RESEARCH WITHIN REACH

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THE BIG IDEA

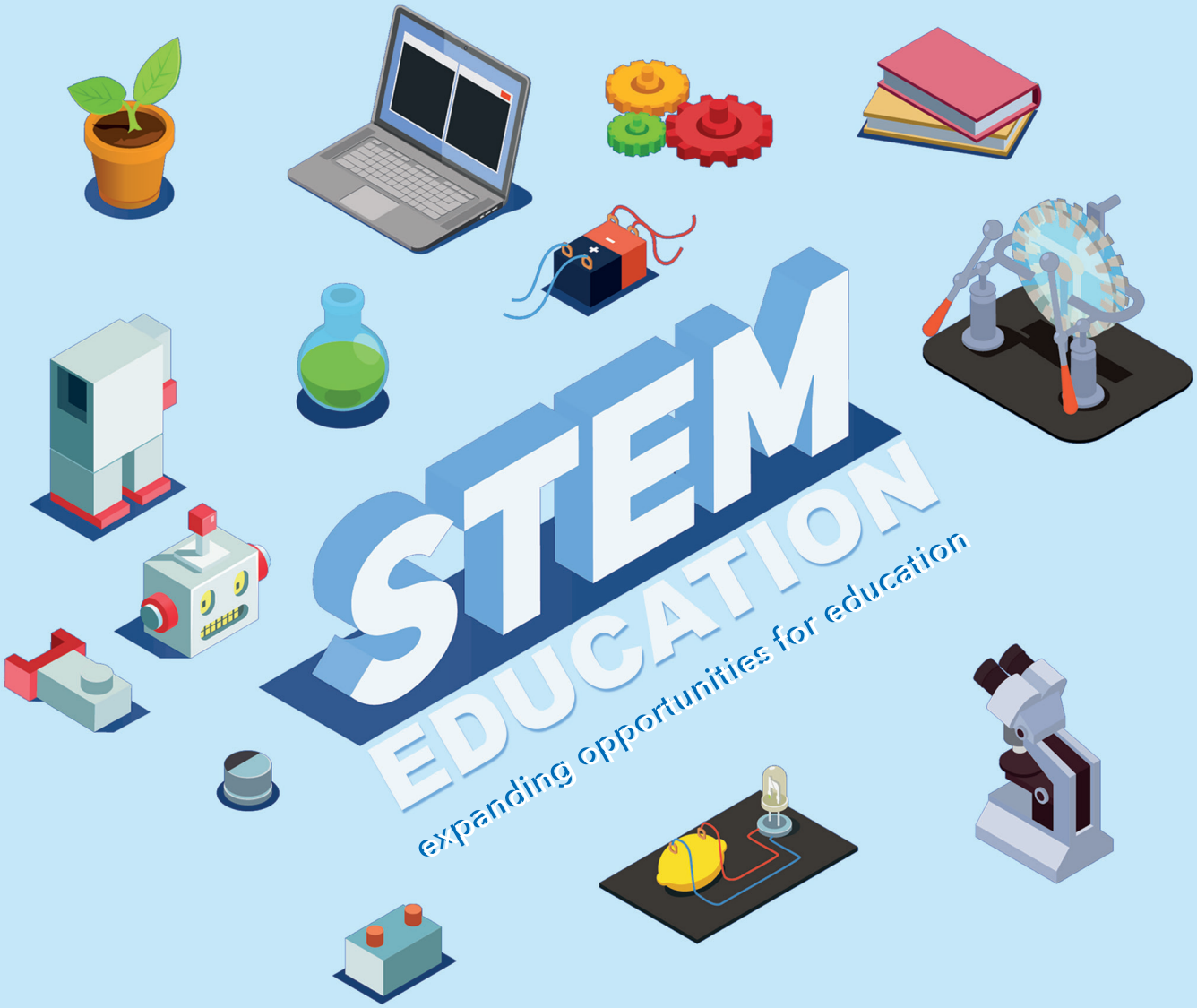
STEM Education: What about It?

CLASSROOM PERSPECTIVES

Igniting Joy and Creativity in Classrooms

IN THEIR OWN WORDS

Making Way for Makerspace



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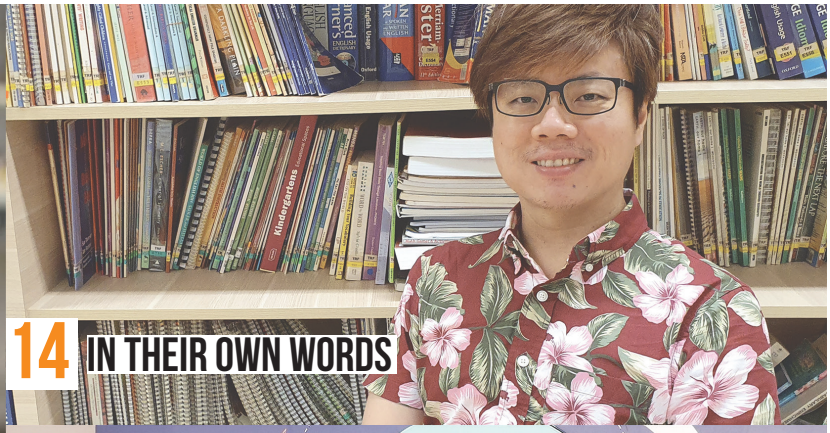

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We believe education research can be practical and relevant to the classroom. *SingTeach* was initiated in 2005 to bridge the gap between research and practice for you, the teacher.

