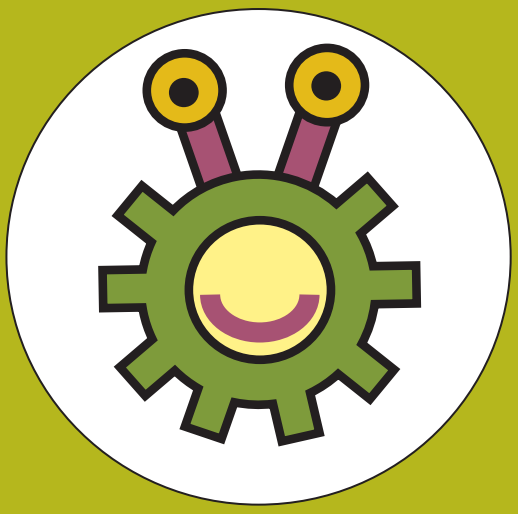
Maker-Centered Learning Playbook for Early Childhood Education

Playbook



Edward P. Clapp, S. Lynneth Solis, Carolyn Kar Ning Ho, Katherine Laguzza

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Agency by Design

Maker-Centered Learning Playbook for Early Childhood Education

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Foreword by Jennifer Cheng

Afterword by Lisa Golds

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The *Maker-Centered Learning Playbook for Early Childhood Education* was produced by the Agency *by* Design: Early Childhood in the Making research team at Project Zero, a research center at the Harvard Graduate School of Education in Cambridge, MA, USA. The collaborative inquiry supporting this work was conducted with a cohort of educators and administrators working within the Victoria Educational Organisation group of schools in Hong Kong.

The original Agency *by* Design thinking routines in the appendix of this work are freely available on the Agency *by* Design website (www.agencybydesign.org). These tools are also available in Clapp, E. P., Ross, J., Ryan, J. O., and Tishman, S. (2016). *Maker-centered learning: Empowering young children to shape their worlds*. San Francisco, CA: Jossey-Bass.

Back cover photo caption: One of Jennifer's students consults a map as she navigates the airplane during role play.

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ACKNOWLEDGEMENTS

The Agency *by* Design: Early Childhood in the Making research initiative—and this playbook—were generously supported by the CTF Education Group and Victoria Educational Organisation. The content of this playbook was developed through a process of collaborative inquiry over two years with a devoted cohort of teachers and administrators in Hong Kong. The Agency *by* Design: Early Childhood in the Making research team would like to especially thank Dr. Adrian and Jennifer Cheng of the CTF Education Group and Victoria Educational Organisation for their generous support of this work. We would like to further thank Victoria Educational Organisation's leadership and administrative staff for their support of this project and for taking care of our needs during our site visits in Hong Kong.

The Agency *by* Design: Early Childhood in the Making project—and the materials outlined in this playbook—would not have been possible without the hard work and support of the teachers and principals at our partnering schools. We are especially grateful for the contributions of Justin Chislett, Jennifer Lee, Belle Liu, Louise McCann, Claudia Wong, Tina Yu, and principal Debbie Cheng at Victoria Nursery (Harbour Heights) and Kit Cheng, Shannon Chung, Liyi Guo, Cecily Ko, May Poon, Joyce To, and principal Dianna Chan at Victoria (Harbour Green) Kindergarten.

Through this research project, we have had the pleasure to meet and become thought partners with a host of other researchers, educators, and advocates of education throughout Hong Kong and China. Here, we would like to thank Cesar Harada and Maria Lok Yee Li at Maker Bay, Mo Kwok at Lifelong Labs, Dr. Lydia L.S. Chan, Ms. Nicky Weir, and the Yew Chung College of Early Childhood Education faculty and staff members, Dr. Doris Cheng of Tung Wah College, Dr. A. Lin Goodwin, Dr. Carrie Lau, and Dr. Diana Lee of the Faculty of Education at Hong Kong University, Yvonne Yihsing Liu-Constant of Lesley University and Wai Kwan Gail Yuen of the Education University of Hong Kong. We would like to also thank Candy Yang of Bamboo Bicycles Beijing for her support in translating the original Agency *by* Design thinking routines.

In addition to our colleagues in Hong Kong and throughout the Greater Bay Area, we are also grateful for the support of our fellow researchers and administrators at Project Zero, including our director Daniel Wilson, our finance director Faith Harvey, and the Project Zero core team, including Sarah Alvord, Tina Blythe, Margaret Mullen, Jordy Oakland, Leyla Omeragic, and Matt Reicken. We would like to further express our gratitude to Andrea Sachdeva, for her early work on this project, and Ben Mardell, for his ongoing counsel and support. Additionally we would like to thank Sarah Sheya, Sophia Blumert, and Christina Smiraglia for the expertise they shared with us over

the course of this study, and the original Agency *by* Design research team—Jessica Ross, Jennifer Oxman Ryan, and Shari Tishman—for the foundational work they established within the domain of maker-centered learning. We would like to further thank the broader Agency *by* Design network for offering feedback on early drafts of tools presented in this playbook. We also owe our thanks to the Harvard Graduate School of Education Dean's Office and Department of Development and Alumni Relations for their support of this work, especially Dean Bridget Terry Long and Soo Sheung Wong. Additionally, we would like to thank Andrea Tishman for her expertise and advice in designing this playbook.

Lastly, we would like to express our utmost gratitude to Lisa Golds for all of the energy, insight, and spirit that she brought to this work as our devoted project liaison. The Agency *by* Design: Early Childhood in the Making initiative would truly not have been possible without her efforts.

FOREWORD

Founded in 1965, Victoria Educational Organisation (VEO) is a member of the CTF Education Group, an organization committed to providing high quality education; to advance the frontiers of teaching and learning; and to support research and education initiatives that can prepare all students to succeed in the 21st century.

VEO has seven kindergartens, one nursery, and three playgroup centers offering high quality education for over 4,000 children in Hong Kong. VEO strives to adopt best practices using contemporary research and pedagogies in order to enhance the education of our young learners. Thus, we were honored to have the opportunity to work with the world-class research team at Project Zero, engaging in a pilot research initiative to explore the Agency *by* Design framework for maker-centered learning in our early years settings.

Perhaps due to my engineering background, I was particularly interested in exploring how we can better equip our children for the pursuit of maker-centered learning from an early age. Empowering our students as designers and makers is certainly not just learning about how—how to build a robot, how to build a house made of cardboard, or how to write code—but it is also about developing a creative mindset, and the fundamental skills and dispositions that allow children to learn between and beyond the disciplines. Matching the challenges of the 21st century, maker-centered learning has become an important global education trend aiming to encourage, nurture, and inspire young peoples' creativity and empathy. Unlike traditional education practices that often focus on developing fact-based knowledge and technique, maker-centered learning inspires students to use their hands and their minds, encouraging enhanced critical thinking.

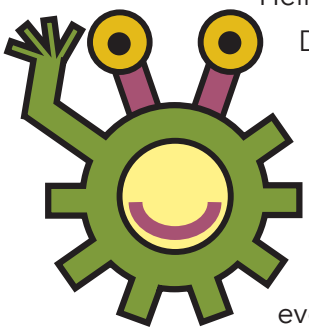
With the support from the CTF Education Group, in 2018 we embarked upon the Agency *by* Design: Early Childhood in the Making collaborative inquiry by engaging a number of VEO faculty from Victoria (Harbour Green) Kindergarten and Victoria Nursery (Harbour Heights) with the Project Zero research team. We are so excited to share the resulting achievements from the research carried out in their classrooms. From as young as three to six years-old, our students have been able to engage with maker-centered learning in a number of ways. We have excitedly observed our kindergarten students as they used screwdrivers to take their toys apart, analyzing how complex the inner workings are; or as they redesigned the Hong Kong MTR (Mass Transit Railway) system to be safer and more efficient for all citizens. Through maker-centered learning, we have seen our students develop important skills such as creativity, observation, problem solving, and collaboration—which will all be necessary for their future pursuit of school, work, and personal development.

We believe this meaningful project not only benefits our students but also the education field by providing this playbook for early childhood educators. We also believe that maker-centered learning can be used in early years settings to make a positive impact on Hong Kong's education system, as well as in settings all around the world. And we ultimately believe that maker-centered learning can be used to empower our younger generations to believe in themselves, and to create and shape a better world for tomorrow.

My heartfelt thanks to the Project Zero research team at the Harvard Graduate School of Education for their tremendous support throughout the past two years, as well as the VEO Principals, Curriculum Team, teachers, and staff who have worked on this project.

Jennifer Cheng
Deputy Vice Chairman, CTF Education Group
Supervisor, Victoria Educational Organisation
Hong Kong, October 2019

PREFACE



Hello there! My name is Vic. A couple of years ago, I met the Agency *by* Design: Early Childhood in the Making research team during their first visit to Hong Kong. They were meeting with their new friends at the Victoria Educational Organisation when we bumped into each other on the street—or was it at the playground? or maybe at a dim sum restaurant? or on a ferry? or maybe . . . oh, I can't remember. What's important is that we became quick friends on that first visit—and we've been good pals ever since.

Just like the research team, I'm curious about how people learn—especially really young people—and I have always enjoyed making. When the team first told me that they were studying something called maker-centered learning I got so excited! "Making and learning," I thought, "what's not to like?"

During the team's most recent visit to Hong Kong, we were sitting in the sun, drinking bubble tea in Victoria Park when they mentioned the playbook you're reading right now. They said they were working on a playbook that would share all of the lessons they learned and stories from their time working with teachers in Hong Kong and stuff like that. "That's so cool," I said, "I can't wait to read it!" And then they said, "Y'know what Vic, you represent what it means to be an empowered maker. You explore how things are made and try to make them better for your community. Would you be interested in being our guide to the playbook, to introduce readers to the different aspects of the book—and to provide your perspective?"

"Would I?" I exclaimed. "Yes! Sign me up." And that's how I got this job.

So, in the pages ahead, you'll see me pop up every now and then. I'll be introducing each of the chapters you'll be reading so you know what each section of the playbook is about. It's a really important job—and I'll be sure to take it really, really seriously. But I'll also be hanging out in between the chapters to lead you along the way—and to make sure you're having a good time. I hope you enjoy the playbook. There's lots of interesting stuff in it that the team and I think you'll find useful—and fun! In fact, since there is so much good stuff to read, we should get started. Are you ready? Ok, then just turn the page and we'll jump in. Let's go!

INTRODUCTION

While studying science information writing as part of their writing workshop, a group of 5- and 6-year-old students engage in a variety of hands-on explorations, including making eggs bouncy by soaking them in vinegar. The students create a how-to guide for making bouncy ball eggs as a means for other young people to reproduce their experiences. The guide the students create includes a list of necessary materials—and a detailed step-by-step narrative that can be used by others to achieve the same bouncy egg effect.

After researching inclined planes, screws, wheels and pulleys, and other simple machines, young students are building makeshift arcade games using as many simple machines as they can. With flippers, bumpers, and gears a-plenty, the students work in teams to create an arcade full of games that are awesome to play with their classmates.

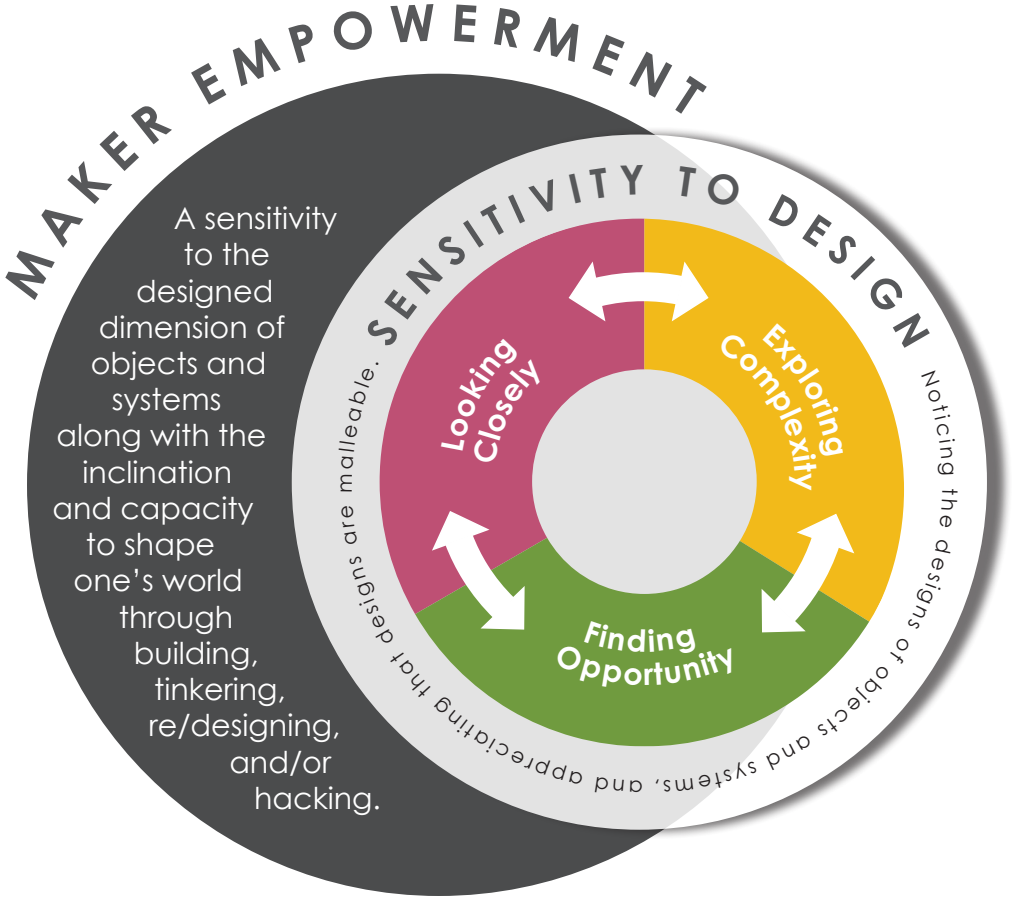
The above anecdotes of young people at work are examples of maker-centered learning in action within early childhood education. Each of these examples comes from the work of teachers in Hong Kong during their engagement in the Agency *by* Design: Early Childhood in the Making project.

AGENCY *BY* DESIGN AND THE ORIGINS OF MAKER-CENTERED LEARNING

In 2012, the Agency *by* Design research initiative was launched at Project Zero, a research center at the Harvard Graduate School of Education in Cambridge, Massachusetts.[1] Originally funded by the Abundance Foundation, a San Francisco Bay Area family foundation, the Agency *by* Design project was framed as an exploration of the promises, practices, and pedagogies of maker-centered learning. At the time, the Maker Movement—an interest in learning and sharing with others while working with one's hands within interdisciplinary environments that combine a variety of tools and technologies—was gaining momentum throughout the United States and around the world. Noting the Maker Movement taking root all around them, the Abundance Foundation wondered what might be the educational benefits of incorporating making into a variety of teaching and learning environments. The research team called the practice of incorporating making into educational contexts, *maker-centered learning.*

[1]For more about Project Zero, see http://www.pz.harvard.edu

Loosely defined, maker-centered learning is a pedagogical approach for thinking and learning centered on making to foster individual and collective agency and empower young people to shape their worlds. After an iterative process of qualitative research and collaborative inquiry, the Agency *by* Design research team established a framework for maker-centered learning and outlined this in the book *Maker-Centered Learning: Empowering Young People to Shape their Worlds* (Clapp, Ross, Ryan, & Tishman, 2016). This framework includes the two core concepts of maker empowerment and sensitivity to design, three teachable maker capacities (looking closely, exploring complexity, and finding opportunity), and a host of making moves and indicators that scaffold each capacity.[2] Relatedly, the research team also developed an assortment of protocols, activities, and thinking routines (short cognitive tools meant to routinize generative thinking skills),



The Agency *by* Design framework for maker-centered learning.

[2]For a complete overview of the Agency *by* Design framework for maker-centered learning, see http://www.agencybydesign.org/explore-the-framework

each designed to support young people in becoming more maker empowered and sensitive to design.[3]

Originally co-developed and pilot tested by Pre-K–12 teachers in Oakland, California, this framework came to be widely adopted by educators throughout the United States and around the world. As the Agency *by* Design framework for maker-centered learning continued to grow in popularity, the prospects for further research began to bubble to the surface for researchers at Project Zero and their teacher colleagues.

