliefs about school and schooling. Many are very ‘worksheet-driven’ and examination-focused. They can be resistant to new ideas that appear to have no direct bearing on their examination performance. Therefore, it is important that teachers act quickly, but gently, to change this mindset. Mr. Goh’s research into design thinking gives him confidence that it can help change habits and expectations in students during their early secondary-school years.

As Mr. Goh learned more about design thinking, he became more convinced of its value as a tool for bringing about broad-based changes in teaching and learning. The following potential benefits of design thinking in teaching and learning stand out:

1. Design thinking fosters mindset change in its practitioners by encouraging them to approach problems from multiple perspectives. Participating in a design thinking project, one quickly learns that problems are never simple. They can be framed in multiple ways. Furthermore, the way a problem is defined plays a significant role in determining the nature and scope of possible solutions. The complex nature of problem-solving suggests that it is important to cultivate critical and inventive thinking skills. The multi-perspectival nature of design thinking also helps practitioners to appreciate the need for teamwork and collaboration in problem-solving.
2. Engaging in design thinking fosters the development of desirable dispositions. The ability to empathise with people very different from oneself is a primary benefit. Another benefit comes from the ideation and prototyping activities. The early ideas and prototypes are unlikely to be well-structured or adequately address the problems being tackled. So, ideation and prototyping help students learn how to handle messiness and failures. Furthermore, the iterative nature of design thinking develops the quality of perseverance in its practitioners, because they simply must keep going until they succeed. They learn to regard every solution as only provisional and become more open-minded about and respectful of the ideas and individuality of others.
3. Design thinking helps to develop in its practitioners various fundamental skills, such as observation skills, communication skills, interview techniques, and perspective-taking. To understand people’s needs, designers must observe and interact closely with them. Observation skills and interview techniques are honed when one engages in design thinking. Through the exercise of these skills, practitioners learn that adopting different perspectives when interpreting

what they have observed or heard can help them make sense of the variety of data they have collected.

4. The creation of a product or service requires the involvement of many people with different skills and abilities. By engaging in design thinking, one acquires the competencies required for effective collaboration, including the skills needed for working across subject disciplines. Within the school context, using design thinking to develop innovative curriculum helps to facilitate collaboration among teachers from different disciplines. Students participating in design thinking projects will come to appreciate the value of both the arts and the sciences in the creation of solutions to problems.

8.2.3 Implementing Design Thinking

Anticipating resistance to change, Mr. Goh ensured that change occurred only slowly and gently. He sought to create a safe environment that would be supportive of experimentation and change. Beginning with the students in the lower levels, he got teachers to engage them in small-scale design thinking projects. He wanted teachers to make these projects interesting and meaningful to students. These activities would be low stakes: students were not formally assessed, and no serious consequences would follow were the projects to fail. Teachers therefore felt comfortable enough to take some amount of risk in their design and facilitation of these projects.

However, teachers must first be trained in design thinking. Fortunately, for Mr. Goh, there were several young teachers who were curious and eager to learn about design thinking as a possible pedagogical tool. This small team of volunteers was sent to a local polytechnic for a 3-day workshop. At the workshop, the team was tasked to infuse creativity into their lessons. The team quickly realised that the design thinking model taught was developed primarily for Business and Engineering students at the polytechnic. It had to be modified to address the needs of secondary-school students and teachers, but the consultants had little knowledge of secondary-school students and teachers, but the consultants had little knowledge of secondary schools in Singapore. In the spirit of design thinking, the consultants and the team worked together to develop activities and protocols that would be suitable for secondary-school students and teachers. Students from the school were also brought in to evaluate the work done by the team and played a part in the design process.

Having now developed an adaptation of the design thinking model for the school's use, Mr. Goh decided to introduce all teachers in the school to design thinking. At a 2-day strategic planning exercise, teachers were asked to improve various programmes by following a prescribed process. Only at the end of the exercise were the teachers told that they had participated in a design thinking project. The teachers responded well to the experience because the learning activities were fun and engaging. Consequently, they became well-disposed to the use of design thinking in the school.

8.2.4 Fostering Innovative Teaching Through Design Pedagogy

The next step was to introduce design thinking to students at the lower secondary level. The first thing the pioneer design thinking team had to do was recruit and train teachers who would be serving as facilitators in the lower secondary projects. Part of the training involved designing lessons to familiarise students with the different stages of the design thinking process. Students were enlisted to test the prototypes. The new teacher recruits found themselves improvising and innovating as they gradually rolled out the design thinking programme to students.

The students' response to design thinking was better than the teachers had expected. However, although the students were excited and enthusiastic, they needed more structure and guidance in their engagement with the process. The teachers subsequently introduced a 7–3 learning framework: 'teacher-talk' activities accounted for thirty per cent of the learning; in the remaining seventy per cent of lesson time, students worked in groups on their projects. The teachers also found it useful to set simple communication rules to provide order to the conversations that took place during the lessons.