Published quarterly by the Office of Education Research at the National Institute of Education, Singapore, *SingTeach* is an e-magazine dedicated to improving teaching and enhancing learning. Each article is crafted with teachers in mind.

With easy access to tried-and-tested practices that work in your classroom, *SingTeach* puts research within your reach. We hope you'll be inspired.

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Is STEM the Future of Education?

Dr Michael Tan
Research Scientist
Office of Education Research

Being educators, we are constantly surrounded by young people whose potentials are unforeseeable. As a result, we embrace change, are highly adaptable and always celebrate the new despite the challenges that come with them.

However, we should also remind ourselves to take a step back every once in a while to look at and understand whether these changes are actually improvements. As we welcome the new, we should also remember not to get overly distracted by "more, faster, cheaper", and ignore truth, beauty and wisdom. And so it is with Science, Technology, Engineering, Mathematics (STEM) education–with the proliferation of shiny new technologies, with new artefacts, new furniture, new paint–it may be useful for us is to take a brief respite from the busyness and think about what we are doing.

Yes, STEM is *a* future for education. But we must not forget the lessons we have learnt from the past. Incorporating ICT tools in education went from forgettable attempts in the earlier days till today's better examples. Today, few of us can consider not using some form of ICT tool in our teaching. The recent interesting times of extended Home-Based Learning has made streaming stars of all of us. Crucially, we should remember that "schools" and "ICT tools" no longer feel like a strange juxtaposition like it did in the past.

If we think about things we take for granted today, can we imagine how school might be different in the future if we continue on our current tentative steps forward? Would schools *improve* if we remove disciplinary silos (in favour of inter- and trans-disciplinarity), recitation style assessments (in favour of performance-based assessments) and industrial logic (in favour of *wisdom* guiding educational decisions)?

If we are to be truly future-centred, we really should widen our imagination to consider paths not currently taken. Yes, not everyone will be ready. Yes, few of us are even sure we know what we are doing. Yes, there is much work to be done, but that is precisely why we signed up for this job, isn't it?

ONLINE EXCLUSIVES

VIRTUAL STAFF LOUNGE

Digital Learning in the Time of a Pandemic

T.E.A.C.H. from Home

Digitizing Empathy in Online Teaching

Maintaining Positivity and Building Resilience amid the COVID-19 Pandemic: Practical Tips for Parents

CONTRIBUTION

Developing and Nurturing a Thinking Classroom

Read *SingTeach* online

SINGTEACH VIRTUAL STAFF LOUNGE

As social distancing becomes a new norm, it may become tempting for us to think about how much "better" our lives were before COVID-19. Instead of taking this as a period of deprivation, let us take this opportunity to reconnect, recharge and rethink how we can learn from and support one another in our efforts to give our learners the best education whether physically or virtually.

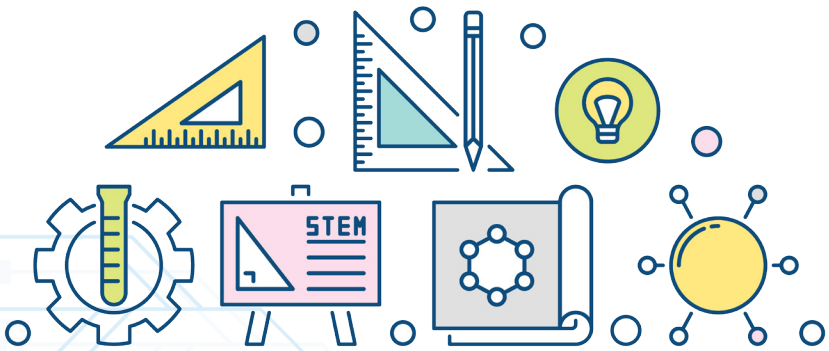
While *SingTeach* continues its pursuit to bridge education research and practice for you, we also want to create a collaborative platform where we can support one another and where you can bring forth your education experiences during this challenging period. In *SingTeach*'s new *Virtual Staff Lounge*, we hope to feature your stories and experiences on how this pandemic has affected you.

We invite you to contribute on the following range of topics:

- ***think pieces*** on how the pandemic has affected education/education research;
- ***challenges*** you faced and how you overcame them;
- ***tips*** on how to make distance lessons more engaging;
- ***reflections*** on COVID-19, distance learning or home-based learning; and/or
- any interesting ***stories*** that give insight into the nature of teaching and learning during this crisis.

By consolidating these materials, we hope that despite the disruption, we can continue to support one another through this pandemic.

Scan the QR code to access the *Virtual Staff Lounge* for more information on how you can contribute and submission guidelines.



STEM EDUCATION: WHAT ABOUT IT?