INCORPORATING MAKER-CENTERED LEARNING INTO EARLY CHILDHOOD EDUCATION

The Agency *by* Design: Early Childhood in the Making project arose from an interest in developing tools and strategies for maker-centered learning that are specific to early childhood education. Fueling this project were early childhood educators who had interacted with the Agency *by* Design framework for maker-centered learning and who—despite their enthusiasm for incorporating the practices of maker-centered learning into their classrooms—felt that some of the language and core concepts associated with the framework were not developmentally appropriate for their very young learners.

Educators first argued that some of the vocabulary that was used within the thinking routines and other pedagogical tools connected to the framework was too complex for young learners who were still developing their language skills. Words like *complexity, ethics, perspectives,* and others, they said, were too abstract or advanced for their learners to grasp.

Beyond vocabulary, educators additionally believed that there were three central concepts associated with the Agency *by* Design framework for maker-centered learning that needed to be adapted for young learners. The first of these concepts was the notion of complexity itself. Complexity plays a central role within the Agency *by* Design framework for maker-centered learning. It is at the heart of the exploring complexity maker capacity and features prominently in several thinking routines. The concern from some early childhood educators was that their young learners may not be equipped to comprehend the concept of complexity, nor able to explore the complexity of objects or systems—as the Agency *by* Design framework for maker-centered learning prompts young learners to do.

The second concept that some early childhood educators said their young students may not be able to grasp was the concept of *systems* and the act of *systems thinking*. Systems thinking also

[3]To explore the full suite of Agency by Design's pedagogical tools, see http://www.agencybydesign.org/thinking-routines-tools-practices

plays a key role in the Agency *by* Design framework for maker-centered learning—and is one of the aspects of the framework that many educators feel makes it both powerful and unique. Indeed, systems thinking is a higher order cognitive activity, a capacity that some theorists have suggested is not possible to develop until adolescence or even adulthood (see for example, Kegan, 1982). In this regard, some early childhood educators argued that their students may not be developmentally equipped to think in terms of complex systems.

Lastly, some early childhood educators argued that developing empathy and engaging in perspective taking might be out of reach for their young learners. Like complexity and systems thinking, empathy and perspective taking are key elements of the Agency *by* Design framework for maker-centered learning. As with the many protocols associated with design thinking (see for example, IDEO, 2013), the Agency *by* Design framework for maker-centered learning encourages young learners to consider the perspectives of the many people who use the objects and systems that they endeavor to design, hack, or redesign. The *Think, Feel, Care* thinking routine, in particular, prompts young learners to consider how individuals or groups of people within a system think, feel, and care about their position in that system—before making an attempt to alter or change that system.[4] Some early childhood educators noted that young children are engaged in the process of developing a sense of self, and therefore, may be more egocentric and less able to have empathy for or take the perspectives of others. These educators made the case that their young learners would struggle to engage in the empathy and perspective taking that the Agency *by* Design framework for maker-centered learning encourages.

Of course, just as there were educators of young learners who made the case that the Agency *by* Design framework for maker-centered learning may not be developmentally appropriate for their students, there were also educators of young learners who argued the opposite—contesting that the vocabulary associated with the framework was within reach of their young learners (or could be easily changed to be more appropriate), and that making could support their students in developing a further understanding of complexity, seeing the world through the lens of systems, and building their capacity for empathy and perspective taking. Through research and everyday observations, we have come to understand that even our youngest learners experience complex lives—and navigate that complexity. From birth, young children negotiate their way through complex routines: they come to understand that there are times to sleep, times to play, times to nurse and eat, times to bathe, etc. They get shuffled from one environment to the next and must adapt quickly. They hear, learn, and come to recognize multiple faces, voices, and speech patterns—all the while

[4]For more about the *Think, Feel, Care* thinking routine, see http://www.agencybydesign.org/sites/default/files/AbD%20Think%20Feel%20Care%20.pdf

experimenting with their own voices and the limitations and capabilities of their young bodies. At the same time, young children experience complexity by encountering, making sense of, and manipulating any number of tools and materials in their worlds.

Likewise, we have come to understand that young children regularly engage with and manipulate systems. Many of us have seen a very young child engage in the process of dropping a toy to the ground—which their caregiver then picks up and hands back to them. Which the child then drops to the ground again. Which their caregiver picks up and hands back to them again. Which the child drops to the ground—and on, and on, and on. While this process may indeed be perceived as a playful game, it is also a simple system that the child not only understands, but controls. As with complexity, the systems young children engage with each day become more complex as they get older. The system of drop-off and pick-up at daycare or at a family member's house and the system of washing one's hands, eating, and then cleaning up one's plate after a meal are examples of systems that young children encounter. Systems abound in the lives of young children, and they successfully participate in those systems each day. The research team felt that young children could learn to think critically and creatively about these systems by using the tools/resources associated with the Agency *by* Design framework

While it is true that young children are in the process of developing a sense of self, we have also come to understand that they are capable of empathy and perspective taking. This view is highly supported by an abundance of research that argues that even infants have a range of social abilities, including an inclination to cooperate with others, a capacity for joint attention, and a proclivity for imitation—all abilities that require one to adopt perspectives different from their own. These findings debunk the idea that young people don't have the capacity for empathy and perspective taking and suggest that very young people—including infants—are more in tune with other people than earlier research has suggested (Birch, Li, Haddock, Ghrear, Brosseau-Liard, Baimel, & Whyte, 2017). Again, as young children get older, their capacity for empathy and perspective taking increases. A toddler may come to understand joy, fear, concern, or frustration as expressed by characters in the children's books that are read to her. Toddlers and other young children may also understand the feelings of others as they learn to share toys and tools with their friends, comfort each other spontaneously, and navigate social conflicts at daycare, in the playground, or at preschool. In these situations, young children come to understand that their actions have impacts on others. They regularly enact empathy and perspective taking as they decide how to engage in a given scenario, knowing that their actions may positively or negatively impact the feelings of those around them.

ESTABLISHING A NEW INQUIRY

While we understood that young learners were capable of understanding complexity, navigating systems, and taking the perspectives of others, we also recognized that we could support these capacities with research-based pedagogical tools and strategies. Like many others, we saw the potential in maker-centered learning to act as an effective pedagogical approach that could support young learners in understanding complexity, thinking through systems, and developing empathy and perspective taking—just as we envisioned that maker-centered learning could support young learners in becoming more sensitive to design and maker empowered.

It was at this time that we came to know the Victoria Educational Organisation, a network of schools in Hong Kong that served young learners ages two–six.[5] The Victoria Educational Organisation had long embraced hands-on, inquiry-based approaches to early childhood education, but maker-centered learning was new to them. Therefore, the schools under the wing of the Victoria Educational Organisation presented themselves as fertile ground for testing our hypotheses and exploring the key questions we had about the prospects of maker-centered learning in early childhood education. With the support of the CTF Education Group, in 2018 we established the Agency *by* Design: Early Childhood in the Making project as a pilot study. Working with a small cohort of educators from the Victoria Educational Organisation in Hong Kong, the goal of this collaborative inquiry has been to adapt the Agency *by* Design framework for maker-centered learning for young learners. Two research questions informed this process of investigating how maker-centered learning is used in early childhood education:

1. What evidence do early childhood educators observe of young learners engaging with complexity, systems thinking, and perspective taking through maker-centered learning?

2. What insights and strategies emerge as early childhood educators incorporate the Agency *by* Design framework for maker-centered learning into their teaching and learning practices in their classrooms?

Below, we further describe the Hong Kong educational environment and the Victoria Educational Organisation before presenting the methodological approach we used in addressing these two guiding questions.

[5] For more about the Victoria Educational Organisation, see victoria.edu.hk.

THE HONG KONG CONTEXT AND THE VICTORIA EDUCATIONAL ORGANISATION

Early childhood education in Hong Kong has been rapidly growing and evolving over the past few years. A majority of young children in Hong Kong take part in early childhood programs, but despite the large enrollment, the Hong Kong government had not focused on early childhood education until initiating school reform in 2000. Since then, notions of child-centredness and holistic development have been promulgated as the core values of early childhood education throughout Hong Kong.

Considering the local interest in supporting new developments in early childhood education, the Victoria Educational Organisation became a fitting research site for this project, especially given its interest in using innovation and technology to promote students' agency in design and civic responsibilities. Through the Agency *by* Design: Early Childhood in the Making pilot study, we worked with the Victoria (Harbour Green) Kindergarten and Victoria Nursery (Harbour Heights) campuses—two private kindergarten schools that are a part of the greater Victoria Educational Organisation network. Both of the schools follow the International Baccalaureate (IB) Primary Years Program, an inquiry-based, transdisciplinary curriculum for early childhood education, and provide trilingual instruction for their students, teaching lessons in English, Cantonese, and Putonghua (a standardized dialect of Chinese, also known as Mandarin).[6]

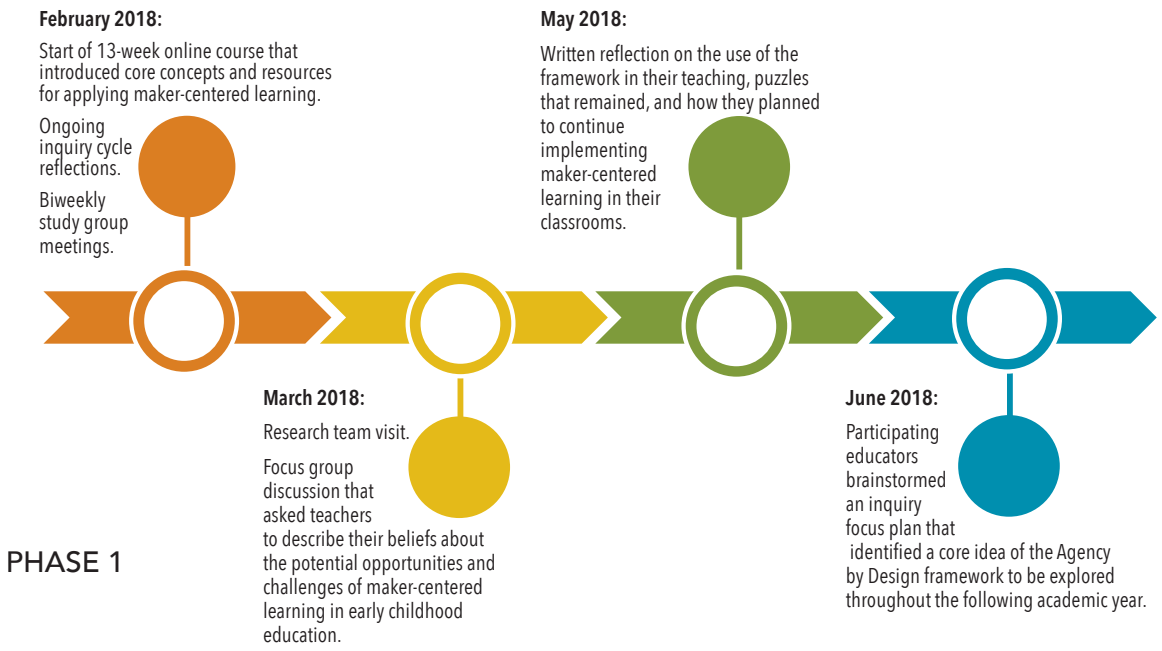
While the Hong Kong educational sphere and the Harbour Heights and Harbour Green kindergartens serve as very unique and specific educational settings, we believe that the pedagogical tools and strategies that emerged from this pilot study are applicable—with appropriate adaptation—in other environments where educators work with young learners.

METHODOLOGICAL APPROACH

We conducted this collaborative inquiry project (DeLuca, Shulha, Luhanga, Shulha, Christou, & Klinger, 2014) over two years, grounded in the principles of design-based research (Anderson & Shattuck, 2012; Brown, 1992; Design Based Research Collective, 2003; Sandoval & Bell, 2004). This participatory approach to research combines the expertise of researchers and practitioners to develop dynamic interventions that result in "usable knowledge" (Lagemann, 2002) that is specific to a particular context, while also being generalizable to others.

[6] For more information about the International Bacchalaureate Primary Years Program, see https://www.ibo.org/programmes/primary-years-programme/

Agency *by* Design: Early Childhood in the Making Project Timeline.

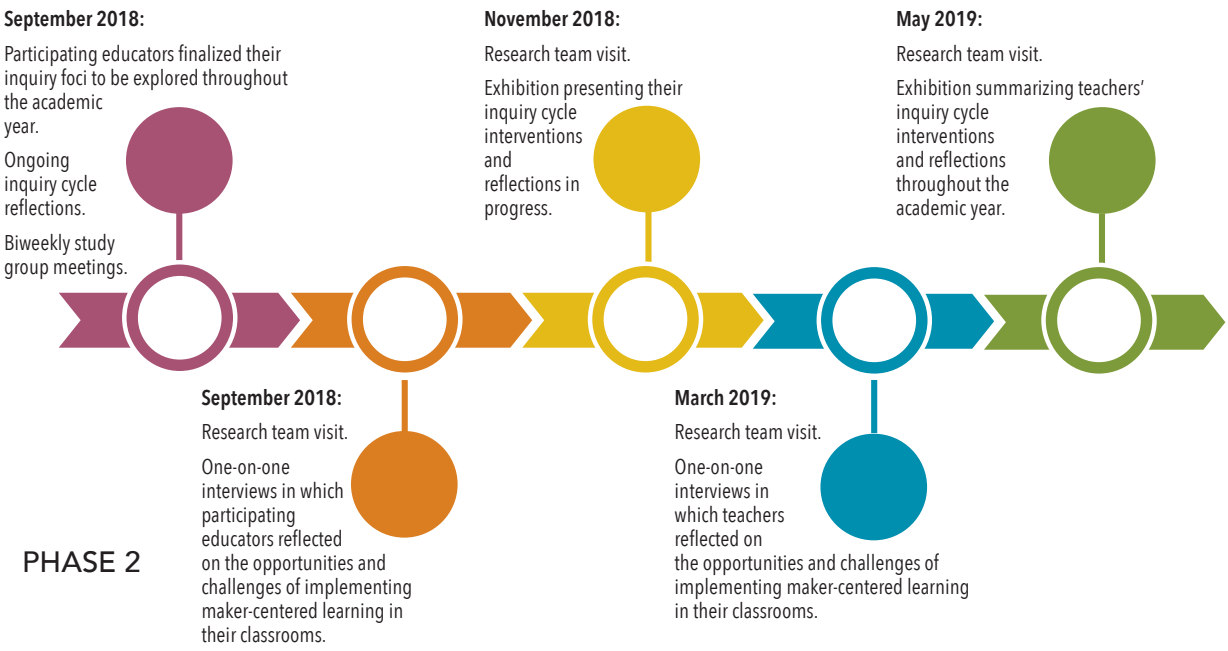


Twelve teachers from the two Victoria Educational Organisation kindergartens (six from each school), along with the Head of Curriculum Studies (who was also the project liaison), participated in the study. The teachers involved in the study taught in one of three age groups: K1 (ages 3-4), K2 (ages 4-5), and K3 (ages 5-6). The principals at each of the participating schools were highly engaged in the work of the cohort but did not generate data of their own for this study.

There were two phases to this collaborative inquiry project. During the first phase, the educators participated in a 13-week online course that introduced the core concepts and resources of the Agency *by* Design framework for maker-centered learning.[7] During the second phase, at the beginning of the following academic year, our research team supported our teacher colleagues in developing inquiry focus questions that identified a core idea of the Agency *by* Design framework that each participating teacher was interested in exploring through instructional interventions in their classrooms (individual teachers' inquiry focus questions are included in the Meet the Teachers section of this playbook).

[7] For more information about the *Thinking and Learning in the Maker-Centered Classroom* online course, see https://www.gse.harvard.edu/ppe/program/thinking-and-learning

Agency *by* Design: Early Childhood in the Making Project Timeline.