At the beginning, teachers allowed students to suggest their own projects. However, they soon discovered that many of the students' ideas were too wild and unsuitable. The teachers had to learn to reject these ideas without dampening the students' enthusiasm and at the same time guide the students to develop projects that were more manageable and practical, such as making improvements to the school canteen, finding ways to alleviate the poor traffic conditions in and around the school in the mornings, and redesigning the signage at the nearby bus terminal so as to make them more helpful to commuters. Some of the projects developed, such as those related to the elderly and the disabled, coincided with the requirements of the school's community service programmes.

One of the most challenging jobs teachers faced was the question of how to effectively develop observation skills and empathy competencies in students. These capabilities are closely related. To create a product or service that meet users' needs, designers must empathise with the users' needs and motivations. This requires designers to observe users' behaviours and gain insights into how they use and feel about the existing solutions. Having watched students in action and consulted with teachers afterwards, Mr. Goh is now more convinced than ever that this part of the design thinking process nurtures fundamental life skills.

One can try to understand users' needs through observation by simply watching users in action or taking photographs and making videos of them to arrive at an initial impression of what they do and experience. These raw data must then be interpreted. To verify or support an interpretation, one needs to speak to the users involved. This requires one to connect with users in a way that makes them want to open up and reveal valuable insights into their emotions and motivations. Students typically have trouble designing appropriate questions to draw such insights from users. The questions that students ask tend to be too direct and closed-ended. They do not invite users to share significant insights into their experiences. For example, in a wallet

design exercise, students tended to ask questions about the users' current wallet, such as how much it cost, where it was bought, and what they liked about the wallet. They were unable to probe deep into users' emotional experiences and connections to their wallets. To help the students, the teachers role-played both good and bad interview techniques and made them into videos that students could easily access.

Students also tend to have an insufficiently broad notion of the users they should target for observation and interviews. For example, in a project to improve the signage at a bus terminal, students did not realise that it would be helpful to also observe and speak to people who rely on signs to get things done in supermarkets, food courts, malls, etc. Successfully guiding students to make good observations and ask good questions during interviews not only activates students' ability to see things through the eyes of others but also develops in them the ability to engage multiple senses in their interactions with their surroundings and teaches them not to take their living spaces and environments for granted. It reinforces in students the learning that things around them can always be improved to produce positive impacts on people's lives.

Teachers also had to help students understand what it means to empathise with others and how to develop empathy with others. They initially struggled with this problem: how could they get students to feel something that do not normally experience? Eventually, they developed several simulation exercises to help students empathise with the conditions of others. For instance, to give students an experience of what it is like to have limited dexterity in one's hands, they made students use chopsticks while wearing thick gloves; to help students understand what it is like to have limited mobility, they had students move around the school with their legs tied closely together. Making students go through such exercises enabled them to draw on these experiences when they observe and interview users.

For both teachers and students, the ideation and prototyping stages are the most fun and engaging. Suitable locations in the school had to be found for students to brainstorm ideas and build their prototypes. Students needed big spaces to do very messy work. While teachers did not have to worry excessively about the budget, building and maintaining an appropriate store of ideation and prototyping materials (e.g. post-it notepads, coloured pens, craft paper, cardboards, PlayDoh, etc.) was still a challenge.

Although the ideation stage can be very unpredictable and free-ranging, the prototyping stage imposes a degree of discipline and reality into the design thinking process. Ideas are only good if they can be translated into workable solutions. To help students learn this, teachers gave them a great deal of freedom and personal responsibility to develop their own solutions. In constructing their prototypes, students realised that the challenge was not about getting the right or wrong answer, but to come up with something that works after going through several unsuccessful attempts. In addition, after coming up with a functioning model, they had to test it with users for feedback, which often necessitated further modification. Sometimes, the prototypes were even rejected. Students learned to see that what works for them may not necessarily work for the user. More importantly, at this stage, the students as designers learned to appreciate the value of feedback and to treat users as co-creators.

8.2.5 A Preliminary Assessment and Review

Design thinking is not yet pervasively practiced in the school. However, it has been tried out during the school's strategic planning exercise and all teachers have a basic understanding of it. A core team of teachers, however, has a deep understanding of design thinking and they gain more experience in using it with each passing year as they experiment with different ways of infusing design thinking into the school's curriculum. As for the students, design thinking programmes have been implemented in the lower secondary levels for the past 4 years. Mr. Goh has observed students becoming more confident in speaking and engaging with their teachers during lessons. He has also personally supervised a handful of lower secondary students in independent study modules and has observed how creative the students have become.