Education is about taking risks; we prepare our students of today in hopes that they will be equipped for a world that has not existed and whose form we cannot foresee. Certainly, some limited aspects of the near future can be predicted, but reach too far into the future, and uncertainties begin clouding our sight. But that does not mean we should stop considering what we are doing today and wondering if things can be improved in schools. One possible avenue for change that has swept up educational systems worldwide is the prospects for creative, interdisciplinary education in the form of STEM education. NIE guest editor, Dr Michael Tan, curates this issue of SingTeach *to introduce the unique challenge of STEM education in Singapore.*

At the economic level, STEM education is proposed as a solution to the problem of "how do we prepare students for the novel industries of the 21st century?". We recognize that even today, knowledge boundaries are porous. There are likely few, if any, scientists who do not use computational resources in their work. Technologies have always contributed to scientific progress, and vice versa. Yet, in schools, we continue teaching in disciplinary silos that do not accurately represent the practices.

There is also an increasing challenge of educating for creativity: *What might an open-minded embrace of unforeseeable futures look like? What kinds of school and classroom cultures will best nurture creativity?* As education is *not* about putting information into students' brains, how might we attend to aspects of learning that are not amenable to rational analysis? For instance: how might we orchestrate emotions and sociocultural resources to convince and motivate students to *be* creative?

What is STEM Education? Why is it Important?

Science, Technology, Engineering, Mathematics (STEM) has been an acronym from at least the 1980s, as a shorthand used by the US National Science Foundation to refer to the collection of disciplines which were closely related together.

Not long after, economists realized that STEM disciplines were large contributors to the success of contemporary firms, and the rhetoric of education for success in STEM disciplines started to take off. Today, as there is no "standard STEM", there is no standard STEM education either. Practitioners do STEM in various ways, with different combinations of skills and practices. Educators have been inspired to expand the scope of the possible too.

"STEM education can be an opportunity for educators to rethink processes and goals of schooling," says Michael, who is also

a Research Scientist at the Office of Education Research at NIE. Despite the lack of clear definition surrounding STEM, the diversity of interpretations can offer educators the possibility for increased autonomy and professionalism in the way in which curriculum and pedagogy are conceived.

"If there is a range of practices which are acceptable as STEM, that means teachers can adapt their lessons to the kinds of interests and motivations that their students have," Michael explains. "STEM can be about building a bridge to withstand heavy loads. STEM can also be about building a robot, designing human-friendly interfaces to help seniors negotiate their world, or building an electromechanical apparatus for a scientific investigation."

As we better understand the impact contemporary science and technology can have on humanity and its habitats, it gets increasingly crucial for schools to relook what they consider "preparing students for the future".

We need new questions and new answers, and while school still needs to reproduce disciplinary expertise, the question has always been: *How might we transcend what we have?*

STEM Education in Singapore

Given the numerous possible definitions of STEM, surely many schools are already "doing STEM"?

"Yes," says Michael, "but more can and should be done." Typically, schools will approach STEM through the Applied Learning Programs (ALPs) where different programme vendors deliver lessons that excite students and show them what is possible.

"At the entry level are lectures. Because STEM lessons often involves novel, sometimes toy-like devices and systems, lessons do not feel like typical school science, and it will not take much for instructors to captivate students." Yet, many of these things can bring students to much deeper waters than they are usually deployed. "As we have learnt through our history of deploying computers in education, changing things without changing cultures of teaching and learning can be futile."

Michael recommends that schools reconsider what it is that they want their students to achieve. "There will always be changes in schools. The question for the educator is to become clearer which of these changes are actually *improvements*."

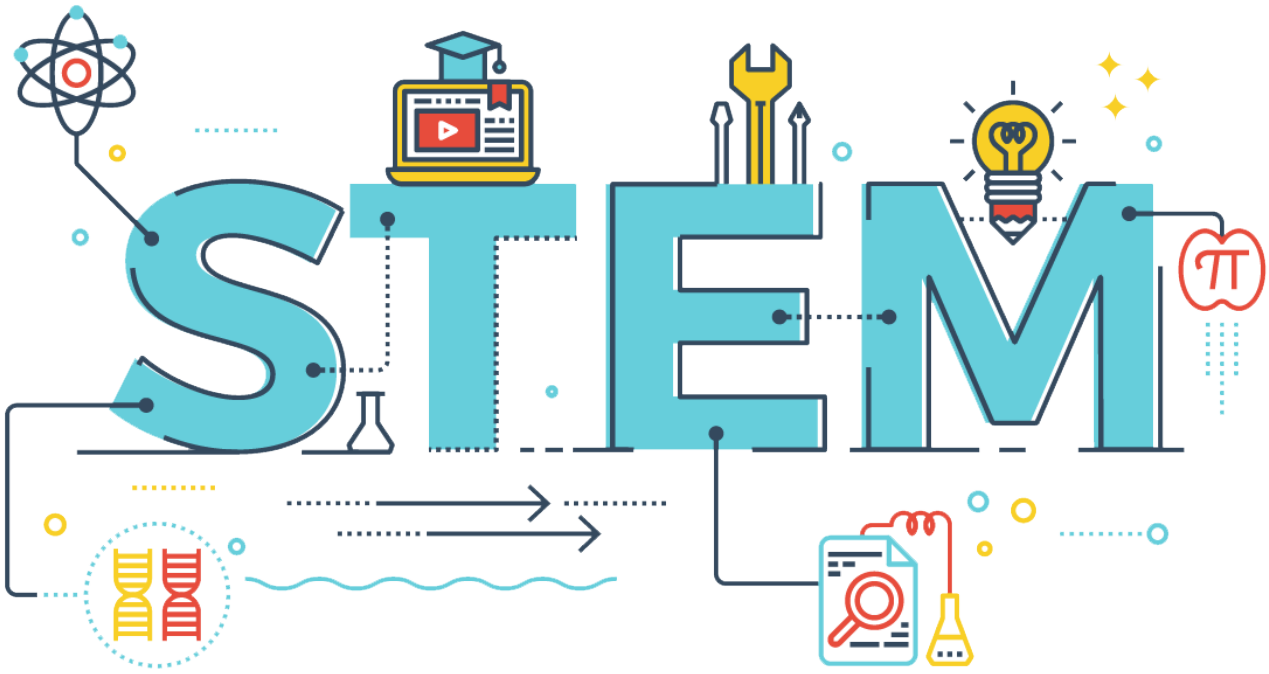
STEM can be part of a holistic school strategy to nurture students that can have an impact on the world. Here, what is needed is not just the skills that help students understand the world; what is also important are the attitudes that can help them leave a positive impact on society.