Throughout the project, teachers used an *Inquiry Cycle* reflection tool (Ross & Clapp, 2018), a structured online process designed to support educators as they plan, document, assess, and reflect upon their maker-centered teaching and learning interventions.[8] They also attended biweekly study group meetings with other participating teachers in their school, facilitated by the curriculum coordinator, to share and receive support in developing strategies for implementing maker-centered learning in their classrooms. Our research team supported teachers remotely and made regular site visits to the schools in Hong Kong (three times per year, for a total of six site visits over the two year arc of the project) to observe educators in action, conduct interviews and focus groups, and facilitate whole group learning community workshop sessions. Each learning community session focused on a particular aspect of the Agency *by* Design framework for maker-centered learning (e.g., introducing the making moves, systems thinking, working with adapted tools for young learners, etc.) and provided participating educators with an opportunity to share and receive feedback on their work, and to co-develop new tools with the research team.

[8] For more about the Agency *by* Design Inquiry Cycle reflection tool, see http://www.agencybydesign.org/inquiry-cycle.

Title
Name, School, Grade/Subject Taught, Date

Inquiry Focus: *What is the question or area of growth that you have been focused on for the past few weeks?*

Population: *Who are the people/students you have been intending to impact by exploring your inquiry focus?*

Outcome(s): *What specific changes have you been hoping to bring about as a result of your inquiry focus exploration?*

Intervention(s): *What strategies or changes in practice have you engaged in to bring about your intended outcome(s) for your focal population?*

Documentation: *Samples of images, audio, video, text, observation notes, student work, or other artifacts that show what the exploration of your inquiry focus has looked like over time.*

Insights: *What are some key insights or a-ha moments you have had as a result of exploring your inquiry focus?*

Puzzles: *What are some new questions, challenges, or puzzles that have emerged for you as you have been exploring your inquiry focus?*

Template of exhibition board presented by teachers in November 2018 and May 2019.

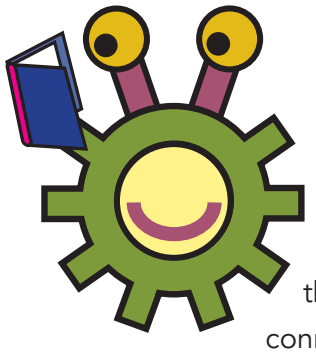
Example of exhibition board presented by teachers in November 2018.

Midway through the project, participating educators prepared exhibition boards and hosted an exhibition to share their work with their colleagues in the cohort. After receiving feedback from their peers by way of an informal feedback protocol, the teachers iterated on their inquiry focus work, conducted further classroom-based interventions, and collected new documentation. To celebrate the full arc of their learning journey, towards the end of the project the participating teachers shared refined exhibition boards and additional documentation from their classrooms with a broader community of Hong Kong teachers, administrators, and education professionals.

Using our two research questions as a guide, our research team analyzed data from teacher focus groups, interviews, reflections, inquiry cycles, and exhibitions. As prominent and consistent themes emerged across data sources, we synthesized the findings into three categories: lessons learned, pictures of practice, and instructional tools.

The following sections of this playbook summarize the results of our work. We begin with a review of the literature that situates maker-centered learning within existing early childhood practices and models. In the Meet the Teachers section, we introduce the participating teachers and the inquiry focus questions they addressed as they incorporated maker-centered learning into their classrooms. The Lessons Learned section provides a synthesis of the insights and accompanying examples gathered from teachers' approaches and adaptations of maker-centered learning for their young students. We dive deeper into these lessons learned in the Pictures of Practice section where we describe in more detail the work and explorations of six teachers. In the Tools and Resources section, we provide early-childhood specific instructional resources and tools that were developed and adapted based on the work of the participating teachers (the original set of thinking routines teachers used are located in the Appendix). In the Looking Ahead section, we reflect on the findings of this collaborative inquiry and propose future directions for this work.

LITERATURE REVIEW



Whenever I visit early childhood classrooms, I always see a lot of making happening. In this section, the research team makes connections between maker-centered learning and the excellent teaching and learning that already takes place in early childhood education.

SITUATING MAKER-CENTERED LEARNING IN EARLY CHILDHOOD EDUCATION

Like many contemporary frameworks for education, the principles and practices of maker-centered learning build upon existing educational theory. With its emphasis on inquiry and hands-on exploration, maker-centered learning complements pedagogical approaches prevalent in early childhood settings, including child-centered, inquiry-based, play-based, Montessori, and Reggio Emilia-inspired approaches to teaching and learning. Similar to maker-centered learning, these approaches value young students as creative and competent learners, and build on children's natural desires to make, play, and engage in personally meaningful work. Here, we briefly explore connections between maker-centered learning and several early childhood education pedagogies, then we consider how maker-centered learning can support and extend making practices that already occur in many early childhood classrooms. While not an exhaustive review of the literature, our goal with this section is to situate maker-centered learning within a wider breadth of research, theory, and practice.

CHILD-CENTERED APPROACHES TO TEACHING AND LEARNING

As in maker-centered learning, in child-centered approaches to teaching and learning children pursue their interests and create their own knowledge. As part of the progressive education movement in the 20th century, John Dewey advocated for learning experiences in which teachers based their teaching on students' interests and experiences so that they might better make sense of the world. Jean Piaget's early work on constructivism noted that young children are in the process of self-development and it is important to ground their learning in experiences that are relevant to them while also creating an environment where they can question their ideas and expand their world views. Lev Vygotsky's theories of learning emphasized the importance of social context by stating that young children learn from each other through social interactions and play and that it is important to provide children opportunities to collaborate, share ideas, and broaden perspectives. More recent developmental research has shown that, with support, young children are capable of more complex thinking and learning than previously thought. The Agency *by* Design framework for maker-centered learning aligns with this past research and theory by viewing young children as makers who actively seek out new perspectives, create new knowledge, and shape their worlds.[1]

[1] For an overview of the work of John Dewey, Jean Piaget, and Lev Vygotsky, see *Theories of childhood: An introduction to Dewey, Montessori, Erikson, Piaget, and Vygotsky* by C. G. Mooney.

INQUIRY-BASED APPROACHES TO TEACHING AND LEARNING

Inquiry behaviors come naturally to young children as they follow their curiosity and learn about their world through play, exploration, and questioning (Bairaktarova, Evangelou, Bagiati, & Brophy, 2011; Copple, Koralek, Charner, & Bredekamp, 2013). In an inquiry-based classroom, a teacher works alongside the students to merge their interests with curricular concepts, while making room for students to have their own ideas and pursue their own questions. For example, in an inquiry-based unit on squirrels, a kindergarten teacher might set the topic, but allow students to generate the questions that direct the unit of inquiry.[2] The Agency *by* Design framework for maker-centered learning harnesses the inquiry inherent in the making process through its maker capacities (looking closely, exploring complexity, and finding opportunity) and pedagogical tools designed to scaffold student thinking as learners interact with and ask questions about the designed world around them.

PLAY-BASED APPROACHES TO TEACHING AND LEARNING

Play-based learning, like maker-centered learning, is joyful, engaging, social, iterative, personally meaningful, and, when employed in the classroom, offers students opportunities to make choices (Parker & Thomsen, 2019). Froebel, who is known for the creation of kindergarten, saw learning and creating through play as central to the development of young children (Smedley & Hoskins, 2018). Play provides a rich context for teaching and learning, as it is infused with social interactions and exploration of the real world (Mooney, 2013; Oers & Duijkers, 2013). While many early childhood educators incorporate play into their teaching because it supports young children's physical, social, emotional, and cognitive development (Jensen et al., 2019), some teachers purposefully incorporate play into making experiences to help children develop fluency with materials and the making process. By playing with materials before using them purposefully in a design, young children build their knowledge of what materials can do (Baynes, 1994; Milne, 2013). Through play, children become fluent at creating worlds, and educators can harness this "playful making" process to provide a maker-centered, play-based learning environment that intersects nicely with maker-centered learning's goal of maker empowerment (Gravel, Bers, Rogers, & Danahy, 2018).

The Agency *by* Design framework acknowledges young children's desire to play and create and supports children as they learn to view the world as something that they can tinker and improve. Sociodramatic play also provides opportunities for children to explore other people's roles and perspectives, which is an important part of the Agency *by* Design framework. Through recognizing and understanding other people's perspectives, students can more thoughtfully critique and

[2] For an in-depth description of an inquiry-based unit on squirrels for kindergarteners, see *Learning about children learning about squirrels* by Julie Diamond.

redesign the systems that they interact with on a regular basis.

THE MONTESSORI APPROACH TO TEACHING AND LEARNING

Maria Montessori emphasized supporting the agency of young children through, among other things, allowing them to work with their hands in meaningful ways, a concept that the Agency *by* Design framework also emphasizes. Montessori wrote of the hand as a "prehensile organ of the mind," (Montessori, 1967, p, 168) stating that it is primarily through doing hands-on work that children develop meaning and character. In Montessori classrooms, children work with real, but child-sized tools and have meaningful responsibilities (Montessori, 1914; Mooney, 2013). The teacher's role is to guide children without becoming an obstacle, and to trust children to seek out challenges and learning opportunities on their own (Montessori, 1914). The Agency *by* Design framework for maker-centered learning also positions children at the center of the classroom, viewing them as agentive individuals with the capacity to seek out ways to make with meaning. As in Montessori classrooms, the role of the teacher in a maker-centered classroom is to prepare an environment conducive to child-centered work and to observe children and guide them as needed.

REGGIO EMILIA-INSPIRED APPROACHES TO TEACHING AND LEARNING

In Reggio Emilia-inspired classrooms and in maker-centered classrooms, teachers view young children as authors of their experiences. Students take in information, make connections, pursue meaning, and express their ideas using multiple methods and materials, eventually developing fluency with particular materials through repeated exploration, use, and feedback (Gandini, Hill, Cadwell, & Schwall, 2015; Krechevsky, Mardell, Rivard, & Wilson, 2013). This is the "make" in maker-centered learning: children actively make as they explore an idea, express themselves, and share with others. Through making, children find out more about themselves, their peers, and their community; in both Reggio Emilia approaches and maker-centered teaching and learning, using materials to express themselves helps young learners to make meaning of concepts and ideas.

In addition to the resonance between the Agency *by* Design framework for maker-centered learning and the various pedagogical frameworks and precedents mentioned above, many early childhood teachers already incorporate making into their classrooms through experiences ranging from general arts and crafts activities to extended work in school design studios and makerspaces. In the following sections, we discuss how these existing practices show that maker-centered learning is well-suited for early childhood classrooms and how the Agency *by* Design framework can add focus and depth to the making that already occurs in early childhood settings.

ARTS AND CRAFTS

Arts and crafts activities such as drawing, painting, collaging, and sculpting are common in many preschool classrooms. These hands-on activities range from product-based activities, in which everyone follows directions to make a similar object, to process-based activities, in which everyone makes something quite different through the guided exploration of a material, technique, or tool. Educators who teach using process-based activities often view art experiences as a meaning-making process and strive to give students opportunities to make things that are meaningful to them (Moomaw & Hieronymus, 2002). Indeed, arts making experiences are maker experiences, and so many of the qualities of arts teaching and learning (Seidel, Tishman, Winner, Hetland, & Palmer, 2007) as well as the dispositions that arts teaching and learning foster (Hetland, Winner, Veenema, & Sheridan, 2007; Tishman & Palmer, 2006) are complementary to maker-centered learning (Thomas, 2014).

There are direct connections with maker-centered learning when teachers view students as makers and when students have access to a variety of craft materials. Pete Moorhouse (2018), an artist educator who teaches woodworking to preschoolers, explains, "Woodworking is really about children making, embracing the processes of making and empowering children to become makers with a 'can-do' spirit" (p. 5). By integrating the Agency *by* Design framework for maker-centered learning into preschool arts and crafts activities, teachers can foster this type of maker empowerment even in very young children.

LOOSE PARTS PLAY AND TINKERING

Loose parts play (in which students literally play with "loose parts"—bits of materials that serve no obvious purpose until used in a certain way) and tinkering experiences give young students the opportunity to explore materials freely and to use them to make meaning. When engaged in loose parts play and tinkering, students might arrange materials into patterns, incorporate materials into their dramatic play, combine materials to make a new object, or take apart something to see what's inside and how it all works. In *The Art of Tinkering*, Karen Wilkinson and Mike Petrich (2014) define tinkering as a whimsical, inquiry-based perspective on tools, materials, and phenomena in the world around us. They state that tinkerers learn about the world through exploring, taking apart, building, and making. In addition to developing creativity, critical thinking, and active learning (Daly & Beloglovsky, 2015), engaging with tools and materials in this playful way also develops fluency with using materials to explore and communicate ideas (Thompson & Compton, 2019; Topal & Gandini, 1999; Wood, 2019). The Agency *by* Design framework for maker-centered learning also supports using materials to make student thinking visible. If used in conjunction with loose parts play and exploratory tinkering activities, it could provide a new lens for student thinking that emphasizes

sensitivity to design by drawing students' attention to the parts, purposes, and complexity of their creations.

TECHNOLOGY EDUCATION

Technology education, broadly considered, may include the integration of digital tools and computer science with more hands-on learning experiences as described by Sylvia Martinez and Gary Stager (2013) in their book, *Invent to Learn*, or it may refer to the making that happens in online platforms such as Scratch (Brennan, Hernández, & Resnick, 2009). Of course, technology education may also refer to the study and use of analogue tools, which are also forms of technology. In whatever form it takes, technology education connects with many aspects of the Agency *by* Design framework, in particular the understanding that we live in a designed world and that we can use our knowledge of tools, materials, and societal needs to make changes to the designed elements in our world. Young children already have a great deal of technological knowledge and skills—they know how many things work and they know how to make many things (Mawson, 2013)—from which materials might be most comfortable to use to make a blanket to how, exactly, to get that smartphone to play a song they like. And yet, young children often do not have much experience thinking about how various technologies impact people and what roles technologies play in larger systems (ibid). The Agency *by* Design framework for maker-centered learning supports children as they learn about the designed world by situating technologies and making within a meaningful social context, helping students consider both the individuals and the systems that a technology impacts.

ENGINEERING EDUCATION

Engineering in early childhood settings often focuses on hands-on, problem-solving within a STEM context in which students learn that they can modify their world to help others (Hoisington & Winokur, 2015; Meeteren & Zan, 2010). In this way, engineering education directly overlaps with maker-centered learning, which also emphasizes hands-on problem-solving within a social context and maker empowerment. The Agency *by* Design framework, though, is not limited to engineering or to the STEM subjects and is designed to be applied more broadly in any subject. The pedagogical tools associated with the framework have the potential to support early engineering by providing a systems thinking lens through which students can view the problems and solutions they are exploring.

MAKERSPACES AND MAKER EDUCATION

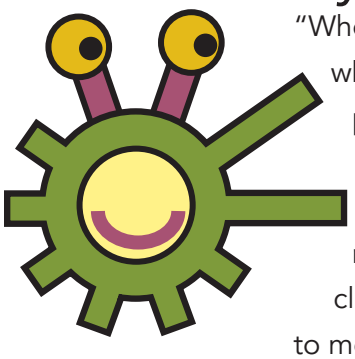
Makerspaces and maker education are part of a growing trend in K-12 education across the globe (Dougherty & Conrad, 2016; Halverson & Sheridan, 2014; Marsh, et al., 2017; Martinez & Stager

2013; Peppler, Halverson, & Kafai, 2016; Thomas, 2014). Maker education is a movement that has close links with Seymour Papert's theory of learning called constructionism (Pappert & Harel, 1991), in which people learn best when they are "engaged in a personally meaningful activity outside of their head that makes the learning real and shareable" (Martinez & Stager, 2013, p. 32). Many maker educators resonate with this idea as they support learning through the construction of artifacts that range from block towers to computer codes. One goal of maker education is to support students as they develop digital literacy, which moves beyond just being able to use a variety of digital technologies to being able to create and critique digital technologies through collaborative, transdisciplinary problem-solving (ibid). Schools seeking to promote digital literacy often do so by incorporating new programs such as robotics electives or programming courses, or by adding designated learning spaces such as fablabs or makerspaces. Making is not just about digital learning and literacy, though. In fact, some of the most fruitful making-centered learning experiences come from the use of low-tech or no-tech tools and materials—such as those found in abundance in most early childhood education settings. In general, early childhood makerspaces are not just spaces where young students go to make; they are spaces in which students engage in maker-centered learning. In these spaces, teachers emphasize student-directed exploration, iteration, risk-taking, learning from mistakes, collaboration, communication, and open-ended work (Bers, Strawhacker, & Vizner, 2018; Brahms & Wardrip, 2016; Gravel, et al., 2018). Often, early childhood makerspaces incorporate mechanical and digital tools that children can experiment with and learn to use over time (Bers, et al., 2018; Gravel, et al., 2018). The Agency *by* Design framework for maker-centered learning can support the thinking and learning that occurs in makerspaces by encouraging students to think about their work from various physical and social perspectives and extend this thinking beyond the makerspace and across the curriculum.