Mr. Goh is optimistic that design thinking would eventually lead to mindset changes among the teachers. Already, he has observed some teachers attempting to make changes to their pedagogical practices. He once saw a Mathematics teacher try to implement a problem-based learning approach in her lessons. Although she was cautious and tentative in her attempts, and she struggled to hold back from immediately correcting her students' misconceptions, this was an instance of the kind of change Mr. Goh has envisaged for the teachers. The process is slow, but it is evolving in the desired direction.

Mr. Goh cannot be certain that this and other changes he has observed among some of his teachers are the direct result of the design thinking. However, he firmly believes that the use of design thinking in the school has contributed significantly to the culture of change that is beginning to emerge, and that design thinking has given some teachers the confidence to experiment with new approaches to teaching and learning.

As a general principle, Mr. Goh will not bring in programmes that are likely to be abandoned when he leaves the school for another appointment. He wants to have solid programmes that will be sustained over long periods of time. For this to happen, teachers must be convinced of the value of the programmes. Indeed, teachers must become champions of these programmes. The school has a core team of design thinking champions, and they have been effective in promoting design thinking in the school. As with any major educational change, Mr. Goh thinks it would take around 5 years to lay the groundwork, another 5 years to implement the changes, and a further 5 to finally experience the full results. It takes a long time to make meaningful changes. So, there is no need to rush the teachers. It is important to give them time and space to make the adjustments.

8.3 Case 2: Mr. Musa's Design Thinking Journey

Mr. Musa is a new principal at a popular neighbourhood secondary school. He has been actively promoting design thinking since joining the school.

8.3.1 Design Thinking: Mr. Musa's Learning Journey

Mr. Musa first heard about design thinking from a friend who studied engineering at Stanford University. The friend had attended a course at the university's Hasso Plattner Institute of Design (popularly called 'd.school') that required him to participate in a multidisciplinary project to provide solutions to poor rural communities in Third World countries. Mr. Musa remembers clearly how impressed he had been when he heard about design thinking's emphasis on developing empathy with users to better understand their needs and motivations. He had the opportunity to learn more about design thinking and its possible applications in a school when he was selected for the Leaders in Education Programme (LEP) at the National Institute of Education. The LEP is a 6-month full-time executive programme to prepare participants for principalship. It so happened that the programme offered a course in design thinking. Participants in the course were also required to work on an innovation project at a school. Mr. Musa's project was to develop an Arts education programme for the school he was attached to and he used design thinking tools and processes to carry it out. Upon completing the LEP, Mr. Musa was given a scholarship by the Ministry of Education to pursue a master's degree. He gained admittance to Stanford University's graduate programme and chose to explore the educational potential of design thinking as his course of study.

While at Stanford, Mr. Musa interned for 9 months at the Research in Education Design (RED) Lab. There he worked with fellow graduate students from various disciplines on a STEM (Science, Technology, Engineering, and Mathematics) project that targeted middle school children from disadvantaged backgrounds. The graduate students on this project had the privilege of working with design thinking experts in a rich learning environment.

The open, experimental nature of the project meant that the team encountered more failures than successes, but the failures were highly instructive. Often, ideas that seemed interesting and powerful to the team did not work when they were applied to the middle school children. For example, the graduate students had the idea that sharing their learning journeys in the sciences with the children would inspire them in their studies. When the team tried to dazzle the children with their stories through colourful presentation slides, they failed; but when they experimented with hands-on activities, like magic tricks, they were more successful at reaching the children. Simple activities like carrying buckets of water to simulate the experiences of impoverished people with limited access to clean water were more effective than teacher-centred presentations in motivating the children's interest in using STEM to solve real problems. (For more details on this project, see Carroll 2014).

His time at Stanford confirmed Mr. Musa's intuitions about the educational value of design thinking and the challenges one might face when using design thinking to teach. Like many other pedagogical models, design thinking encourages idea generation, but what distinguishes design thinking from the other models is its focus on users' needs. Therein also lies one of the most challenging aspects of design thinking: coming up with practical ideas that users themselves would

recognise as useful responses to their needs and problems. A big part of the challenge is that users often do not fully understand what their own needs are. Often, designers notice discrepancies between what users think or say they need and what they do. Trying to meet users' needs therefore also involves helping them realise what their real needs are.

The experience with the middle school children also alerted Mr. Musa to the need for more structure in a design thinking project for learning. Many of the failures he and his teammates encountered had to do with the fact that as an after-school programme the design thinking project was vulnerable to disruptions caused by the children being held back for detention or simply failing to show up for various reasons. Even when there is stability in attendance, one must pay attention to the dynamics of the groups the children are in. Ideas that work with one group of students may not work with another. A lot depends on how the children relate to one another within their groups. This means that teachers who use design thinking need to be sensitive to how the students interact among themselves. This affirms the value of user-centredness in design thinking, even in the teaching of design thinking itself. To Mr. Musa, one of the great benefits of design thinking is its ability to foster over time a user-centred mindset in its practitioners, which ought to be cherished as one of the desired outcomes of education.