How to STEM?

Many models exist for STEM instruction, but they often have in common the use of engineering practices to design and make practical solutions to complex problems. It appears that the "secret sauce" is in the selection of a good design prompt. Too specific, and the solution becomes too unique. Too general, and the solution would become too difficult to implement.

For example, if the problem is posed in terms of "find a way to make use of a lever as part of a device to open food containers", the number of possible solutions are few, and most would be within reach of search engines.

On the other hand, a prompt such as: "Design a method to improve the lives of the elderly" would be far too open. An intermediate problem that delimits the context, but yet contains a problem that is not easily solved, is ideal.



For schools who do not think they are ready for design challenges, Michael suggests that teachers can make use of STEM classes as a means to physically and/or metaphorically take apart artefacts and systems. “Arthur C Clarke said that ‘Any sufficiently developed technology is indistinguishable from magic.’ We are surrounded by magic and this can be very disempowering.”

The goal is to regain control over the inventions that we have become reliant upon. However, Michael reminds us that we should resist the temptation to simply tell students what they are supposed to know: “The methods for deconstruction are useful skills to learn in and of itself. We can be true to the ALP ideal, and introduce STEM as a means to understand how science is applied in contemporary technologies.”

The Future of Education

Does STEM represent a future for education? Michael certainly thinks so: “Much has been said about how information is now ubiquitous. That may be correct, but there are mindsets, qualitative human appreciation, and a subjective ‘feel’ for things that cannot be expressed even in videos.” For these kinds of knowledge, nothing beats actually getting one’s hands dirty, at least metaphorically.

As events of this year have reminded us once again, we are not solely rational machines that can be programmed by exact sequences of instruction. We have different preferences, different desires, different values, and the teacher-as-professional should be able to take these into account to develop instruction that attends to their students as individual autonomous agents.

> “There will always be changes in schools. The question for the educator is to become clearer which of these changes are actually improvements.”

Michael tells us of his favourite quote from Yeats and what it means for him: “If ‘education is not the filling of a pail, but the lighting of a fire’, we can understand that education is an inherently risky process: things may not catch on fire. On the other hand, it could burn far stronger than we can ever imagine. Yes, we would love to be able to create standardized fire starting procedures that always work, but what might this reduce our students into?”

Instead of thinking of STEM as thrust upon teachers as merely more work to be done, STEM can be seen instead as a means to bring us back to the core of what it means to educate. For this, Michael seems to raise a glass to toast: “Let’s set the place on fire!”

ABOUT THE GUEST EDITOR

Michael Tan *is a Research Scientist with the Office of Education Research at NIE, Singapore. He has spearheaded several research projects focusing on makerspace and is currently a Co-Principal Investigator of a project that looks at enhancing STEM education through improvisational tinkering and computational thinking.*

Strengthening STEM Instruction through Student-Centred Approaches

Science, Technology, Engineering and Mathematics (STEM) education, an interdisciplinary approach to learning and teaching, plays a critical role in fostering 21st century skills such as critical thinking, collaboration, communication and creativity. How can teachers sharpen their tools and widen their strategies in teaching STEM subjects more efficiently in the classroom? SingTeach *talks to an associate professor from NIE, Tan Aik Ling, on her latest research study that compares students' learning experiences when engaging in problem-centric and solution-centric STEM activities.*

According to the U.S. Bureau of Labor Statistics, there were 8.6 million science, technology, engineering and mathematics (STEM) jobs in the country in 2015 (U.S. Bureau of Labor Statistics, 2017). STEM employment is also predicted to rise in the United States by about 13% between 2012 and 2022 (U.S. Bureau of Labor Statistics, 2014). In Singapore, the demand for STEM graduates is expected to grow.

"A similar trend will also likely be seen in Singapore," says Associate Professor Tan Aik Ling, who is also one of the founding members of meriSTEM@NIE, a STEM education research centre in NIE. "It is a given that the jobs of the future will be integrally STEM driven. Hence, it is important to not only provide, but also improve STEM education."

Closing the Gap in STEM Education

Current integrated STEM education, however, remains fragmented. Aik Ling points out that there are gaps in the areas of designing and teaching of STEM education programmes. She emphasizes the need for an evidence-informed approach to address the problem.

"My research study aims to close the knowledge gaps in this area. One of its main objectives is to collect data on the different experiences that each student faces as they engage with integrated STEM activities in the classroom. We focus on three key aspects: *questioning*, *argumentation* and *creative thinking*," she explains.