The Agency *by* Design framework for maker-centered learning can complement the teaching and learning happening in early childhood settings in many ways. From the perspective of this framework, any environment where making and learning intentionally take place is considered a maker-centered classroom. It is not necessary to have a makerspace or special tools to engage in maker-centered learning. Because of the hands-on, inquiry-based nature of most early childhood classrooms, they are already set up to be maker-centered classrooms and require only a shift in pedagogy. As with any pedagogical shift, teachers benefit from support as they work to integrate a new framework into their existing teaching practice. In the following sections, we first introduce our teacher colleagues who worked with us throughout this pilot study, then we share our findings from the study, and finally we illustrate how early childhood educators can adapt the Agency *by* Design framework to meet their needs and the needs of their young students.

MEET THE TEACHERS

You may be wondering,



"Who are the brave and creative teachers who participated in this research project? What were their interests? And what big questions did they have in mind as they incorporated maker-centered learning into their classrooms?" In this section, you get to meet them all!

Kit Cheng

K2, IB Primary Years Program Coordinator
Harbour Green Campus

How can I use the thinking routines to support learning in an inquiry-based classroom?

Students used the *Imagine If...* thinking routine to create an ideal home.

Students used the *Think, Feel, Care* thinking routine to think about the motivations of famous artists.

Students used the *Imagine If...* thinking routine to create a backdrop featuring *The Scream*.

Justin Chislett

K1 Teacher, Curriculum Coordinator,
Harbour Heights Campus

How can we help children in the early years understand and talk about emotion? How can we help them develop empathy?

A student used photos of herself to share her emotions with the class.

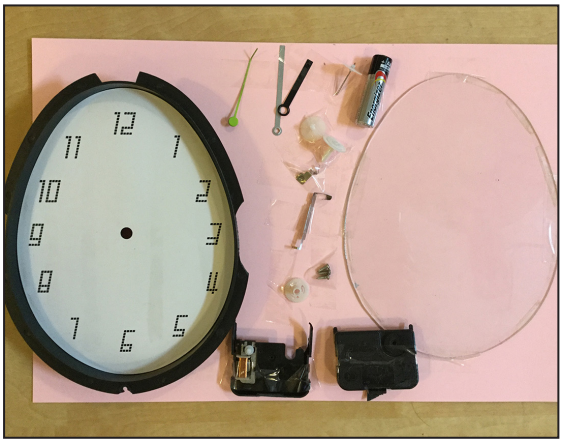
Students created "color monsters" to represent certain emotions.

Students shared advice with Kenny the puppet to help him feel better.

Shannon Chung

K2 Teacher,
Harbour Green Campus

How do K2 students understand the maker capacity of looking closely through taking apart different things?



Students took apart clocks, looked closely at the parts, and drew what they saw.

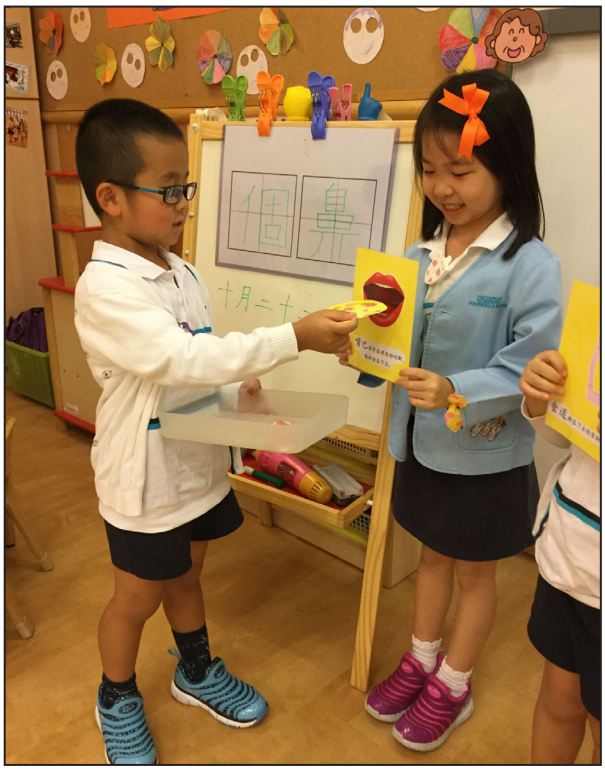
Students took apart a toy train and looked closely at its parts.

Students "took apart" their daily routines, looked closely at them, and compared them with their peers' routines.

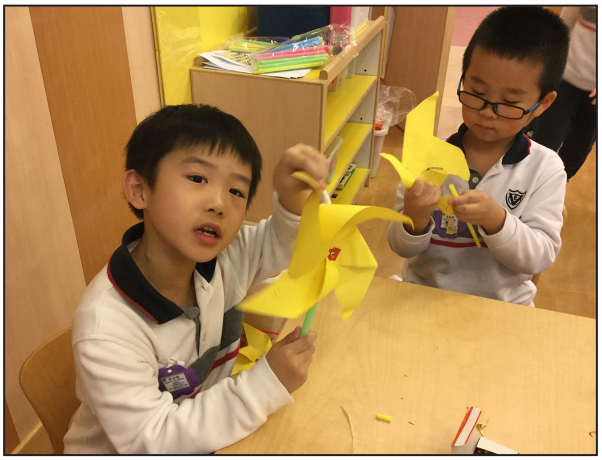
Liyi Guo

K3 Teacher,
Harbour Green Campus

How can I embed
the habit of looking closely
in young learners?



Students used manipulatives to look closely at the digestive system.



Students looked closely at windmills to figure out how they turn.

Students looked closely at problems in the classroom.

Cecily Ko

K1, English Head Teacher,
Harbour Green Campus

What provocations or resources can be provided for students to look closely?

Students looked closely at the physical features of dolls.

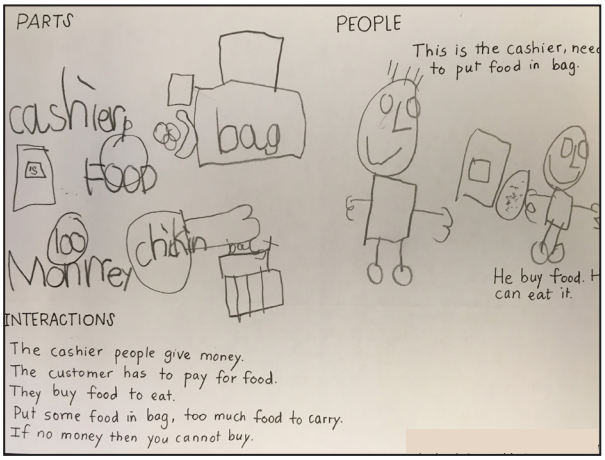
Students looked closely at the physical features of people using cameras.

Students looked closely at their school using handmade binoculars.

Jennifer Lee

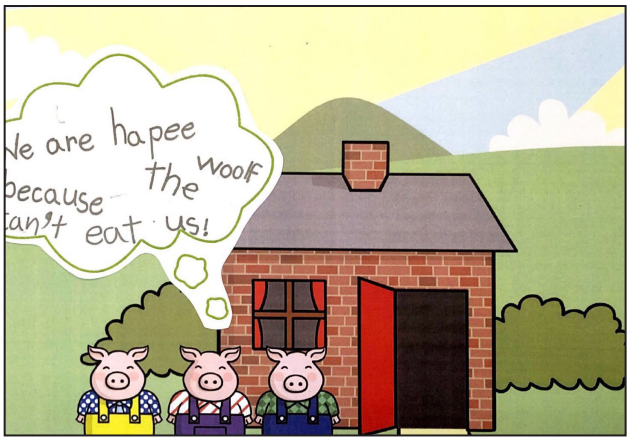
K3 Teacher,
Harbour Heights Campus

What strategies can we use to help children grapple with the concepts of perspective taking and empathy?



Students used the *Parts, People, Interactions* thinking routine to consider the experiences of people in a supermarket.

Students explored different perspectives during role play.



Students practiced perspective taking while reading a familiar story.

Belle Liu

K3 Teacher,
Harbour Heights Campus

What types of scaffolding can I use to help my students build systems thinking?

Students identified parts of the local train system.

Students used the internet to answer questions they had about the local train system.

Students explored a model of the local train system during role play.

Louise McCann

K2 Teacher,
Harbour Heights Campus

What multimodal approaches can we employ in order to explore the thinking routines?

Students explored ramps using the *Parts, Purposes, and Complexities* thinking routine.

Students designed and created better catapults using the *Imagine If...* thinking routine.

A student took the perspective of Little Red Riding Hood.

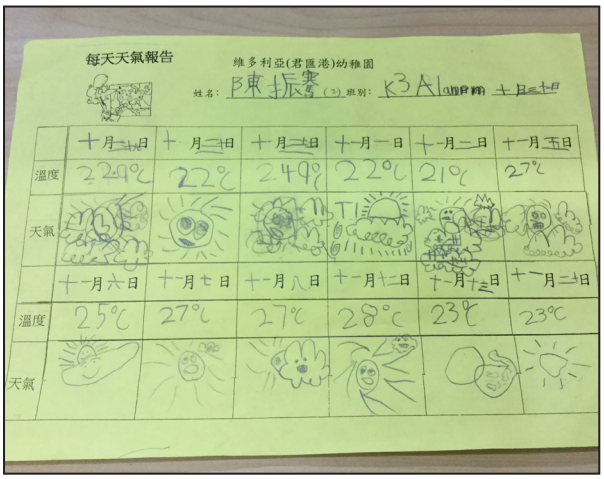
May Poon

K3 Teacher,
Harbour Green Campus

How can I help students develop the maker capacity of looking closely?

Students looked closely at currency from different countries.

Students used categories to look closely at the food pyramid.

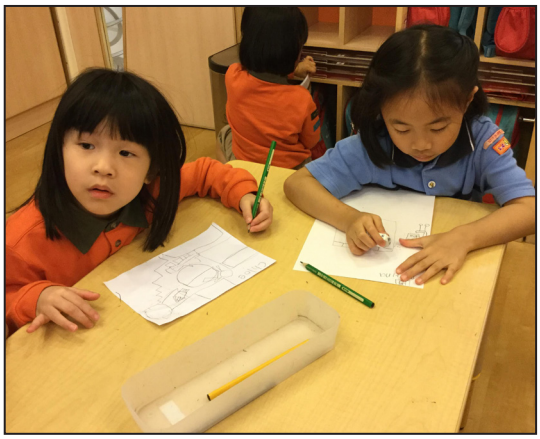


Students looked closely at different ways to display data.

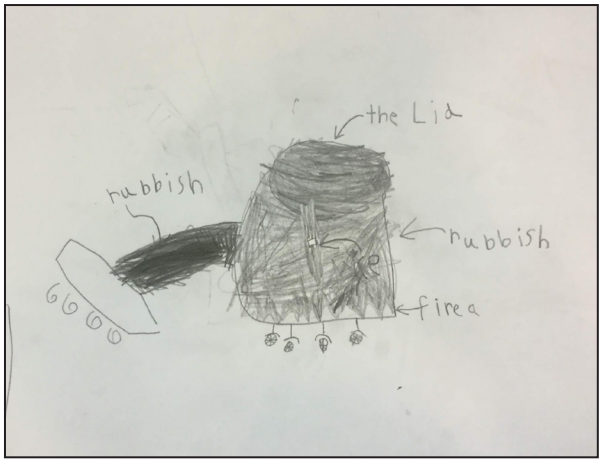
Joyce To

K3 Teacher, Curriculum Coordinator,
Harbour Green Campus

How can I tinker with thinking routines to support student-centered learning?



Students looked closely at their classroom and created a map.



Students used the *Imagine If...* thinking routine to design a tool that disposes of garbage.

Students used the *Parts, Purposes, Complexities* thinking routine to learn about flags and to create their own.

Claudia Wong

IB Primary Years Program Coordinator,
Harbour Heights Campus

How can I use a Maker Table to encourage children to engage with the maker capacity of "finding opportunity"?

A student sketched an idea at the maker table.

A student used the maker table to create an idea and try it out.

Students used the maker table to explore an idea they found interesting - wheels.

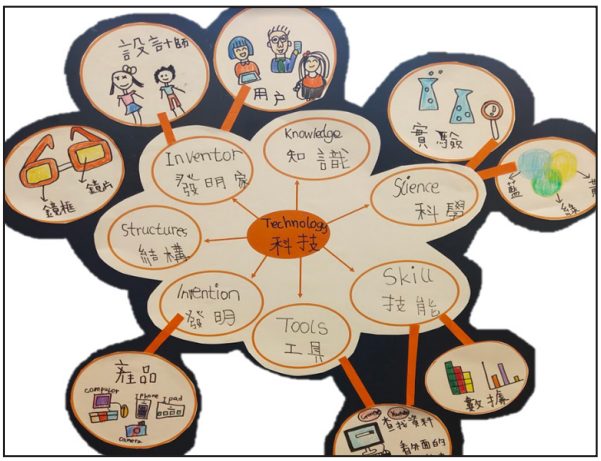
Tina Yu

K3 Teacher,
Harbour Heights Campus

How do the thinking routines fit into the IB Inquiry Cycle?

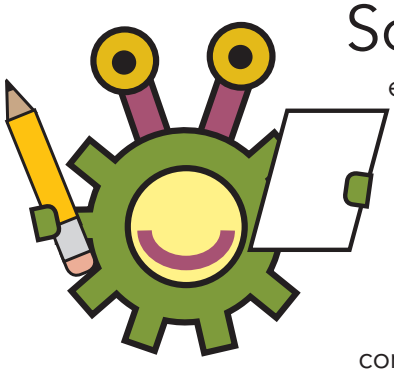
Students looked closely at the parts and purposes of ball point pens as part of their unit on inventors and inventions.

Students used the *Imagine If...* thinking routine to brainstorm beautiful and effective inventions, and then used various materials to build a model of their ideas.



Students used the *Parts, People, Interactions* thinking routine to talk about technology as a system and to engage in a debate.

LESSONS LEARNED



So... after all of this work with educators, what did the research team learn? Well, the team collaborated with their teacher colleagues to identify a variety of insights and strategies that emerged from their work. The team compiled these insights and strategies into the following lessons learned section—including examples from the teachers' classrooms that illustrate what maker-centered learning looks like in early childhood settings.

TEACHER INSIGHTS AND STRATEGIES FOR ADAPTING THE AGENCY BY DESIGN FRAMEWORK FOR MAKER-CENTERED LEARNING INTO THEIR CLASSROOMS

In this pilot study, we aimed to investigate the insights that the cohort of early childhood teachers developed while incorporating maker-centered learning into their classrooms over the 2018-2019 academic year and to look closely at the strategies they developed as they adapted the Agency *by* Design framework for maker-centered learning and the associated resources to be more suitable for their young learners. We were particularly interested in how this cohort engaged their students with concepts related to complexity, systems thinking, and perspective taking.

In the pages ahead, we first describe our teacher colleagues' initial thoughts about incorporating maker-centered learning into their teaching practice. We then share their insights related to student learning that emerged throughout this study—and describe the various strategies that teachers developed to best incorporate maker-centered learning into their practice. Lastly, we discuss educator insights related to teaching that emerged through this study. Within each of these sections, we offer examples from participating teachers' classrooms.

TEACHERS' INITIAL THOUGHTS ABOUT MAKER-CENTERED LEARNING

Although teachers were excited to implement maker-centered learning with their students, they also had concerns. First, teachers felt that students' still-developing language skills would hinder their abilities to engage in maker-centered learning, both because of their young age and because of the trilingual nature of their classrooms. Second, teachers expressed the concern that their students would struggle to understand important concepts in the Agency *by* Design framework because of their limited life experiences and developing cognitive abilities. For example, one concept that teachers felt would be difficult for their young students to understand was the concept of complexity. As one teacher described, "For kids it is not so easy to understand, what is the complexity. I also think that part is difficult to share with them."