8.3.2 Design Thinking for Teachers and Students

Mr. Musa was appointed the principal of a popular neighbourhood school shortly after graduation. By this time, he was already deeply committed to design thinking as an important educational tool. Although the process of mastering design thinking is long and involved, it pays to expose educators to design thinking as early as possible and to do so in a way that ensures that it will be well received. Current trends in education and recent policy initiatives all point towards the relevance of design thinking as one of the main tools of education reform.

Increasingly, teachers need to see themselves as designers of students' educational experiences. There is more to teaching than delivering content. Teachers today need to focus more on helping students learn, and to transform them into self-directed, and hopefully also lifelong, learners. These objectives can be achieved by giving students the best possible learning experiences in school. Design thinking can play a huge role in helping teachers create those experiences.

In the context of facilitating educational change in Singapore, design thinking helps to move teachers away from the traditional teacher-centred approach to learning. Design thinking directs teachers to consider the educational experience from the perspectives of the people receiving it, rather than from the perspectives of those delivering it. Design thinking motivates teachers to tailor lessons that better meet the learning needs of students.

Design thinking is also an important tool for student development. As a set of different competencies brought together to address real-world issues, engaging in design thinking projects becomes a natural means to nurture in students a range of

critical and inventive thinking skills, and to do so in an organic, meaningful, and purposeful way. Having seen first-hand how children work on design thinking projects, Mr. Musa knows that students will engage enthusiastically in creative and practical tasks directed at producing workable solutions that people would want to use. This may have something to do with the energising nature of active prototyping. Children become very caught up when they are designing a product and using various materials to give concrete expression to their ideas. The excitement can be quite palpable for the children: ‘Hey, I made this! I tried it out on somebody and got a reaction’.

Design thinking can also be used to develop students’ character. Having to work in teams, students learn to value and respect the contributions of others. Children in their early teens can be quite self-absorbed. Engaging them in design thinking requires them to look beyond themselves to understand the situations others are in. Mr. Musa learned from his experiences in the LEP that both the designer and the user benefit from being part of a design thinking project. The designer and the user work together to co-create solutions in a design thinking project. They are collaborators rather than creator-and-beneficiary. In trying to help others, the designer receives help from the very people he is seeking to benefit. He is therefore humbled in the process. The user, on the other hand, is dignified in the process, because he is an active contributor to the *solutioning* process, and not a mere helpless or passive recipient. The designer and the user are also both beneficiaries. The user receives a solution to a problem he has; at the same time, the designer gets a chance to hone his skills and learns more about himself and his abilities through his empathetic creative engagement with the user.

8.3.3 Implementing Design Thinking with Staff

A month before his official appointment as principal, Mr. Musa was given the opportunity to take charge of a school management retreat. He used that as the occasion to introduce the school’s key personnel (KP) to design thinking. After a short lecture on design thinking, he brought the KP to a youth centre downtown. He did not set a specific task for the KP, but merely told them to observe what the youths were doing. There were no specific targets to be met. The activity was meant to be fun-filled: a day of watching youths having fun.

Mr. Musa’s intention was to get the KP to see the world from the perspectives of the youths. To his pleasant surprise, they did return with many interesting observations. For example, they saw a group of young people practicing their dance moves in front of a mirror. The youths were at it for over 2 hours. The KP noted how self-motivated the young people were, and this brought home the point that the school children could be just as motivated and disciplined if they were given learning tasks that were meaningful to them. They would not have to be constantly monitored. They also observed how two young men, one clearly a more experienced dancer than the other, were constantly engaged in conversation and trying out new moves. They were learning from each other.

The experience at the youth centre was used to challenge the KP to review the teaching and learning experiences in the school. Mr. Musa brought in teachers and students to engage the KP in conversation. Again, the aim was not to deliver real concrete results, but to immerse the KP in the design thinking experience. From their interviews with the teachers and students, the KP were able to identify needs that were later refined into design challenges. They learned from the teachers that management decisions ought to be communicated in ways that would make teachers feel that they are valued partners in the provision of a service. The KP learned from the students that some of them were disengaged from learning because they felt socially marginalised and unvalued by the school community. That they were able to acquire these insights in a short day-long activity helped convince the KP of the value of design thinking. Mr. Musa emphasised here that it is important to create a safe, non-threatening environment that all parties feel comfortable in for meaningful conversations to take place.