Involving lower secondary classes from three secondary schools, Aik Ling adds that the activities are carried out under specific conditions.

"Each school will have one class experiencing the curriculum starting with a problem (problem-centric) and another class which will be experiencing the curriculum starting with a solution (solution-centric)."

The problem-centric classroom will have students studying and solving a problem, for example, traffic

congestion at a junction while the solution-centric classroom will begin with a solution, for example, an intelligent traffic light. Both of these teaching approaches go beyond the memorization of content and place students at the centre of the learning process.

So how does applying these inquiry-based learning approaches help equip students with 21st century competencies?

Nurturing STEM Skills

Aik Ling shares some preliminary observations: "The two different approaches—problem-centric and solution-centric—show that the learning experiences of students, in terms of their questioning, argumentation and creative thinking, would be different."

"A problem-centric integrated STEM activity will afford more divergent learning experiences for students as there could be multiple solutions suggested for a specific problem. The array of possible solutions offered will enable the development of skills such as critical evaluation and negotiation."

In comparison, a solution-centric integrated STEM activity, in which the students deconstruct the solution, provides limited opportunities for students to generate alternative ideas, critique and negotiate ideas. The learning outcomes, however, will be more focused and specific, and will likely lead to better conceptual learning.

"The data gathered at this stage on the different learning experiences and outcomes of the students give us an indication of how teachers should prepare when planning STEM activities in the classroom," Aik Ling says.

For example, when carrying out a problem-centric integrated STEM activity, teachers will need to be versatile and prepared to handle novel and unexpected solutions. In contrast, when facilitating a solution-centric STEM activity, teachers will have the benefit of being able to accurately map the learning outcomes.

Educators are encouraged to keep all of these factors in mind when designing integrated STEM activities. "Using what we have observed in the classroom, we are also generating the key features that define a STEM classroom so as to further facilitate teachers' planning and reflection," adds Aik Ling.

The Future of STEM Education

"When given the room and opportunity, we find that the students are extremely divergent and enjoy generating creative solutions to the problems presented," she shares.

Even though teachers find it challenging to set aside time within the curriculum for STEM programmes, they are focusing on the positives. "Teachers are excited about being involved with STEM activities as they see value in exposing their students to complex, persistent and extended problem-solving," she adds.

The positive feedback has been encouraging but Aik Ling admits that more can be done for STEM education in Singapore. In line with meriSTEM@NIE's future plans, Aik Ling's project is a stepping stone to nurturing, developing and refining STEM learning and teaching in Singapore and beyond.

"In the short term, meriSTEM@NIE hopes to generate sufficient research evidence to inform integrated STEM education in Singapore and in Asia. In the long term, we hope to develop the organization into a 'go-to' centre for integrated STEM education internationally," she says.

ABOUT THE INTERVIEWEE

Tan Aik Ling *is Associate Professor and Deputy Head (Teaching and Curriculum Matters) with the Natural Sciences and Science Education Academic Group at NIE, Singapore. Her research interests include classroom interactions, STEM education, inquiry-based learning, and science teacher professional development. She is also one of the co-founders of meriSTEM@NIE and is involved in planning research projects as well as local and international outreach for the centre.*

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The team behind the Hildan Playscape: *Jasjit, Gina Ow, Jasmine David, Elaine Wong, Jeline Tan, Daniel Ng, Dan Tan and Andy Ng.*

IGNITING JOY AND CREATIVITY IN CLASSROOMS

Do you remember that sense of accomplishment you felt as a child when you built your very first LEGO model? The sheer joy and satisfaction from the activity just makes you want to share your masterpiece with the world. Imagine if those same feelings can be replicated in classrooms today. What would it take to change the way teachers teach for that to happen and how would it change the way students learn if it happens? A team of teachers from St Hilda's Primary School shares how they do it in the Hildan's classrooms through constructivist learning activities.

INTRINSIC MOTIVATION TO LEARN

Being in a time-constrained environment, the focus in most classrooms today tends to be placed on academic learning. But for one team of teachers from St Hilda's Primary School, sparking that joy of learning and nurturing creativity in their students constantly remains their priority.

Consisting of a team of teachers from different disciplines co-led by Mrs Elaine Wong (Head of Science Department) and Mr Andy Ng (Head of Gifted Education Programme), the team strongly believes that it is crucial to imbue in their students an intrinsic desire to learn. They hope to do so through student-centric pedagogy that fosters positive values and mindsets in students.

"In a world where knowledge and skills are made obsolete rapidly, the only way to have future-ready students is to imbue in them a strong desire to learn," Elaine shares. "So when then-Minister for Education Ng Chee Meng spoke about joy of learning in 2017, it struck a chord in us." Elaine believes that when a child sees joy in learning, he or she will be intrinsically motivated to constantly seek new knowledge.

So how can teachers inculcate a love for learning in students? For Elaine and her team, the answer lies in the concept of makerspace.

MAKING WAY FOR A LANDSCAPE OF PLAY

"'Making' is a form of play, which is a means to foster a joy of learning and entrepreneurial dare in children," Andy explains the idea of makerspace. "But if 'play' only resides in a physical space, its impact on learning is limited."