It's important to note that the concerns we heard from our teacher colleagues were not new; we have also heard these concerns mentioned by other early childhood teachers outside of this study.

However, as the cohort of teachers gained experience with maker-centered learning, they began to blend the early childhood teaching strategies they already used in their classrooms with the Agency *by* Design framework to to develop new insights and strategies for incorporating making into their practice.

After experimenting with the tools and strategies related to the Agency *by* Design framework for maker-centered learning in a structured and supported manner, over time, the educators in this study began to think differently about their students' abilities and the prospects for incorporating maker-centered learning into their classrooms. Below we share some of our teacher colleagues' insights related to student learning, as well as some of the strategies they developed to integrate maker-centered learning into their practice.

TEACHER INSIGHTS RELATED TO STUDENT LEARNING

Over the course of this study, teachers reflected on the impact maker-centered learning had on their students. Although every teacher had a different learning journey, the cohort generated several insights about student learning that resonated with everyone. Teachers felt that maker-centered learning was appropriate for young learners and felt surprised by their students' abilities as makers and thinkers. Through maker-centered learning, teachers felt that their students demonstrated agency and independence, engaged in deeper thinking, practiced perspective taking and empathy, engaged in systems thinking, and learned from their peers. We discuss each of these insights below with examples from the classroom.

Teachers believed that maker-centered learning is appropriate for young learners.

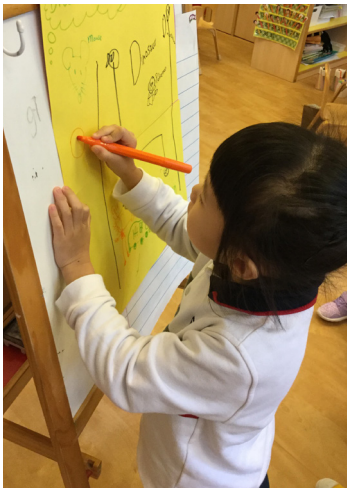
Teachers began the study with the belief that maker-centered learning would be appropriate for their students, and this belief persisted throughout the study as teachers put maker-centered learning into practice. Teachers stated that young children are natural observers and explorers. They felt that there was a strong link between children's curiosity, their desire to make things, and maker-centered learning. As Joyce, a K3 teacher, described:

Students in Joyce's classroom look closely at the boats they designed and built as part of a unit on forces.

Children are natural inquirers. They enjoy looking closely at various objects and appreciate being able to do so without limits. . . . Play comes naturally and building also comes naturally, so when [children] learn through experience and inquiry, they can really learn in multifaceted ways through communication and through what comes naturally to them.

In some cases, teachers expressed that maker-centered learning was more than just appropriate for their students; it was actually fun and joyful. For example, Liyi, a K3 teacher, reflected:

Children like to play. They think that [the maker-centered learning activity] is playing, that they are playing. But actually—they are learning.



During a unit on self-expression and storytelling, a student in Cecily's classroom brainstorms ideas for a story.

Teachers were surprised by children's abilities as makers and thinkers.

Toward the latter part of the study, teachers began to report that they were surprised by their students' competence as makers and thinkers. Teachers expressed a desire to push their students' thinking even more as they continue this work in the future.

Cecily shared this about her K1 students:

On a daily basis they surprise me with different things. . . . Which is so exciting to me, I am like, wow, it is such a discovery to see them grow. You can't imagine. Before I did [maker-centered learning] I would never have thought that 3 year-olds would be able to take on the leading role and make connections.

Kit, a K2 teacher, also felt that her students could harness their own creative ideas to make and invent. She explained:

I learned that children have a lot of capacity to invent. They have their own ideas and "Dream Big" and this is a very important aspect of children that needs to be explored often. . . . They proved that they can use their imagination and what is available to them to create something so this is something I will continue to provide in the future.

A student in Kit's classroom presents her idea for a "dream vehicle" as part of a unit on art and transportation.

Teachers noted that, through maker-centered learning, students demonstrated agency and independence.

One important aspect of maker-centered learning is that students try to figure things out on their own, by seeking the knowledge they need and by engaging in iterative work. Throughout the study, we saw teachers describe instances in which their students sought out information, solved problems on their own, and found the opportunity to make.

As part of a unit on transportation, a student in Belle's classroom made a drawing of a spaceship that can clean up garbage while transporting people to outer space.

After facilitating an activity in which her K3 students used their knowledge of existing transportation options to design improved vehicles (such as a spaceship that can clean up garbage while transporting people to space), Belle reflected:

> *From this activity, I learned that making motivates kids in learning and exploring new things. It is a good opportunity for them to find problems and solve [them] independently. Searching the information by themselves can strengthen their [understanding], which is much better than taught by teachers.*

Teachers also linked making with the maker capacity of finding opportunity, which is all about taking initiative and finding ways to change the world around you. In her work at the school's maker table, Claudia noticed that one group of students was thinking a lot about wheels. Rather than give them wheels to explore, she encouraged them to seek out more information by sending them on a "Wheel Hunt" in which they searched for objects that they thought would function well as wheels. To do this, her students had to identify the key elements that make something function as a wheel, rather than just seek out objects that looked like wheels. One student, for example, recognized that pencils could be used as wheels—not so practical when it comes to sharing the road, but they functioned well. Claudia noted that this type of thinking is important when engaging in maker-centered learning, because

This student, working at Claudia's maker table during an exploration of cars, realized that pencils can serve the same function as wheels.

through exploring how things actually work, students can begin to exercise their agency by making changes that have an impact on the real world.

Teachers observed that, through maker-centered learning, students engaged in deeper thinking.

Throughout the study, teachers noted that certain elements of the Agency *by* Design framework, such as the use of hands-on learning experiences, teacher scaffolding, and the Agency *by* Design thinking routines, helped their students "think more deeply" about other people's perspectives and about the complexity of systems. One thing we heard from several teachers was that, through maker-centered learning, their students could think more deeply because they, as teachers, could slow down, ask students more questions, and give students more time and opportunities to develop their own ideas, rather than repeating suggestions made by the teacher.

Kit's students imagine how the painter of *The Scream* felt when painting.

Kit pointed specifically to the *Think, Feel, Care* thinking routine, stating that this thinking routine encouraged her students to think about the subjects they typically studied through a new lens. Reflecting on an activity involving the exploration of a painting, she noted:

> *Before [implementing maker-centered learning] I thought, I'll let them [students] explore something, do something funny and then they can do some hands-on activities. Now I think, I'll use the thinking routines to let them think more deeply. And then they can think from other angles. . . . Now I will let them think more using* Think, Feel, Care*. Why will the painter paint this picture? What is the meaning? If you were the painter, what would you draw? So I think that is different than before.*

Belle explained that, through maker-centered learning, she gave her students more time to think and more opportunities to think independently. She explained:

> *I think compared with before [implementing maker-centered learning], my students have more time to think. . . . Because they can do things by themselves, not only watch what I do. They can have hands-on experiences and maybe they can think by themselves. More time, more opportunities.*


A student-made elevator in Belle's classroom.

In Belle's K3 class, for example, during a unit on inventions, students modified systems as part of a problem-solving activity—how to move a heavy object upstairs. One group of students decided to make an elevator to solve this problem. As they worked, they became familiar with the various parts and purposes of an elevator system: the floor, ceiling, and walls, the ropes, and the pulleys. They also became aware that parts of the system were not functioning well. Instead of giving up or relying on the teacher for answers, Belle's students used the "Reframe" making move to figure out how to hack their existing system to make it work better.[1] After some trial and error, students successfully modified their system to make it work smoothly by using a different type of rope and attaching support ropes to the corners of the elevator. After facilitating this activity, Belle noted, "From this activity, students kept thinking and learned a lot about how to use a pulley to save energy. The [Reframe making move] helped them explore deeper."

Teachers noted that, through maker-centered learning, students developed perspective taking and empathy.

At the beginning of this study, teachers felt that their students struggled to understand other people's feelings, needs, and motivations because of their students' limited life experience and language abilities. Although this concern persisted throughout the study, after employing strategies they developed, teachers reported being surprised by their students' abilities to consider the perspectives of other people.


Shannon's students shared their daily routine wheels with a partner.

One aspect of perspective taking is realizing that other people can have different experiences than you do. Teachers helped their young learners recognize this by giving students the opportunity to share and compare their experiences with their peers. Shannon's K2 students, for example, during

[1] For more about the making moves associated with the Agency *by* Design framework, see http://www.agencybydesign.org/sites/default/files/AbD%20Making%20Moves%20-%20one-pager.pdf

a unit on daily routines, constructed "daily routine wheels" which used photographs from students' homes to represent their daily routines. After each student finished their wheel, they met with a partner to look closely at both of their daily routine wheels to find similarities and differences. Through this activity, Shannon's students learned that everyone had a different daily routine. When Shannon reflected on this activity, she noted that her students were excited to share with each other and ask each other questions about their routines. Activities in which students share with each other, such as the activity Shannon facilitated, are important as they help nurture a curiosity about others that can serve as motivation for perspective taking.

Jennifer's K3 students practiced perspective taking using stories, role play, and objects. Read more about this on page 57.

Teachers felt that, through maker-centered learning, students engaged in systems thinking.

Students in Liyi's classroom engage in systems thinking as they explore the classroom trolley.

All of the teachers in this study engaged their students in exploring the interactions between the parts and/or people that make up various systems. Students explored both material and immaterial systems, ranging from newly constructed marshmallow towers to their own Maker Table community space. Through this work, teachers employed a variety of strategies to help their young learners explore the interactions inherent in these systems. These strategies included looking closely, engaging in hands-on exploration, using Agency *by* Design thinking routines, and mapping systems.

For example, in Liyi's K3 class, students were tasked with making something that could move ten classroom chairs across the room. To do this, Liyi encouraged her students to look closely at objects in the classroom that might help them. One group of students looked closely at the classroom trolley, exploring how the parts of the trolley interact to transport objects from one place to another.

After facilitating this lesson, Liyi noted: "When discussing the purpose and function of certain parts of the objects, I noticed them [students] begin to think about the link between two parts and notice the complexities." By exploring the interactions between the parts of the trolley, students were thinking about the trolley as a system.

Teachers observed that, through maker-centered learning, students engaged in peer-to-peer learning.

Liyi's students work together to transport objects from one room to another.

Teachers felt that hands-on making and learning experiences created opportunities for peer-to-peer learning. The Agency *by* Design framework for maker-centered learning stresses the importance of *distributed teaching and learning* in the maker-centered classroom.[2] A key aspect of distributed teaching and learning is repositioning students as teachers—and redirecting authority away from the teacher in the maker-centered classroom, to students, the community, or online forums. In this regard, many of our teacher colleagues highlighted examples of their students looking to each other for help, seeing one another as teachers, and noting different authority figures in the room other than the educator at the front of the class. This resulted in students becoming more independent in the face of problems and more receptive to ideas that were different from their own.

Tina regularly engaged in the practice of re-directing authority from the teacher to the students by encouraging her K3 students to look to each other for help during making experiences. She explained:

> *If they [students] get materials and they don't know how to use [them]. . . . they come to ask teachers. "Oh, can you help me? Can you tell me how to use it?" And then I will just tell them, "maybe you can ask your friend first. See if your friend can help you." . . . If the friend still doesn't know how to help her, then I will tell her, "maybe you can try this way. And then try that way. Just try and see if it works or not."*

[2] For more about the concept of distributed teaching and learning, see Chapter Two: Teaching and Learning in the Maker Centered Classroom in the book *Maker-Centered Learning: Empowering Young People to Shape their Worlds*, by E. P. Clapp, J. Ross, J. O. Ryan, & S. Tishman.

From the perspective of the Agency *by* Design initiative, another key element of distributed teaching and learning is co-inspiration. Maker-centered learning provides opportunities for students to engage in co-inspiration, in which they look to each other for new ideas. Claudia, who set up a maker table for multiple classes to use, felt that her students looked to each other for help with new or challenging materials. She noted, "although they might face difficulty at times, such as not having the exact materials they needed to make something, they were still able to discuss it with friends and figure out new ways to solve the problem." Liyi described something similar when reflecting on work in her own K3 classroom. She noted that, because her students were engaged in more hands-on activities through maker-centered learning, they had more opportunities to share ideas with their peers and to negotiate the best way to do or make something.

All teachers in the study agreed that collaborating with each other came very naturally to their young students once they were given the opportunity. Through the variety of distributed teaching and learning experiences that making offers, young people learn with and from their peers.

TEACHING AND LEARNING STRATEGIES

Our teacher colleagues would not have had the insights they did without developing new strategies that enabled them to engage their students successfully in maker-centered learning: using visuals and manipulatives, harnessing role play and storytelling to engage students in perspective taking, and nurturing the Agency *by* Design maker capacities with thinking routines and making moves. We describe these three strategies developed by teachers throughout the study and share examples of how teachers used these to support their young learners.

Teachers used visuals and manipulatives to support their students as they engaged with maker-centered learning.

Throughout the study, teachers used visual aids and physical materials as ways of introducing concepts and providing examples to support young learners in envisioning some of the abstract, complex ideas that are part of the Agency *by* Design framework. The use of visuals and manipulatives is a common strategy in early childhood classrooms, and one that exemplifies the practice of "tools and materials as teachers," as identified by the original Agency *by* Design study.

For example, in Tina's K3 class, her students used cups, sticks, toy bears, and photographs to learn about bridges as a system of interrelated parts. To begin the activity, her students used flat, wooden sticks and paper cups to make bridges that could support the weight of several toy bears. Tina

noticed that several students were laying the sticks flat on the table and then placing the toy bears on top. To support her students understanding of what bridges are, she showed them several photographs of real bridges. She asked her students to look closely at the parts of each bridge—what parts did they notice, and what were the purposes of those parts? Students realized that bridges often have supports to hold them up over whatever the bridge is crossing. On their second attempt at building a bridge, students used the paper cups as supports. From this experience, Tina realized that it was helpful for her students to see real-world photographs and that, by breaking the bridges down into parts with specific purposes, her students gained a more sophisticated understanding of bridges and were able to refine their own bridge models based on what they saw and discussed.

Students in Tina's classroom explore bridges using manipulatives during a unit on relationships and working together.

Many teachers also used visual aids to support their students' practice of perspective taking, an important concept in the Agency *by* Design framework. In Louise's class, after reading *The Three Little Pigs* during a unit on self-expression and storytelling, her K2 students made a class chart titled "How Does Mr. Wolf Feel?" They added emojis to the chart that represented the way they thought Mr. Wolf felt at any point in the story, and then explained their reasoning to the class. Louise purposefully provided emojis that would expand her students' typical repertoire of "happy" and "sad" by including emojis that represented emotions such as "upset," "pleased," and "disappointed." Louise felt that this strategy worked well, writing, "After a discussion on the various feelings in the chart, the children choose a range of different emotions to describe how Mr. Wolf felt at different points in the story —this is exactly what I was aiming for!"

During a unit on self-expression and storytelling, a student in Louise's classroom reviews the emojis that the class placed on the How Does Mr. Wolf Feel? Chart.

Teachers used role play and storytelling to support the perspective taking that is an important part of the Agency *by* Design framework.

Many early childhood educators already engage their students in role play and storytelling, but teachers in this cohort used role play and storytelling to support students as they engaged in the type of perspective taking encouraged in the Agency *by* Design framework—thinking about the thoughts, feelings, and concerns of various people in a system.

Role play seems a natural fit for perspective taking since, during a role play, students can consider someone else's perspective. Louise engaged her K2 students in a dramatic role play technique called Hot Seating in which one student explored the role of a character (in this case, a character from *The Three Little Pigs*) and sat at the front of a group of students. The rest of the group asked the student questions as if the student actually were the character. Below is a transcript of a session with one of the students representing Mr. Wolf. It's important to note that, in this version of the Three Little Pigs, the wolf was recast as the victim and was visiting the pigs' houses in order to ask for an ingredient that he needed to make pancakes.

Q:	*Why did the neighbors don't help you?*
Mr. Wolf:	*They were too rude.*
Q:	*Why you don't know how to cook the pancakes?*
Mr. Wolf:	*Because that was the first time to do my pancakes.*
Q:	*Why you are so mean?*
Mr. Wolf	*Because they are not trying to help me.*
Q:	*Why do you be sad?*
Mr. Wolf	*Because no one helped me.*

Students in Louise's classroom engage in Hot Seating to practice taking on other people's perspectives.