8.3.4 Implementing Design Thinking with Students

The positive response from the KP paved the way for the setting up of a special department. It was sheer luck that one of the KP was very familiar with design thinking and was keen to take charge of this department. The department would train teachers in design thinking and help them facilitate design thinking projects with students. In 2013, Mr. Musa worked with the department to pilot a design thinking project with a class of high-ability secondary two students. The project was timetabled as part of the school's Thinking Programme. Mr. Musa met the class once a week for an hour and a half each time over 2 months to work on a project involving the disabled. The students were divided into groups and assigned to work with a disabled person per group. They were tasked to understand the person's needs and design a solution to better meet the person's needs.

One of the groups had to deal with a particularly challenging case. All the students had been put through the design thinking process as thoroughly possible. So, they were all quite prepared to engage their disabled partners with their interview questions; they were also ready to carry out their respective individual roles, like interviewer, note-taker, and so on. But in this case, the disabled person was a lady who could not speak. She was also very self-conscious. She would answer the students' questions by typing into her phone, but if she made a mistake mid-way through a sentence, she would delete the entire sentence and start again. So, in the 25–30 min, they had with the lady, the group managed to ask only one question; meanwhile, the other groups had gone through 3–4 questions.

The students were concerned that they did not get sufficient information from their interview. This experience became a learning point for both Mr. Musa and the students. As they pondered the problem, Mr. Musa realised that the experience itself was instructive. The students did not complete their interview with the disabled lady, but why had this happened? What could they learn from the experience? What insight could they glean from how the interview session had progressed?

What the students experienced would no doubt be experienced by anyone who ever communicated with the lady. This was the insight. So, the students' design challenge emerged naturally: how might they improve the way the disabled lady communicated with people?

This experience reinforced Mr. Musa's belief in the pedagogical value of design thinking. He was further heartened when he saw the efforts the students put in to address the design challenge. The prototype was a simulation of a web-based application that the disabled lady could use on her phone. The application contained icons for things that she would typically require in her daily activities, like food, the restroom, the bus stop, and so on. With the application, she would no longer have to type out whole sentences when communicating these needs to others. The application would also contain common phrases that she would normally use, so this would further shorten the time she needs to type out her responses. The students refined this idea during their further interactions with the lady, who clearly liked and appreciated the idea. Even though the final product was just a paper prototype, the entire experience clearly demonstrated the educational potential of design thinking for all the stakeholders involved: the teachers, the students, as well as the disabled users.

8.3.5 Design Thinking and the Value of Social Mixing

A second pilot project involving students from the Express and the Normal (Technical) streams was recently conducted in the school. Students in the Normal (Technical) stream are academically less accomplished than their counterparts in the Express stream. Most of the students in the Normal (Technical) stream will eventually continue their schooling at either the Institute of Technical Education or one of the polytechnics. On the other hand, many of the Express stream students will progress to the Junior Colleges and subsequently to the universities. From his experience with middle school students during his time in Stanford, Mr. Musa knew that the Normal (Technical) students would be no less able than the Express students in participating in a design thinking project. However, Mr. Musa had another agenda in bringing together the students from the two streams.

As part of their learning of the design thinking process, the students had to complete a prototyping activity. This was a short eighteen-minute activity involving some simple materials: twenty sticks of uncooked spaghetti, one metre of string, and one metre of tape. The task was to build a free-standing structure using these materials. The only requirement was that the completed structure must be strong enough to hold up a marshmallow. Students from each stream were divided into eight groups. Seven out of eight groups from the Normal (Technical) stream completed the task successfully, but only three out of eight Express stream groups were successful. The Normal (Technical) students demonstrated to themselves and others their ability to excel at ideation and prototyping. They experimented more freely than their Express counterparts and were less concerned with whether their ideas would work before testing them. On the other hand, the Express students

tended to be more self-critical and self-conscious about the quality of their ideas and were consequently inhibited from exploring a wider range of possible solutions.

The aim of the exercise was not to pit one group of students against another. An unfortunate side effect of academic streaming is that students from different streams tend to keep to themselves. The exercise was intended to show the students that they had varying abilities and could therefore learn from one another and help one another accomplish a common goal. In other words, the design thinking exercise helped the students overcome social prejudices and learn to work together in multi-ability teams. To that end, the school has deliberately created cross-programme groups with students from different levels and different streams working together in each of these groups. Mr. Musa hopes that through the design thinking projects students from the different streams will develop friendships with one another and learn to respect one another as valued members of the school community.

8.3.6 The Road Ahead

The school has collaborated with a local polytechnic to run design thinking workshops for students and teachers. All teachers went through the design thinking workshop in 2013, and 16 volunteered to be design thinking facilitators. All lower secondary students participated in the design thinking workshop in 2014. Secondary one students participated in projects that involved users within the school community, while secondary two students worked on projects involving users from outside the school. The teachers are currently working on how to further develop the design competencies of the current secondary two students when they progress to secondary three. The tentative plan is to allow them to propose their own projects.