As such, the team envisions more than just a space but a *spirit* of play that starts from the physical space and spreads to other spaces: the classroom, staff room, and then into the hearts, heads and hands of students and teachers, forming a landscape of play at St Hilda's.

"Makerspace is about creating an environment for students to engage in constructivist learning activities," Andy adds. It is a space where students use available resources to create tangible artefacts and, in the process, nurture intangible qualities such as creativity, resilience and the joy of learning," Andy adds.

With a strong leadership support, the team creates the *Hildan Playscape* with confidence that the spirit of playing and making within it can and will spread further beyond that physical space itself.

THE HILDAN PLAYSCAPE

Today, a room filled with students building *LEGO* models, creating straw sculptures and tinkering on iPads is a common sight at St Hilda's.

Elaine notices that when students are fully immersed in their constructivist activities, they are less averse to failure and start to have an appetite for risk. "Development of growth mindset, and a tolerance for risk and failure are valuable characteristics that we see students developing slowly," she shares. "The students also seem more inquisitive and more motivated in their own learning."

The *Hildan Playscape* is not just a fringe activity for students to participate in during their free time. It is a whole-school movement that challenges the conventional ways of teaching to inspire learning. With this aspiration, the team takes small, intentional steps to integrate *Playscape Activities* into the classrooms and the school's curriculum.

A WHOLE-SCHOOL APPROACH

Through a ground-up approach to ensure that their action plans are effective and sustainable for the school, a multi-discipline team brainstorms on how to include play in their respective subject lessons. The team will then try out these ideas in their respective classrooms and adjust accordingly as they progress.

After rigorous testing, the ideas are infused into level programmes. "The infusion process allows the team to assess if both the rigour of the subject's learning objective and the intent of learning through play strike a balance. At this stage, the team will start to train and mentor teachers who are not familiar with implementing *Playscape Activities* in their lessons." Andy explains.

Once the infused lessons achieve the subject's learning objectives, the team integrates these ideas into the school's scheme of work. This is when teachers from the various departments will work together and integrate the *Playscape Activities* into the school's curriculum for future implementation.

BENEFITS OF PLAYSCAPE

In the pursuit of fostering the joy of learning in students through play, the implementation of *Playscape* also brings about other benefits.

At the individual level, it provides opportunities for students to pick up new skills and take ownership of their learning. "St Hilda's Primary's own version of makerspace is a space and an outlet for our students to fuel engagement, curiosity and creativity and at the same time, experiment, take risks and play with their own ideas," Elaine shares.

ONLINE EXTRAS!

Find out how St Hilda's Primary inculcate the spirit of making and playing through a series of activities called *Playscape Activities* in the online version of *SingTeach*!

From the perspective of an educator, the *Hildan Playscape* creates a personalized avenue for students to learn in their own preferred way and pace. This flexibility allows teachers to better cater to the needs of multiple intelligences within the classroom.

"Students also develop a maker mindset through the different Hildan School Distinctive modules introduced at various levels," Elaine adds. "Students engage in coding, use design thinking and maker pedagogy to solve real life problems, underpinned by attributes such as resourcefulness, and a willingness to collaborate and share expertise and experiences."

Through all these, the *Playscape* team hopes that students in St Hilda's Primary will become the agents of their own learning and the change makers of tomorrow.