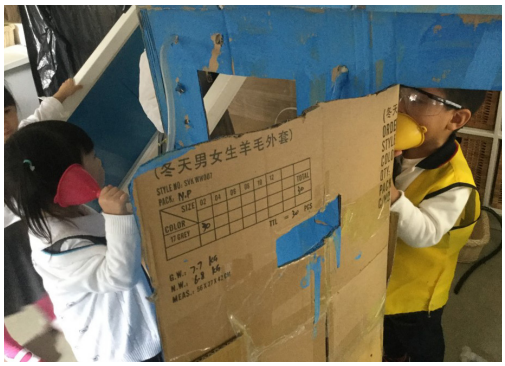
Louise reflected:

> *I learned that the children are really good at expressing themselves in many ways and that, even though they had never done Hot Seating before, they were able to quickly adapt to a character and give answers from that character's perspective.*

In this example, and in others, teachers used storybooks to set a familiar context within which students could practice taking another's perspective. In both Louise's and Jennifer's classes,

students used *The Three Little Pigs* as context for imagining the characters' thoughts and feelings. Jennifer reflected:

> *Literacy truly has a profound way of engaging and educating children on both the concepts of perspective taking and empathy. Through the study of characters and their motivations and intentions, children are able to understand different roles and perspectives. Story-based questioning can also facilitate their language for emotions.*



Students work together to solve problems in the model power station.

In addition to engaging students in role play to take the perspectives of others, teachers also used role play to support students' understanding of systems. For example, Justin's K1 class made a model of a power station as part of a unit on how people use light as a resource. Students learned about power stations by looking closely at photos and by watching videos. Then, they made a graphic organizer showing what they would need in their own model of a power station. Students, with Justin's help, made a power station based on their ideas and then took turns using the power station in a role play in which they imagined they were experiencing a power outage. This helped students understand the complex nature of the power station as a system. Justin reflected:

> *Once the power station was built, the children were able to use it for role play . . . they collaborated to push buttons, pull levers, thread wires/tubing to get the power to turn back on. The way they interacted during the role play was purposeful and productive. . . . They learned that energy comes from outside sources and it is not just "inside the light switch." They learned there is more to the system—which we can now explore more in circle time.*

Teachers regularly nurtured the Agency *by* Design maker capacities with thinking routines and making moves to engage students with maker-centered learning.

Throughout the entire study, teachers placed value on the Agency *by* Design thinking routines and making moves. Teachers felt that the thinking routines and making moves associated with looking closely were good places to begin engaging their young students in maker-centered learning. Many teachers also used the *Think, Feel, Care* thinking routine to help students consider the perspectives of different people within a system.

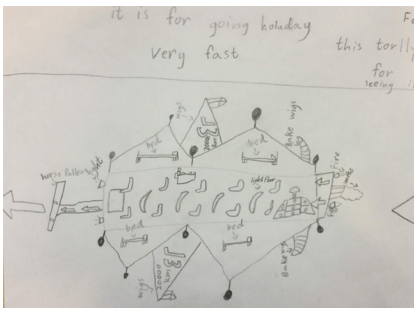
Throughout the entire study, teachers placed value on the Agency *by* Design maker capacities (looking closely, exploring complexity, and finding opportunity) and fostered those capacities through the use of thinking routines and making moves. Teachers felt that the thinking routines and making moves associated with looking closely were good places to begin engaging their young students in maker-centered learning. Shannon, a K2 teacher, explained:

> *I think looking closely is very useful. Everything, every lesson, it should be look first. Look is the first step. That's why I think this is the most important for the children. When they go deeper into the unit, they can take a look first, to look detailedly. . . . then they will ask more questions*

May built on this idea, explaining that looking closely with her K3 students led them naturally into exploring complexity and systems thinking. She described:

> *Through a series of activities, I found that students changed from the habit of quickly scanning things to carefully observing objects. In addition, students made a range of discoveries during the observation process. They actively asked questions and shared their opinions. They learned to compare things with different and identical characteristics in each other's conversations. These experiences made the children very curious. They were eager to find a further variety of characteristics and understand and analyze them with their teachers and classmates. . . . After looking closely, students also discovered the connection between the items, and could tell the operation of the whole thing through these links, which led them to carry out systematic exploration. This seemed like the perfect opportunity to introduce how a system works. Through continuous observation, it can be noted that the children were interested and immersed in the process of discovery and exploration.*

A story from Joyce's K3 classroom illustrates how the practice of looking closely can prepare and motivate students to explore complexity and, in some cases, find opportunity. After students in Joyce's class used the class trolley to transport their peers, Joyce led her students through the *Imagine If…* thinking routine to help them imagine ways to make the trolley more effective and efficient. Students began by looking closely at the parts and purposes of the trolley and explored how the parts interacted to make the trolley function. Many students, perhaps based on their experience riding the trolley in the previous activity, wanted



A student drawing from Joyce's classroom showing an improved trolley design.

to make the trolley more comfortable for the rider. This idea ballooned into student designs in which the trolley became a "holiday home" complete with beds, lights, and a "horse puller." While students, understandably, were not able to enact these modifications, their designs expressed their enthusiasm for modifying a system to meet a specific need or desire.

Many teachers also used the *Think, Feel, Care* thinking routine, which prompts students to consider the thoughts, feelings, and concerns of people within a larger system. Many teachers used this thinking routine to engage students in considering other people's perspectives or to help students identify their own perspectives in relation to a system.

A student in Tina's classroom repurposes an old jar and paper to make a piggy bank.

For example, Tina used the *Think, Feel, Care* thinking routine to guide her K3 students to reflect on their thoughts, feelings, and motivations in relation to environmental pollution, and then she used this reflection as context for a making activity. Her students began by observing and reacting to photographs of ocean animals impacted negatively by pollution. One student responded to a photograph of a sea turtle ingesting a plastic bag, writing, "he [the sea turtle] is not happy. People should put this bag into the bin. I want to help this sea turtle." Students then collected things they were going to throw away and instead repurposed them into something useful. One student taped a circle of paper to the top of a used jar to make a piggy bank. Others made containers for holding hair clips or pencils out of used cardboard. The ideas that arose from the *Think, Feel, Care* thinking routine gave Tina's students a personal and motivating context for this making experience.

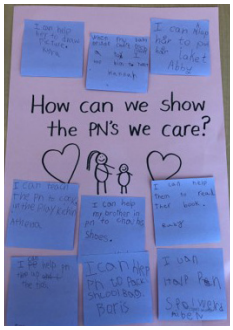
Teachers also used the *Think, Feel, Care* thinking routine to help students consider other perspectives within smaller systems. In May's K3 class, for example, her students used the *Think, Feel, Care* thinking routine to reflect on how various people might react to a board game that they made as part of a summative assessment activity during a unit on weather and geography. This reflection helped students understand that users might have needs that were unmet by their current design. For example, students noticed that some of the questions they wrote were more challenging

Students in May's classroom used the *Think, Feel, Care* thinking routine to reflect on how they can redesign their game to meet the needs of all users.

A Note on Empathy

Throughout their documentation and reflection, some of our teacher colleagues refered to the concept of *empathy* in relation to maker-centered learning. These teachers tended to describe empathy as the ability to step into another's shoes or to care about someone enough to help them. Empathy can be challenging to define and to document, so in this pilot study, we decided to focus on the broader concept of perspective taking. Perspective taking and empathy are related, as both require being able to consider someone else's thoughts, feelings, and experiences. That being said, we want to honor our teacher colleagues' experiences, in particular those experiences that they felt helped their students practice and develop empathy, so we've included some examples of this exciting work here.

To help their students practice empathy, some teachers set up learning experiences that would directly involve their students with other people. For example, Jennifer's K3 students visited the Pre-Nursery (PN) classroom, where students are generally 2-3 years old. Before the visit, Jennifer asked her students, "How can we show the PNs we care?" Students offered ideas such as, "I can teach the PNs to cook in the play kitchen," and "I can help her to draw a picture." By helping the younger students and showing that they care about them, Jennifer felt that her students were engaged in empathy.



Students in Jen's classroom made a chart showing how they can show younger students that they care about them.

Justin introduces a puppet to the class to help his students practice empathy.

In Justin's K1 classroom, he set up a similar learning activity, except instead of bringing his students elsewhere, he brought in a new student (in the form of a puppet). As the puppet experienced social difficulties, Justin invited his students to find ways to help the puppet fit in. He felt that, by using this fictional character as a learning tool, he was engaging his students in practicing empathy.

than others and should therefore be scored accordingly, and that it was difficult to figure out where to place some of the cards. After using the *Think, Feel, Care* thinking routine to reflect on their design, students revised their game to make it more user-friendly.

TEACHER INSIGHTS RELATED TO TEACHING

As can be expected in a study in which teachers incorporated a new pedagogical framework into their teaching practice, the cohort generated insights related to their teaching. Teachers felt that they intentionally stepped back to let their students lead. They valued coming together with other teachers in the cohort to share their experiences and learn from each other. They also came to feel that maker-centered learning aligned well with their curriculum. We discuss each of these insights below.

Teachers intentionally stepped back and let their students lead.

When we asked teachers to reflect on how their teaching had changed since implementing the Agency *by* Design framework for maker-centered learning in their classrooms, some responses we heard included the following:

> *For me, I think I will slow down more to listen to their [students'] voices and their opinions. Because they always have lots of surprises and are very creative, even the K1 students.*

> *I think the biggest benefit is helping me open my eyes to see there is more than one way to do things, to kind of help me let go of the control.*

> *It is building that confidence in them and it also helps us in a such a way to appreciate what they are able to do. You see much more growth, you step back more rather than being at the front line teaching. [We are] looking at the process more.*

In other words, these teachers felt that they could learn from their students if they slowed down, stepped back, and listened. We saw lots of evidence of this over the course of the study. Teachers stepped back to allow student interest to direct an activity, or to allow students to learn from each other and from the materials they worked with. These are indicators that the teachers began to weave more distributed teaching and learning approaches into their practice. Tina shared:

> *They [students] have more confidence to do things, because I don't tell them, "oh, you have to do that, you have to do that." They know they have freedom; they are not limited in the activities.*

Tina echoed what we heard from many teachers over the course of this study: when given the opportunity and appropriate support, young students can direct their learning and figure things out on their own. May, a K3 teacher, eloquently summed this up when reflecting on how her own teaching had changed since implementing maker-centered learning. She stated:

> *I think this is the great idea for me, [to] let the kids to do it by themselves. Really they can be makers; they can be doing many things by themselves. We trust them and then we let them explore and make it work.*

Teachers valued learning from and sharing with their peers in the cohort.

Over the course of the study, teachers valued collaborating with and learning from other teachers who were also implementing maker-centered learning for the first time. Teachers met in study groups within their respective school and full-cohort learning communities where they could share their work, hear what their peers were doing, and troubleshoot together. Jennifer, a K3 teacher at Harbour Heights, shared that, "it's always nice to talk to a learning community where we share ideas. We feed off each other to help each other make our ideas better or come up with different ways to deal with the challenges we might face." Shannon, a K2 teacher at Harbour Green, agreed, stating that through these study groups, she gained new insights into how to implement maker-centered learning. She shared:

Cecily and Shannon reflect together at a learning community.

> *But after maybe doing more, and then having a small meeting at school, then I can hear from my colleagues, then I feel more comfortable. Oh, looking closely, a particular way to do it. And then I learn from them and their experience. I think it's really important.*

Justin's K1 students made cardboard binoculars to search for colors in their classroom as part of a unit on visual art. Cecily, who taught at a different campus than Justin, chatted with him about his work during a full-cohort learning community and was interested in trying it in her own classroom. She had her K1 students make binoculars as well, and they ended up using the binoculars in ways that were more focused than Cecily expected—to learn more, see page 65.

Teachers noted that maker-centered learning aligned well with their curriculum.

At the beginning of this study, teachers saw a gap between their curriculum and maker-centered learning, but by the end of the study, teachers felt that this gap had disappeared. We have observed this shift in our work with other educators implementing a new framework, as well. At first, it can seem difficult or "extra" to apply new pedagogical tools, but as teachers gained experience, they started to see ways in which maker-centered learning both intersected with and supported their practice.

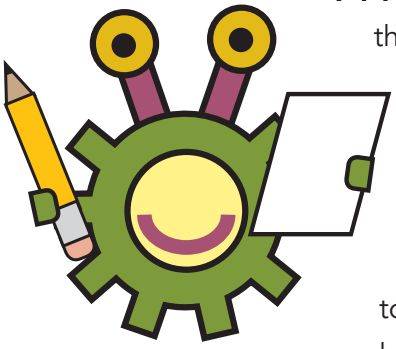
In Liyi's K3 class, her students engaged in the maker capacity of "looking closely" in order to find a lost stuffed animal as part of a "Where We Are In Place and Time" unit of inquiry. She reflected, "The thing I appreciate most is I always try to link [maker-centered learning] with our IB curriculum. Most of the time I find that the relationship is very close."

A student in Liyi's class uses a map of the school to find a lost item.

Joyce also found ways to integrate maker-centered learning with the IB curriculum and the writing curriculum used by her school. For example, she incorporated the *Think, Feel, Care* thinking routine into her persuasive writing activities to support student writing while also integrating the two different teaching frameworks.

Through this pilot study we gathered evidence supporting the idea that maker-centered learning is appropriate and beneficial for young students, and we also gained insight into some strategies that early childhood teachers can use to engage their students in maker-centered learning. We saw that even very young students can engage in complex thinking including thinking about systems and considering other people's perspectives. As we expected, young students are better able to do these things when given appropriate support, such as opportunities to consider different perspectives through role play or opportunuties to work with physical materials such as models and manipulatives.

PICTURES OF PRACTICE



Throughout this study,

the research team saw so many great examples of maker-centered learning in action! In this section, the team provides six pictures of practice that illustrate how teachers adapted the Agency *by* Design framework for maker-centered learning to suit their classrooms and curricular goals. The examples featured here come from a range of content areas, age groups, and teaching languages. Hopefully these pictures of practice will inspire you to incorporate maker-centered learning into your classroom, too!

DEVELOPING PERSPECTIVE TAKING AND EMPATHY THROUGH MAKER-CENTERED LEARNING

During the 2018-2019 academic year, Ms. Jennifer Lee explored ways to support her students in developing perspective taking and empathy through maker-centered learning activities.

Jennifer grew up in Vancouver, B.C. and completed her education degree at the University of British Columbia. During this study, she taught in English in a K3 classroom (5- to 6-year-old learners) at Victoria Nursery (Harbour Heights). As part of her inquiry focus, Jennifer investigated the following question:

> *What strategies or activities can we use to help children grapple with the idea of perspective taking and empathy?*

Jennifer was not alone in asking this question. Early childhood teachers have often expressed that it can be hard to engage young learners in taking others' perspectives and being empathetic. It is not always easy for young learners to identify the motivations of other people, what they value, and what they consider priorities. Through her inquiry work, Jennifer took on the challenge of figuring out how to support her students in practicing their perspective-taking skills and empathy in considering the different actors in a system. She explained the following,

> *The ability to imagine a situation from another person's point of view is helpful in [children] understanding their feelings, experiences, and emotions. Exploring empathy in early childhood is important because it encourages kindness, tolerance, and acceptance of one another—something I believe we need more of in this world. I think it's the foundation to building relationships with people, building bridges between individuals, for them to understand what it means to be in someone else's shoes. It's an important skill that children develop over time, and it will help them develop stronger relationships in the future. Especially when they grow up and they have to work in society.*

According to Jennifer, the systems thinking involved in maker-centered learning encourages young learners to look closely at the complexities of interactions: to think of relationships between various parts of a system and to consider the people involved. And in order to look at these complexities, young learners first need to develop perspective-taking skills, which in turn leads to a deeper development of empathy.

To support her students' perspective taking and empathy development, Jennifer employed multiple approaches, including having students role play different individuals' experiences, thinking, and emotions as part of a system; making visual representations of thoughts and emotions; and using children's books to enhance students' existing vocabulary related to emotions. Through these strategies, students were able to explore the roles portrayed within systems and reason through individuals' thoughts and emotions.