The training for both teachers and teacher facilitators will continue as there are many aspects of design thinking they have yet to completely master. Mr. Musa believes that training and development is very important, especially for the teacher facilitators, because their abilities as facilitators impact significantly on learners' (whether students or teachers) experiences in design thinking.

Good facilitation is key to convincing teachers that design thinking is not just another of the many problem-solving tools that they have been inundated with. It takes time to master the design thinking competencies, so it is important to ensure that teachers' attitude towards design thinking is a positive one at the outset. Allowing them to experience the power and value of user-centredness and rapid prototyping is particularly useful in this regard.

It might seem strange to draw attention to rapid prototyping, but it is a unique and valuable feature of design thinking, especially in context of Singapore education. Our students are often afraid to make mistakes because of the examination culture. In an examination, students have only one chance to get it right, so students tend to obsess over getting things right the first time around. Schools today are supposed to prepare students for the knowledge-based economy where creativity is becoming increasingly important, but students' risk-averse attitude in learning

inhibits and consequently limits their creative potential. Participating in rapid prototyping helps students overcome their fear of failure and develops their ability to learn through experimentation. These qualities are vital to the development of the inventiveness they will need for future professional successes.

The value of user-centredness may seem self-evident, but what this means in practice can be challenging from a design thinking perspective. To be user-centred is to observe and listen to the user and take the users' experiences into account when creating a solution to the issue being addressed. In the context of teaching and learning, the value of user-centredness challenges teachers to develop deep empathy with their students' experiences to gain insights into their needs and motivations. Teachers must constantly reflect on their practices and their interactions with students. These things do not come naturally to teachers who have been brought up in a system in which the teacher is traditionally viewed as the authority and the font of knowledge.

Mr. Musa understands that teachers' design capabilities must be given the time they require to mature. As a school leader and an advocate of design thinking, Mr. Musa knows he must create an environment that is supportive of exploration and experimentation. The process of developing a new culture is a slow one. One must begin with small successes to build confidence. The more natural the process of evolution, the more deeply rooted the new culture will be. For the time being, Mr. Musa continues to take the lead in facilitating school projects as he seeks to use these platforms to foster a design culture. Over time, the team of teacher facilitators he has been grooming will share some of the burden.

Although design thinking is not suitable for every aspect of the curriculum, it is a huge step in the direction of providing students with a holistic education. More so than any other pedagogical tool, design thinking effectively integrates the cognitive, affective, and kinesthetic aspects of learning. Along with its emphasis on empathy and teamwork, design thinking also helps to develop several twenty-first-century competencies. Mr. Musa believes that design thinking appeals to the idealism of youths, the sense that one can do something noble or meaningful for society, or in a more modest way to make a difference to the life of another person. In a world that so often emphasises competition and materialism, such idealism provides an important balance.

8.4 Infusing Design Thinking into Schools: Lessons from the Cases

The two cases reveal important lessons for any educator who is hoping to infuse design thinking into his or her school's curriculum and operations. Although we cannot conclude from the cases that the specific strategies adopted by the two principals would work in any school, nor understand the cases as describing all the possible ways of integrating design thinking into a school's curriculum and

operations or all the benefits that could be gained from such an integration, the cases do highlight some possibilities for consideration and sound useful words of caution.

8.4.1 Possibilities

Both Mr. Goh and Mr. Musa experienced some success in their experimentations with design thinking. In both cases, design thinking was used by the teachers as a tool for creating better learning experiences for their students, as well as by students to complete authentic and purposeful learning activities and tasks.

The idea of the teacher as a designer of learning experiences is not a new one in educational theory and research. In modern educational practice, it has its roots in Dewey's philosophy of education (e.g. see Dewey 1902/2008), but it can be traced further back to ideas explored in Rousseau's *Émile, or On Education* (1762/1979). What the two cases demonstrated was that design thinking provides teachers with the practical tools, methods and processes they need to create the child-centred learning experiences promoted by Dewey and Rousseau. The tools, methods and processes of the designer enable the teacher to develop deep empathy with the student's needs, aspirations, and motivations; they help the teacher understand what the student finds meaningful and purposeful, as well as identify more accurately the types of learning activities that the student will respond well to.