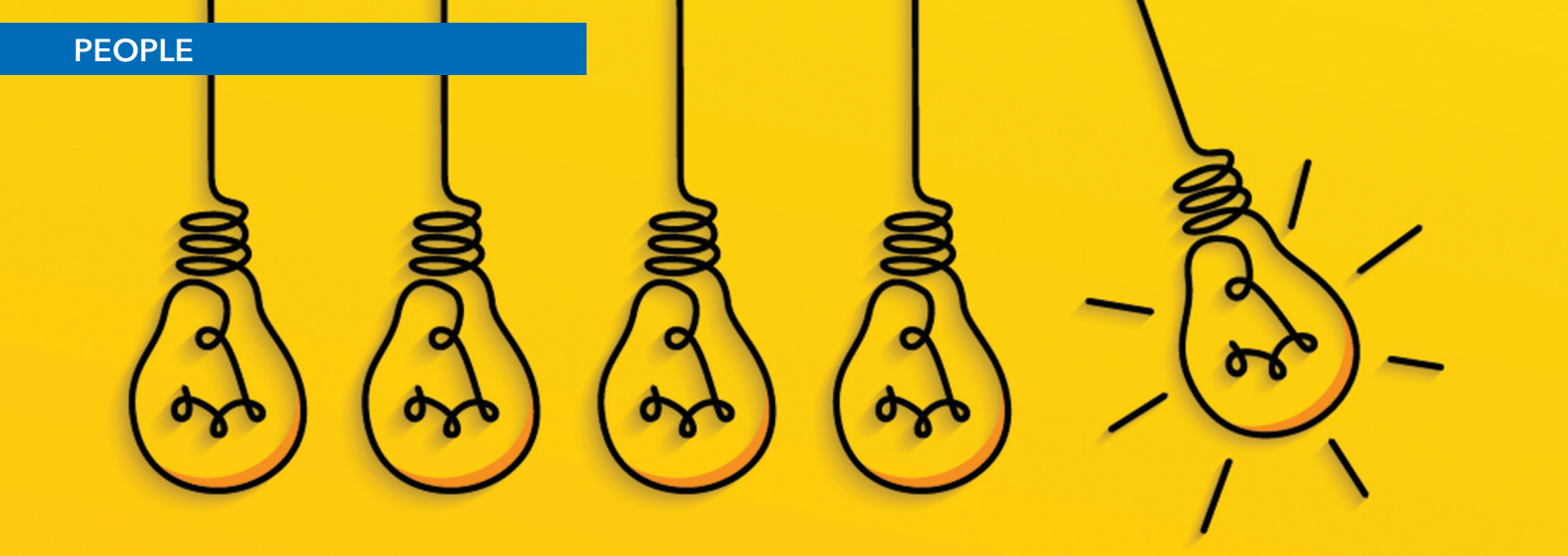
The Hildan Playscape

At the Hildan Playscape, five learning zones were set up to promote the Innovation, Inquisitiveness and Interconnection through an interdisciplinary thematic approach. The five learning spaces are listed below.

- **Tinkerbox:** In *Tinkerbox,* students are encouraged to explore and tinker with their ideas with *LEGO* bricks and *Strawbees*.
- **ACTS Think Tank:** This space has a mini-library with books to help trigger ideas and imaginations and facilitate creative group discussions.
- **Tech Lab:** Students in this futuristic-looking learning space have access to the latest digital technologies such as iPads, 3D printers, programmable robots, micro-controllers to inspire learning.
- **Makerspace:** Students receive tools to engage in hands-on activities such as creating an artefact and prototypes in this space.
- **One Button Studio:** Students can engage in journalism and video-creation in this audio-visual learning space with green screen technology.

ABOUT THE INTERVIEWEES

Elaine Wong *(HOD Science) and* ***Andy Ng*** *(HOD GEP) co-led Hildan Playscape with a team of teachers from different disciplines.*



The Value of CREATIVITY in Interdisciplinary LEARNING

How does one do interdisciplinary learning in a manner that nurtures creativity? Associate Professors Yeo Kang Shua and Chong Keng Hua, both from the Architecture and Sustainable Design Pillar at Singapore University of Technology and Design (SUTD), remind us that architects have long been masters of interdisciplinarity. They draw from diverse resources of knowledge to solve fundamental human problems on the ideal spaces for living, working, and playing. They share with SingTeach *how and why the value of creativity is important in their work.*

Risks in Creativity

Creativity often involves risk-taking because oftentimes in the process of being creative, outcomes tend to be unpredictable and beyond our expectations. Kang Shua shares that the restoration of the *Wak Hai Cheng Bio* (Yueh Hai Ching Temple), which was built in the 1820s, was one of his favourite projects to work on.

"One common misconception (that even some of my students have) regarding conservation or preservation is that there is no need for creativity, as the main point of such projects is for the end result to look as if no one has done any treatment to it," he says.

"In reality, substantial creative thinking and risk-taking are actually required to achieve this."

Kang Shua elaborates on the considerable risks involved in the restoration project, such as taking down the roof, disassembling the timber structure, repairing it and then replacing it back very carefully.

"There are many unknowns in a restoration project," says Kang Shua. "In order to mitigate the risks, my team and I studied the building in great detail, sourced for craftsmen overseas and investigated current conservation techniques that are scientific in nature."

A **SAFE SPACE** SHOULD BE GIVEN TO STUDENTS TO ENCOURAGE THEM TO FAIL, WHILE MAKING SURE THE SYSTEM *ALLOWS* THEM TO FAIL.

– Yeo Kang Shua
Associate Professor and Head of Pillar (Research/ Practice/ Industry), Architecture and Sustainable Design Pillar,
Singapore University of Technology and Design

Learning Spaces to Nurture Creativity

In Kang Shua's opinion, a space for students to get creative from tinkering and making things also needs to be able to "tolerate mess".

"In our contemporary parlance, this would be a makerspace," he says. "A makerspace is not revolutionary in nature and simply allows students to have their own personal space for their computers, and tabletops to sketch and draw out ideas."

Keng Hua adds that not only is the physical environment important, but also the sociocultural element of the space.

"As we tend to focus too much on particular skills, we forget that there are mindsets that need to change as well," he shares. "Students need to learn to be collaborative, adaptive, and resilient—they need to work together with others when the inevitable unforeseeable futures present challenges to their preconceived assumptions."

For creativity to be nurtured in students, Keng Hua opines that we need to move away from ticking off checklists of a student's performance and instead, help them to connect the dots to see the connections across disciplinary silos.

Touching on the cultural aspect of the learning environment, Kang Shua says that a space that students can personalize and be at ease in should be provided for. "Students must be given ownership of the spaces," he shares. "A safe space should be given to them to encourage them to fail, while making sure the system *allows* them to fail."

The working world can be unforgiving to failure, and it is in the safe space of schools that learning from failure needs to be nurtured.

"In these spaces, we should also encourage them to experiment, empower them and not bog them down with too many institutional rules," adds Kang Shua.

Learning for the Future

More than just learning from words on paper, screens or in soundwaves, students should familiarize themselves with spatial thinking by learning with their hands, bodies and through interaction with things, says Keng Hua.

"I think it is important that students become more familiar with spatial thinking and a more holistic orientation to knowledge," he says. "The goal is to be able to metaphorically extend these forms of thinking to develop relationships between concepts that have more depth, so that connections can be seen."