DEVELOPING PERSPECTIVE TAKING AND EMPATHY THROUGH ROLE PLAY: BUILDING AN AIRPLANE AND WEATHERING A STORM

During a unit on transportation, Jennifer's students looked at how transportation systems are created to meet the evolving community needs. Her K3 students studied different types of transportation and looked at how they were suited for different purposes. The students were fascinated by airplanes as many of them recalled first-hand experiences with flying.

Following her students' interest, Jennifer decided to focus the unit on that mode of transportation. The students began their exploration of airplanes by heading to the library to gather books about aircrafts. They also watched videos of pilots flying airplanes and discovered the complex parts found in the cockpit of an airplane. To further their inquiry, Jennifer asked her students if they would help her design an airplane for the role play area using props and recycled materials from their classroom. This role play area would also give her students the opportunity to act out the experiences and responsibilities of different individuals on the airplane to encourage their perspective-taking skills.

Students work together to make the role play area.

Jennifer's students spent time planning what was needed by looking through a variety of books featuring airports and airplanes. The students worked in small groups to create different areas of the role play. Some groups worked together to design the shape of the windows and the size of the airplane body. Others looked carefully through photographs and drew detailed pictures to mirror those of a real cockpit. Some students gathered props needed such as a tray to put airplane meals on, clipboards, and headphones for the pilot.

The process took about a week to complete before the students began playing. As they played, they continued to add different props to enhance their role play experience. For instance, they added a world map for the pilot, made seat belts using ribbons, and even drew small TV screens for the passengers. During this time, Jennifer explained that her role was "to help them find materials and to encourage them to use language as they took on different roles within this system."

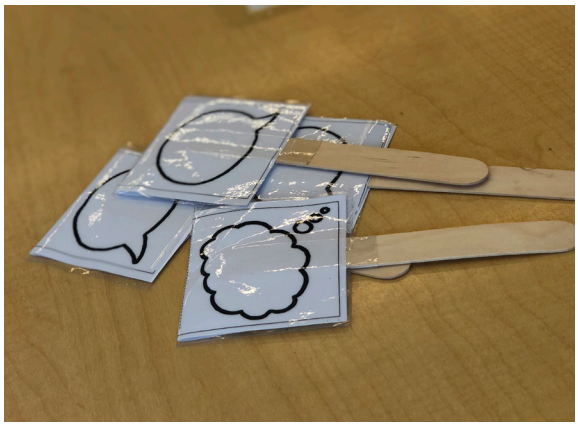
Students engage in role play to take on the perspectives of various people within the airplane system.

To make the airplane role play more purposeful and interactive, Jennifer provided visual representations of thought and speech bubbles to support students in coming up with what their character might feel or think. She adapted this strategy from the Teachers College Reading and Writing Program which her students were familiar with from previous lessons. Jennifer introduced the speech and thought bubble sticks by reminding her students of the different roles in the airplane system. Next she provided a conflict scenario to prompt student dialogue and invite them to reflect on what different emotions and thoughts each individual might experience.

> *There is a big storm heading our way and the plane is currently shaking very badly. There is lightning outside and heavy rain. Who is on our plane? What will they feel? Why?*

Jennifer stepped back and documented the students' conversations. She recorded the following perspectives:

Passenger 1: *I think the plane will fall down.*
Passenger 2: *I feel scared.*
Flight attendant: *I shouldn't give food yet because the food might fall out of the plane.*
Pilot: *I am thinking we go back to the airport because the plane will fall down.*



Students use manipulatives to consider the thoughts of people within the role play.

Using physical manipulatives in the role play area helped students gain awareness of the thoughts and feelings different actors in the scenario might experience. When reflecting on the unit, Jennifer shared,

> *This activity helped my students realize each person is affected in different ways and may have similar or different reactions to the same situation. Children at this age can take on various perspectives, particularly when they read stories where they have the opportunity to imagine they are the character. I also learned that it's important to provide children with appropriate vocabulary, so they all have an equal opportunity to participate and share their ideas.*

Jennifer also found that with similar role play lessons, it is important to come up with a variety of conflicts or situations that are realistic to help young leaners understand these experiences are real and can happen. In future lessons, Jennifer thought that she could extend this activity by asking students to create a role play comic strip conversation based on a conflict scenario they acted out previously.

DEVELOPING PERSPECTIVE TAKING THROUGH STORIES: *THE THREE LITTLE PIGS* AND THE WOLF

In continuing to develop their perspective-taking skills, Jennifer's students read the story of *The Three Little Pigs* and used speech and thought bubbles to look closer at the characters' feelings and perspectives. The activity encouraged students to use literacy as a means of exploring perspectives.

To start off the project, they read *The Three Little Pigs* and discussed the characters as a class. The students associated the three little pigs with positive traits, such as friendly, hardworking, and smart. On the other hand, most of the students associated the wolf with negative traits, such as mean, scary, and angry. Students then compared the first story to two other versions of the *Three Little Pigs*. In *The True Story of the The Three Little Pigs*, the wolf is in fact a nice wolf who is in need of a cup of sugar. In the other version, titled *STEM Tales: A New House for Wolf*, the wolf simply has allergies which explains why he keeps blowing the pigs' houses down. This comparison of the characters showed students how our thoughts and feelings about a character can change depending on the context. The comparison helped them to sympathize with the wolf and understand his feelings in a variety of scenarios. The students were then given printouts of the story pages and wrote different versions of the thought bubbles based on the corresponding storylines.

Jennifer shared that the students demonstrated their understanding that different characters can view the same situation and feel and think very differently from one another. Individuals may or may not share similar feelings depending on the context, which led to a discussion on why the pigs ran away from the wolf and why they made a pot of hot water. Jennifer noticed that after reading three different versions of the same fairytale, her students were able to empathize with the wolf's character. They were able to put themselves in someone else's shoes and imagine their feelings and the reasoning behind them. It was much easier to prompt their thinking with a familiar fairytale.

For her next step, Jennifer planned to continue with a fairytale invention project where students had to work in teams to design and make a sturdy and strong house for the wolf who had allergies. The perspective-taking work students had done previously set the context for this making experience. In partners, the students examined the materials in the maker area and set off to complete the first two parts of an engineering process: Ask and Imagine. They then planned their ideas and collaborated on a single design. The finished product was tested to see if it could withstand the strong gusts of sneezes from the wolf! This step was important as it helped them to reflect on the inventions and whether they needed further improvements to strengthen the houses they created to be useful for the poor wolf.

Students describe what they think a character is thinking in selected pages from *The Three Little Pigs.*
Top left: Pig: *This is terrible, my house is not strong enough. I need to run away.*
Top right: Wolf: *I'm going to go in the house and eat you up.* **Pig:** *I'm scared. I'm going to the brick house.*
Bottom left: Pig: *The wolf will eat me. I don't like him.* Wolf: *My nose is so itchy! Achoo!.*
Bottom right: Wolf: *Mr Pig, Mr Pig are you in? I think the pig will give me sugar.* **Pig:** *Go away I am shaving my hair on my chin. Oh no, I am not letting him to get my sugar.*

CONCLUSION

Over the course of Jennifer's inquiry cycle work, three themes emerged regarding how to support young learners in developing perspective taking and empathy through maker-centered learning.

1. Role playing can help young learners visualize and enact the perspectives and emotions of others.

By engaging in role play over an extended period, Jennifer's students not only actively engaged in creating the airplane area but also accessed their prior experiences to imagine what others might be thinking or feeling. By posing a conflict, Jennifer encouraged her students to go beyond their

Students work collaboratively to design, make, and test a safe house for the wolf.

initial ideas to consider how different individuals within the role play scenario might experience the same situation.

2. Stories can help young learners take others' perspectives.

By juxtaposing versions of the same story and through the study of story characters and their motivations and intentions, Jennifer's students were able to understand different roles and perspectives. In addition, story-based questioning facilitated their vocabulary for emotions.

3. Visual representations of thoughts and language related to emotions can help young learners access complex ideas.

Manipulatives and visual representations such as speech and thought bubble sticks helped Jennifer's students access abstract concepts and develop concrete understandings of the experiences of roles in their play and characters in the stories they read.

Importantly, supporting young learners in developing perspective taking and empathy through maker-centered learning requires allowing students to lead their own learning. By taking a facilitator role, creating situations, and offering supports yet allowing students to explore situations on their own, teachers can help their students develop an understanding of what others might be thinking or feeling. When reflecting on her inquiry cycle process, Jennifer shared that:

> *This experience has pushed me to step back from directing and guiding the children in role play. It showed how young learners are capable of modelling agentive behavior. When they are given free movement and choice, they take responsibility and ownership of their learning as shown with the way they built their classroom airplane role play area. This experience also showed the power of questioning and facilitating young children by asking the right questions to prompt their thinking.*

One of Jennifer's students consults a map as she navigates the airplane during role play.

LOOKING CLOSELY WITH K1 STUDENTS

As part of her inquiry focus work, Ms. Cecily Ko explored provocations and resources that would encourage her three- and four-year-old students to engage in the maker capacity of looking closely. She found that, by providing students with a variety of tools to help them look closely, they were able to lead their own learning in ways that went far beyond her expectations.

Cecily is the Head English Teacher at Victoria (Harbour Green) Kindergarten. During the study, she worked closely and collaboratively with two Chinese (Putonghua and Cantonese) teaching partners in a K1 classroom. She grew up in Toronto, Canada and moved to Hong Kong twelve years ago. Cecily has been a teacher for sixteen years and has worked with students from two to fourteen years old.

At first, Cecily was nervous about bringing the Agency *by* Design framework for maker-centered learning into her K1 classroom. She wasn't sure that her students would be ready for this sort of thinking at the beginning of the school year. Would they be emotionally ready? Would they be able to communicate clearly and share ideas? After meeting them, however, Cecily knew that her students were ready for maker-centered learning. She described:

> *They aren't really talking much but you can tell they are taking things in. They are observers. . . . We [adults] have so much prior knowledge and we just assume, oh this is this, and this is this. But to them [children], everything is kind of new, so I think looking closely would be the first step of guiding them in the maker process.*

LOOKING CLOSELY AT DOLLS

Cecily first asked her students to look closely as part of the "Who We Are" unit of inquiry. To do this, she set up a learning center with a variety of dolls for children to explore. All of the dolls represented people, but they each had different clothing, skin tones, and other physical features.

Cecily chose to have her students look closely at dolls for two reasons. First, almost all of her students have similar hair, eye, and skin color, and she wanted them to think about a more diverse set of physical features. She also felt that dolls were a perfect starting place for this inquiry because of their appropriateness for young learners. She described:

At this age, young learners don't just look closely by using their eyes. They also use their hands to touch and feel the object that they are observing. It's a bit hard for them to gauge the strength of their hands. So, I decided to have children start by looking closely at dolls, instead of at each other.

Students exploring and looking closely at the features of dolls.

As soon as Cecily set up the learning center, her students were interested in it. Without much guidance from her, they began looking closely at the dolls, identifying physical features, and even taking the dolls' clothing off to explore beyond what they could see at first. In reflecting on the activity, Cecily shared:

What I had intended at the beginning was for them to just look at the doll, what body parts the dolls have and then maybe guide them to compare what body parts they have. . . . I did not even tell them to take things apart. They are already taking clothes off the dolls and looking closely. Some of them found belly buttons. They were interested in it! They were like, 'I have belly button!' and one student started to lift up their shirt! I'm like, 'It's okay, you don't need to show me your belly button!'

Cecily felt that the dolls worked well as a provocation for her students. The dolls sparked their interest right away. She reflected:

They surprised me by taking initiative to take the clothes off the dolls to look even closer. . . . I learned that students have a natural instinct to look closely at things that are presented to them.

I didn't have to give elaborate instructions and they were able to discover and find different parts from the dolls. . . . I also learned that students can start to develop their communication skills, observation skills and cooperation skills through looking closely together with their peers.

One of Cecily's goals for this unit was to help children understand that learning about ourselves can help us understand how people are the same or different. To do this, she knew children had to move beyond dolls and begin looking at themselves.

LOOKING CLOSELY AT EACH OTHER

Cecily decided to have her students look closely at their peers' body parts and features using cameras. The camera's limited view encouraged children to look closely at just one body part at a time. As children shared the photos they took, they easily compared various features. They noticed, for example, that some people wore glasses and others didn't, and that the teacher's foot was bigger than their own feet. Cecily noticed that, just as in the doll activity, the children easily worked together, practicing their observation and communication skills, without much guidance from her.

Students use cameras to look closely at peers.

LOOKING CLOSELY AT THE COMMUNITY

Inspired by the children's level of thinking with the camera activity and by the work of a teacher in another K1 classroom, Cecily decided to introduce a new tool to help children look closely: handmade binoculars. Cecily shared:

When they use the binoculars, they zoom in. Even though it's just toilet paper tubes, they see things differently. I tried it, I tried to see it from their perspective, and maybe it does narrow the view for them, even though it doesn't have a lens. . . . At the beginning, I thought, maybe it will spark their interest. It turned out to be bigger than I expected. They are still using them now, at the end of the year!

Cecily originally intended her children to use the binoculars during their study of the school community. They brought their binoculars on a walk around the school and used them to "zoom

in" and identify various people and objects. This activity went well, and Cecily assumed they were done with the binoculars after that. But the children thought differently. Cecily remembered:

Students use the binoculars they created to look around their school.

> *Even going out to the [Mass Transit Railway] station, the children asked, 'Can we bring our binoculars with us?' Even when we continue with other observations or looking closely activities, even just reading a book, they want the binoculars! They want to use them, they are proud and want to use them for everything, whenever they are looking.*

Cecily thought her children particularly liked using the binoculars because they made them themselves. Each student remembered which one they made, and they refused to use someone else's binoculars. Cecily reflected that, if she had just given them binoculars, even a set of real binoculars, they probably wouldn't have felt so attached to them. Because children made their own, they felt ownership over them and were constantly looking for new ways to use them.

Cecily learned a lot from her three-year old students. She reflected:

> *Once we'd been through the process of looking closely, the children actually were able to show me that they're ready for something more. They would ask questions and make connections. They can apply these tools to other things. They were actually exploring complexity – they were looking at different parts and thinking about how to use the binoculars in different systems. . . . I find that they're kind of the leaders, they're leading me, teaching me more so than I'm leading and teaching them. . . . They took the initiative to tell me, 'I want to use this to look at*


Students make their binoculars out of toilet paper tubes.

something else.' They use the words, 'I want to do this.' This makes me realize I need to let go and listen to them better.

CONCLUSION

Over the course of Cecily's inquiry cycle work, three themes rose to the surface.

1. Looking closely comes naturally to young learners.

Students are naturally drawn to objects and pay close attention to their features. To support them in this, it's important to give them a focus so they can look with purpose, rather than looking randomly. For example, Cecily gave her students cameras and they also made their own binoculars to help them focus their explorations.

2. Looking closely helps young learners develop communication and collaboration skills.

Young learners don't just look with their eyes; they also look with their hands, as was the case in the doll activity. They develop their ideas about what they see and feel through dialog with their peers.

3. Looking closely, particularly with and/or at things that have personal meaning, can empower children as learners.

When young learners look closely, they use their senses to find new things; they sort, compare, and make connections; and they explore their world by looking at the same thing from different perspectives. By doing this, not only do they expand their understanding of their world, they also learn to take the initiative to find out more about what they want to know.

Looking closely isn't just for young learners. As part of her inquiry cycle work, Cecily learned that looking closely benefitted her, as well. As students worked, Cecily listened closely to their conversations and used what she heard to craft questions to help her students push their thinking in the moment. The more she listened and observed, the more she learned about her own students' interests and needs, which enabled her to plan more relevant learning experiences for her class.

Towards the end of the school year, Cecily reflected on how engaging in maker-centered learning has impacted her own teaching practice. She noted:

I have learned to let go of 'teacher-directed' types of learning engagements. I'm not saying

I don't have any 'teacher-directed' types of activities in my classroom but for sure, these types of activities are much less than before. Instead of rushing through many stand-alone activities, my teaching has changed from 'quantity to quality.' The focus of my teaching has shifted from final product-based to process-driven. Children have more say in terms of the direction of our inquiry. I have learned to revise my planning based on what children have noticed and explored; hence, learning engagements are more student-led than teacher-led.

A student uses binoculars to look closely at stuffed animal.