Both cases also show that students can engage and learn well through participation in design projects. When service learning and community involvement classes were re-imagined as design projects, students find greater meaning and purpose in the learning activities and acquire greater awareness and deeper understanding of important societal issues than before. We will return to this observation in the next subsection. What we wish to draw attention to here is that the cases make plain that the tools, methods, and processes of the designer cannot be adapted in an uncritical fashion for use by students. Professional designers possess a variety of cognitive skills and competencies that the students in both cases were just being exposed to. While designers can expertly use the tools, methods, and processes to tackle the design challenges they have undertaken, the students must first learn these tools, methods, and processes before engaging with the project, or learn them as they work on the project. So, the cognitive processes of the designer must be broken down and made visible to the students if the students were to experience success with them. Teachers must also be flexible and adaptive when guiding students to use these tools, because design problems are complex, and the design process is fluid and open-ended, which means that the teachers and students are likely to encounter unanticipated developments during the design process.

Both cases also taught an important lesson about pedagogy. In the two schools studied, the students appear to learn better through first-hand experiences than by listening to the stories of others. This learning point extends beyond the matter of infusing design thinking into schools. It is a fundamental insight into how learning takes place. This observation is perhaps unsurprising to those who have been

involved in physical education and character development programmes, because the dominant pedagogy in those areas is ‘learning by doing’. What the two cases studied here have shown, however, is that learning through first-hand experience can also enhance the learning of content that is more theoretical in nature, such as STEM content and societal problems and issues.

8.4.2 Potential Benefits

The benefits of infusing design thinking into schools were obvious in both cases studied. When the teachers used design thinking to develop learning activities and programmes, they were better able to see the educational situation from the perspectives of the students, allowing them to develop insight that they had missed previously, and consequently enabling them to create better learning experiences for their students. When the students used design thinking to tackle their service learning or community projects, they were able to develop greater insights into the needs, aspirations, and fears of various demographic groups in society, thereby acquiring a far superior understanding of societal issues than they had been able to previously. Teachers’ practices become more targeted and effective, with greater diversity in the types of learning activities employed in the classroom; students’ learning becomes more authentic, meaningful, and purposeful, ultimately leading to better performances.

The two cases corroborate some of the findings reported in two studies conducted in the US and Germany—Carroll (2014) and Noweski et al. (2012). Both studies found that the skills and competencies that constitute design thinking map closely onto those commonly included in ‘twenty-first century competencies’, such as innovation and creativity, the ability to work well under uncertain or ambiguous conditions, experimentation, learning from failure, working effectively in multi-disciplinary teams, empathising with the situation of others, etc. In this sense, design thinking promises to be a kind of ‘all-in-one’ solution for schools that are trying to work out how to fit the teaching and learning of various twenty-first-century competencies into an already packed curriculum.

Mr. Musa’s story further suggests that design thinking may have the power to bring about significant mindset shifts in both teachers and students, at least in the Singapore context. Singapore society is highly performance-driven. This, together with the further preoccupation with the economic well-being of the country, has resulted in a strong preference for graduates with knowledge and abilities in subjects and areas related to the sciences, mathematics, economics, and business management. Students who are strong in these areas have over time come to be perceived, by both teachers and students, as the ‘better’ students. Mr. Musa’s experiment with the Express and Normal (Technical) students in his school using the Marshmallow Challenge dispelled this misconception. Both teachers and students who participated in the experiment came to see that the two groups of students have different strengths and weaknesses and can produce impressive results when they work together in complementary ways. The centrality of rapid

prototyping in the design thinking process further encourages experimenting and learning from mistakes. So, in design thinking, we may have found a way to gradually shift the society away from a narrow definition of academic and professional success and towards a more inclusive mindset that allows diverse talents and abilities to flourish and a perspective that understands failure as just another step towards (as opposed to away from) success.

8.4.3 Management of People and Processes

In both cases studied, design thinking was introduced into the school by the principal. Both leaders had a good grasp of change management processes and strategies, which accounted to a large extent for the successes reported in the two cases. Both principals understood that the process cannot be rushed, because the successful introduction of design thinking into a school requires proficiency in new competencies and pedagogies, as well as shifts in cultures, mindsets, and values. The two principals therefore adopted patient approaches, beginning with a small group of teachers and students, who will subsequently ‘infect’ the rest of the school through the sharing of success stories and practices. They were both happy to reap small successes in the first instance and only looked forward to greater successes for the future.

It is also clear that both school leaders recognised the importance of helping the initial group of teachers and students achieve success, no matter how small, in their first projects. In a performance-driven society like Singapore, nothing kills a good idea as surely as failure in the first attempt at implementation. So, the development of design competencies among the initial group of teachers is vitally important. Subsequently, a supportive environment must be created to allow teachers to explore and experiment. This was why service learning and community involvement lessons were selected for the initial experiments. These areas are traditionally regarded as low stakes by teachers and parents, because students are not tested in them. So, the teachers felt free to try out ideas and were not deterred by fear of failure. Underpinning this approach is the understanding that teachers cannot be asked to abandon their existing mindsets and values overnight. So, both principals took pains to draw connections between the benefits of design thinking and academic performance, probably the one aspect of education that Singapore teachers generally hold as the most important.