"Connections can become visible when we allow them to occupy an expanded space, outside of a typical linear or even flattened manner of presentation," he adds.

Kang Shua feels that a culture of experimentation is critical, so as to be able to imagine a problem from different perspectives. His work in architecture allows him to experiment with volumes and shapes, and try out different permutations.

"Critique between peers in the forms of sharing and discussion is also important for improving the quality of ideas," he shares. "We need to move away from binary 'right and wrong' answers, and move towards a fuller understanding of 'better and worse', and why." ■

ABOUT THE INTERVIEWEES

Associate Professor Yeo Kang Shua *is trained as an architect and architectural historian, and is currently Associate Professor and Associate Head of Pillar (Research/Practice/ Industry) of the Architecture and Sustainable Design Pillar at Singapore University of Technology and Design (SUTD).*

Associate Professor Chong Keng Hua *is a pioneer in silver architecture and collaborative design in Singapore, and is currently Associate Professor and Collaboration and Social Programme Coordinator of the Architecture and Sustainable Design Pillar at SUTD.*

MAKING WAY FOR MAKERSPACE

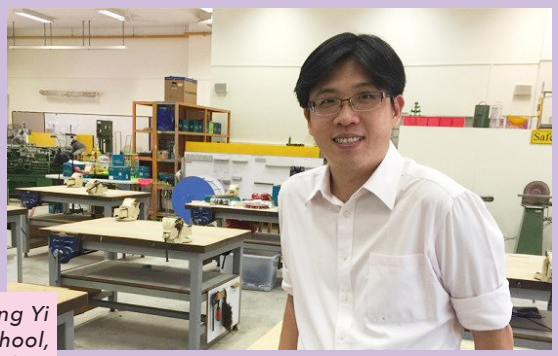
WHY SHOULD TEACHERS CONSIDER A MAKERSPACE FOR EDUCATION?

Makerspaces provide an outlet for students to experiment and explore creatively, beyond the boundaries of timetables and textbooks. Other than allowing students to pursue their own creative interests and ideas, makerspace also provides opportunities for students to co-construct (as an individual or in a team) their understanding of subjects in different ways that can be enriching to both teachers and students.

For example, some students can demonstrate the principles of physics through cardboard drag-cars with different wheel sizes and body shapes of their own design, while others can choose to express the same knowledge through the aerobatic movements of a DIY radio-controlled aircraft. Makerspaces allow students to play different roles: the visionary with his flights of fantasy, the scientist with his intellectual curiosity, and the designer with purpose and passion.

WHAT ARE SOME TIPS FOR IMPLEMENTING A MAKERSPACE?

What distinguishes a makerspace from a regular school workshop is the unique culture of experimentation and learning from mistakes. Students should feel encouraged to pursue their own interests and ideas, and teachers should be mindful of building up an atmosphere of intellectual curiosity and sharing. Do not worry about having to "know" everything under the sun as a makerspace teacher, and allow students to explore and learn together. In short, rather than worry about making "failsafe" makerspaces, aim to create an environment that is "safe-to-fail"!



ABOUT THE INTERVIEWEE

Johnny Wee *is the Subject Head (Design Education) of Ping Yi Secondary School. He is also a pedagogical innovator in the school, who started up his school makerspace and designed its curriculum around students' interest in aerospace engineering.*

While it is not a new concept, makerspace has been gaining traction in Singapore schools for the numerous benefits it brings about to students' learning. Traditional learning tends to be one-way in that students are told what to learn. The makerspace environment, however, values the spirit of collaboration and involves three main elements: tools, people and mindset. Two teacher-advocates of makerspace share with us more about its benefits.

WHAT IS THE DIFFERENCE BETWEEN MAKERSPACES AND CLASSROOMS?

A makerspace serves to enhance the teaching and learning experience. It provides the resources, tools and physical space that may not be possible and/or available in a conventional classroom. This is particularly so for primary schools which, unlike secondary schools, do not have a Design and Technology workshop. Some of the specialized equipment includes cutting equipment, electronic drills, glue guns, workbenches with clamps, etc. This allows teachers to enrich the Maker experience and provide students with the opportunity for richer and more authentic prototyping (which I do for students' prototyping solutions for problems identified). The physical configuration of a makerspace may also differ from a conventional classroom, providing spaces that cater to a variety of Maker activities.

WHAT ARE SOME OF THE CHALLENGES IN IMPLEMENTING MAKERSPACE?

All in all, makerspaces can support and enhance teaching and learning if utilised in a purposeful manner. This requires thoughtful planning in designing the curriculum for the purposeful use of the makerspaces. During our initial phase of implementation, we created and bought some resources without deliberation on creating the curriculum to utilise the resources. This led to challenges faced such as under-utilised resources. Therefore, makerspaces can support learning meaningfully only if driven by thoughtful curriculum design and planning.

ONLINE EXTRAS!

Read more about the two forms of makerspace at Nanyang Primary School in the online version of *SingTeach*!

ABOUT THE INTERVIEWEE

Lin Lixun *is teaching at Nanyang Primary School. He runs the school's innovation programme, and is also in charge of the school's makerspace project which takes place over several sites and timeslots, including a successful recess programme in the library, and a makerspace CCA.*

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