A distinctive feature of the Singapore education system is that the principals are rotated to another school or ministry appointment every 5–7 years. Since the introduction of design thinking into a school requires a shift in culture, mindsets, and values, and this can happen only slowly over a number of years, then it is critical that at least a small group of the school’s teachers come to take ownership over the process of change, otherwise any change or progress achieved during the leadership of one principal may be very quickly undone once he or she leaves the school.

8.5 Conclusion: Future Directions for Exploration

A few questions are raised by the two cases reported here. By way of conclusion, we will articulate the questions that strike us most strongly.

To begin with, in both cases, the efforts were initiated and carefully managed by the school leader. So, the cases can be instructive for any principal or head of department who wishes to introduce design thinking into his or her school or department. But this leads us to wonder how an individual teacher who is convinced by the benefits of design thinking might go about weaving it into his or her own lessons. In schools or departments where the principal or head of department wields a tight control over the purpose, content and organisation of learning experiences, how might a teacher go about experimenting in his or her classroom and convincing his or her superiors?

In both cases, the principals and teachers experimented with non-academic subjects. This was a deliberate strategic move to overcome possible resistance from both teachers and students in a performance-driven culture. To what extent could design thinking improve learning experiences in academic subjects? This question concerns, not the use of design thinking by teachers to design better lessons, but the use of design projects as a pedagogy to facilitate learning of academic content. There is no doubt that students can learn content in academic subjects through a project that requires them to solve a complex problem. The question is this: how much more and how much better will they learn? Some of the studies cited at the beginning of this chapter (e.g. Carroll 2014; Noweski et al. 2012) provide strong indications that teaching students design thinking, as well as teaching subject content through design thinking projects, can bring about better learning experiences and stronger academic performances. These studies found also that when students learn a set of subject content through design thinking projects, they begin to see how that content is related to the content of some other topics in the same subject, as well as the content of some other subjects. Students also come to appreciate in a very real way how the materials they are learning in the classroom are relevant to their daily experiences and the issues and problems they read or hear are going on in the world. What would be interesting and useful to find out are two further things: (a) whether these results can be replicated across different educational contexts, and (b) how effective design thinking projects are in facilitating and improving learning relative to other pedagogical strategies for achieving similar objectives.

Teaching through design thinking projects is not a straightforward matter. New learning materials will have to be created to teach content for which teachers already have teaching resources. Teachers will have to be trained in the new pedagogy. Design thinking projects based around real-world problems are likely to be multidisciplinary in nature and require significantly longer classroom time for students to engage with them in meaningful and effective ways. In short, introducing design thinking projects into the classroom to facilitate the learning of academic content, if done in any meaningful way, will require significant changes

to existing organisational structures, such as the redesign of curricula and learning materials, the timetabling of lessons, the deployment of teachers, the organisation and facilitation of learning groups, and so on. These issues must be examined and worked through carefully to ensure that the introduction of design thinking into the classroom will produce positive results.

Both cases emphasise the benefits design thinking may bring to the students' development of cognitive skills, especially their ability to create innovative solutions that meet human needs. There appears to be an absence of attention to design ethics in both cases. Here, design ethics go beyond considerations of user-centredness. They include questions about how users' needs ought to be met, whether the needs should in fact be met or whether they should be redirected and reshaped, as well as the ethical implications of how the solutions themselves may shape future human behaviour and thought (Fry 2009; Kroes and Verbeek 2014; Vermaas et al. 2008). To what extent is the absence of attention to design ethics in these two cases representative of how educators in general understand design thinking and the prospect of bringing design thinking into school curricula? And if the cases are indeed representative in this respect, to what extent should we be concerned about this absence of attention to design ethics? These issues suggest promising directions for further research into the introduction of design thinking into education.

8.6 Questions for Reflection and Discussion

1. How might one successfully implement design thinking in a school? What are some potential opportunities and challenges? How might one take advantage of these opportunities? How might one turn the challenges into opportunities? Considering the strategies that both Mr. Goh and Mr. Musa have adopted, what might some alternative strategies be?
2. Considering the skills and competencies that constitute design thinking, how might we use design thinking to support or enhance teaching and learning in schools? The examples discussed in the two cases take the form of design thinking projects that are conducted separately from academic lessons; the skills, dispositions, and values targeted seem to be non-academic in nature. How might design thinking be used to support or enhance academic learning?
3. What might some potential limitations of design thinking be when used as a pedagogical tool?
4. What further important research questions need to be explored and answered to better inform schools' efforts to introduce design thinking into the curriculum?

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