I also learned that children have lots of potential and learning capabilities, more so than adults can usually imagine. By just providing simple resources/provocations, they can learn more than what adults expect and notice more details than what adults can. Also, as adults, we have to stop rushing through the process and just go for the end result. We should give children time to learn and go through the process at their own pace; that way, children can look closely to find new things in detail, explore parts and interactions of how things or systems work. In turn, they can tinker, hack, redesign and invent better/more suitable things or systems.

FINDING OPPORTUNITY AT THE MAKER TABLE

Over the course of the 2018-2019 academic year, Ms. Claudia Wong explored how she could use a maker table to help students engage in the maker capacity of finding opportunity. She learned that students found opportunity through freely making with the materials provided at the maker table and through conversation and collaboration with their peers. She also found that, by helping her students understand their role in the maker table system, they were able to find opportunity to improve the maker table so that it met their needs.

Claudia is a Primary Years Program (PYP) Coordinator at Victoria Nursery (Harbour Heights). A large part of her role at the school is to make sure that all teaching materials and strategies are developed based on the IB model of inquiry-based learning. While Claudia did not have her own classroom during this study, she explored maker-centered learning with students aged 3-6 in the school's common play area.

MAKING IN THE PLAYGROUND: BUILDING A COMMUNITY OF YOUNG MAKERS

One important theme for Claudia as she engaged with maker-centered learning was supporting students' sense of agency by creating opportunities for them to make. By setting up a maker table in an area where students spend their free play time, Claudia felt she could help foster students' agency, as well as further their learning, through playing and making.

In the free play area, students would have the freedom to make without necessarily feeling that they had to make what a teacher was expecting. Claudia shared:

> *In the teacher's mind, they already have an outcome, and they want the children to make the outcome. . . . It does not come from children, so you always see that the children's artwork or their things are the same, like everyone is the same. The children have no reason for why they are making. They always say, "I need to make, so I make," When I ask them why they make it, they always say "oh, because the teacher asked me to make it." . . . They don't know why they need to learn. The thing does not belong to them.*

Claudia envisioned this maker table as an area where students could use a variety of tools and materials to make anything they wanted. She wanted to empower students to make their own decisions in terms of what they wanted to make, how they wanted to make it, and how to solve problems that arose throughout the making process.

SETTING UP THE MAKER TABLE

Claudia set up the maker table in the school's free play area. In addition to welcoming free play at the maker table, Claudia recognized that the maker table could also be a useful resource to classroom teachers conducting units of inquiry, and so she worked with classroom teachers to plan units that would allow their students to use the maker table as part of their classwork.

In order to allow for more fluent play and making experiences for her students, Claudia purposefully selected materials that young learners could use independently, such as paper, pencils, adhesives, colorful tape, straws, free-construction toys, and fabric. She also paid attention to the layout of the space, ensuring that all materials were easy to find, use, and put away.

Claudia set up the maker table so that materials were easy to find, use, and put away.

FINDING OPPORTUNITY THROUGH PEER-TO-PEER LEARNING AND PROBLEM SOLVING

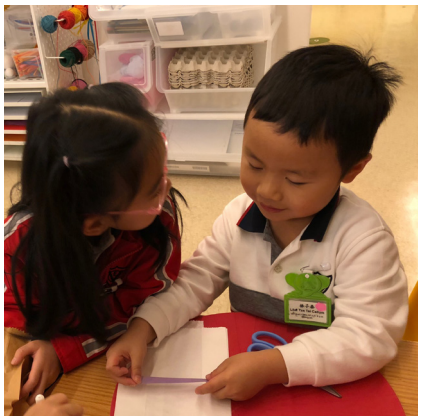
A student explores materials and uses them to make things.

Students were excited to use the maker table and showed a high level of engagement from the start. Claudia noticed that students engaged in the maker capacity of looking closely without help from their teachers, as they explored the variety of materials at the maker table and compared them to each other. Claudia saw students playing together and sharing ideas with each other, which in turn, inspired them to make. When students faced difficulties during their play and making, such as not having the exact materials they needed to create something, they were able to discuss what they wanted to make with friends and figure out ways to solve the problem. Claudia felt that her students were able to develop agency in and ownership over their work.

Claudia described an example of finding opportunity through iterative making that she observed at the maker table:

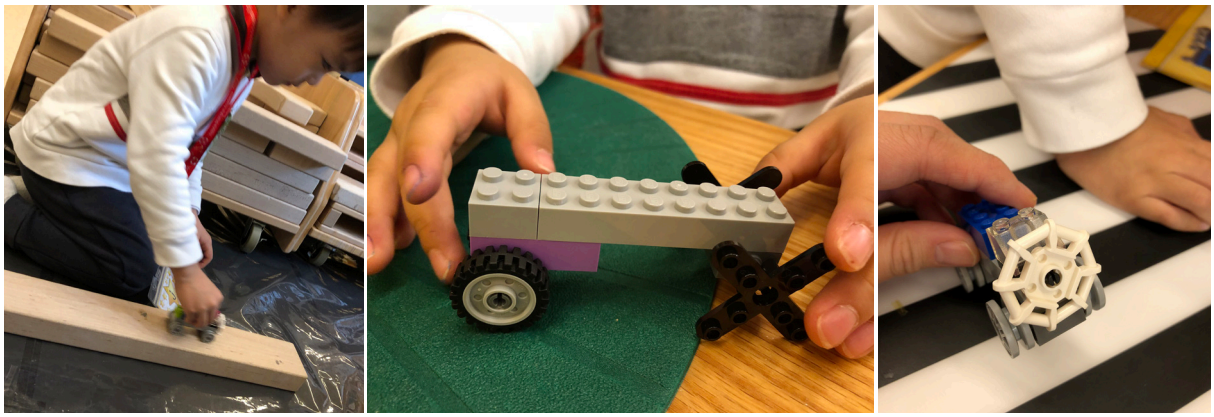
Three of the K1 students I was working with were using Lego bricks and blocks to make their own cars and to build their own runway for the cars. They tried to run their cars on the runway

they developed for the first time but realized that there was an end to the runway they developed. On top of that, they also found it too short. In order to solve the problem, one of the students replaced the wheels of their car with the rotors, and claimed that the car, now that they had equipped it with the rotors, could function as a helicopter that flew high in the sky. Upon listening to this idea, this student's friends went on and designed buttons to add onto this car and demonstrated that by pressing this button, the car would turn into an airplane just like those in the cartoons they watched.



Students share ideas with each other at the maker table.

Claudia felt that, through collaboration and iterative making, her students were able to find opportunities to change their design to reflect new ideas they had about how the vehicle should function. Her students looked closely at the car and its parts, then used their imaginations to add to its complexity with rotors that caused it to fly and buttons that transformed it into an airplane.



Students engage in iterative making at the maker table.

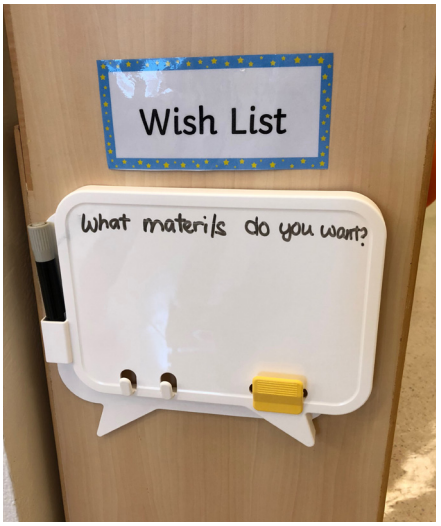
ENGAGING STUDENTS IN SYSTEMS THINKING: PARTS, PEOPLE, INTERACTIONS

The Agency *by* Design framework for maker-centered learning emphasizes systems thinking as elemental to the development of maker empowerment. Through systems thinking, learners practice

seeing themselves as participants in complex systems, and recognize the opportunities to make changes to these systems that can have far-reaching impacts. Claudia viewed the maker table as a system and wanted to help students use systems thinking to identify potential problems with the system and to find opportunity to solve these problems.

Claudia decided to use the *Parts, People, Interactions* thinking routine to help students think about whether they experienced any challenges when using the maker table. In conversation, students discussed the problem that "there might not be the right materials."

Student A: *There might not be the right materials.*
Student B: *Provide more materials.*
Student C: *Here we have a lot of materials.*
Student D: *But what I need is box. I want big box.*
Student C: *I have lots of big box at home*
Student E: *I have big box at home, too.*
Claudia: *We all have a lot of materials at home. Can you find a way to let other people know what materials you need so that they can bring those back to school?*
Student C: *I can write them down on the paper and tell all my friends.*
Student D: *Like a shopping list. Write down what I want—three big box.*



Students decided that a "wish list" would solve the problem of not having the materials they needed.

From this discussion, Claudia learned more about the problem from the students' perspective and got some insights into how they believed the problem could be solved. Rather than solving the problem herself without consulting students, Claudia listened to her students and encouraged them to "find opportunity" by suggesting ways to solve the problem. As a result of this discussion, Claudia brought in a whiteboard that students could use as a materials wish list.

One surprise from this experience was that the maker table quickly became part of the school community. Teachers, administrators, and support staff started contributing materials to the table on their own initiative. For example, school custodians donated empty tissue boxes and toilet paper rolls and a school administrator brought in some colorful tape from home. Claudia also noticed that students started using the maker table without her supervision and without their teachers, which

had not been the case during the initial uses of the maker table. Upon reflecting on the evolution of the maker table, Claudia noted:

> *Initially, I believed that I had the full responsibility of this maker table. Nothing could be achieved without my supervision. But now, I have changed my mind. I realized that once the system, the maker table, is developed, others in the school will also work together in an integrated manner to make it better.*

Claudia felt that her students came to believe that the maker table belonged to them. When they thought of the maker table as a system that they were a part of, they could actively look for opportunities to improve the maker table to better suit their needs as young makers.

CONCLUSION

Over the course of Claudia's work helping students find opportunity at the maker table, three themes rose to the surface.

1. Playing with peers at a maker table gives young learners many opportunities to make and create.

Claudia's students played with each other at the maker table, sharing ideas and troubleshooting with their peers as they used materials to make. Students learned how to solve their own problems instead of asking the teacher for help.

2. Young learners understand their role in shaping a communal space, such as a maker table.

The maker table offered a context that helped students practice systems thinking and develop a sense of agency. Students came to understand that they were part of the maker table system and that they could suggest changes that would make the maker table work more effectively for them.

3. Others in the school community can find opportunities to contribute to and improve a making space.

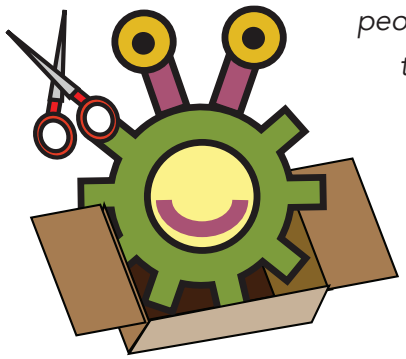
Teachers and staff at the school contributed to the maker table by bringing in materials that students could use freely. In this way, the maker table invited the school community to be a part of the making process.

Claudia reflected on the changes she saw in her students after they began working at the maker table:

在Maker Table 所發生的Agency學習的情節, 真是超出我的預期。在一個沒有單元規範的、沒有老師要求學生完成任何任務的地方, 只有物料提供, 以及自由尊重的環境下, Agency和學習也可自然地發生。幼兒每天愉快地就著自己的興趣和需要, 利用思考模式, 動手把自己的想法和設計實踐出來。在運用各思考模式中, 幼兒嘗試從不同人和角度理解事物, 並顧及各方的需要, 設計內容更仔細, 更有方向。從他們設計的東西中, 你能發現幼兒創意無限, 所想的比成人更周全。

印象深刻的是一段我和小朋友的對話, 一組女孩子們在Maker Table埋頭苦幹準備「化妝舞會」, 我表示想一起參與, 她們異口同聲說:「這是屬於小朋友的地方, 如果你要加入, 你必須保證每天也來, 一齊傾, 一齊唸, 一齊做, 所以你加入前要想清楚。」她們是很重視Maker Table 這個地方, 專心地做她們認為重要和屬於她們的事情。

[translation] *The examples of agency I observed at the Maker Table were beyond my expectations. With no restrictions or boundaries of a unit of study and without commands from teachers to students, only with a supply of materials and an environment with freedom and respect, agency and learning happened naturally. Students carried out their own designs and ideas through the use of thinking routines and what they were interested in and needed. Through the use of thinking routines, young learners were able to look closely at the different perspectives of people and objects and learned to consider others' needs in order to create designs that are more detailed and informative. From the designs they made, you can see that the creativity of young people is limitless and sometimes even more well-rounded than that of adults.*



One of the most memorable conversations I had throughout this experience, was one with a group of girls at the Maker Table. They were working hard on the "Make Up Party" props and I told them that I would like to participate. They immediately said all together at the same time, "This is a space for young learners. If you want to be a part of it, you have to promise to come every day, to chat with us, to brainstorm with us, and make it with us. So you better think clearly before you decide to join us." They really treasure the Maker Table, a place where they can focus on doing what they think is important and that belongs to them.

ELEVATING AND DOCUMENTING STUDENT VOICE

Ms. Kit Cheng's inquiry cycle work highlights the Agency *by* Design framework for maker-centered learning concepts of student empowerment and student-centered learning. Through her work, Kit demonstrated that by giving her young students opportunities to share and view their ideas as meaningful, they were able to build their confidence as learners and independently engage in the maker-centered capacities of looking closely, exploring complexity, and finding opportunity.

During the 2018-2019 school year, Kit was the Putonghua teacher in a K2 classroom (4- and 5- year-old learners) at Victoria (Harbour Green) Kindergarten. She is also the IB Primary Years Program coordinator for the school. Through her work with maker-centered learning, Kit wanted her students to be able to express themselves with confidence, be risk takers with their ideas, and consider how their actions impact other people. To do this, she took care to elevate student voice by seeking out and validating student insights. She also provided a space for diverse interpretations while creating learning experiences that encouraged students to think about other people's perspectives.

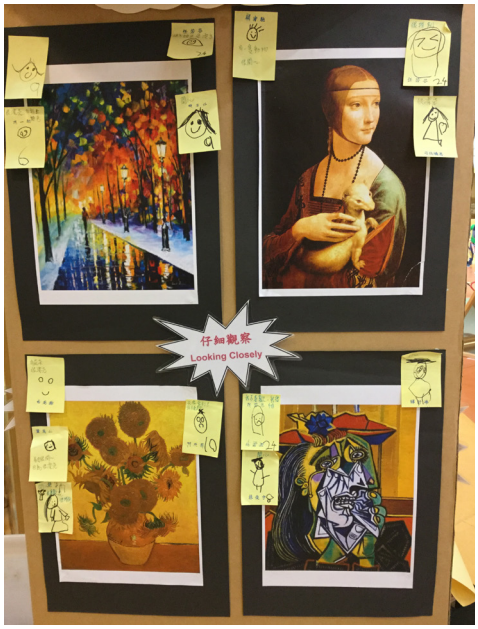
One example of Kit's work comes from the "How We Express Ourselves" unit of inquiry. For this unit, Kit chose to have her students explore the central idea, "We can express and interpret our emotions in different ways." At each stage in the unit, she made sure to slow down to give her students enough time to engage in the content and to express their ideas. Before beginning the unit, Kit reflected:

> *I need to try to slow down. I need to let them have time to think. Also, I need to remind myself to listen, because K2 children, they can't really write what they want to say or label what they did. Now, I hope I have time to listen to them and help them so they can say what they want to say.*

Elevating student voice in the classroom is an important aspect of maker-centered learning, and Kit's work demonstrated some strategies for doing this with young learners.

WHAT DO YOU FEEL? WHAT DID THE PAINTER FEEL?

To begin, Kit set up a small art gallery featuring printouts of famous paintings. Her students visited the gallery in small groups and looked closely at each painting. They thought about how each painting made them feel and recorded their feelings using sticky notes. Kit displayed their responses and noted that there were a variety of reactions to the paintings. One student, for example, drew a frowning face in response to Van Gogh's *Sunflowers*, suggesting that the student felt upset when looking at the painting, while two other students drew smiling faces, suggesting that they felt



Printouts of famous paintings with students' reactions on sticky notes.

happy. Kit acknowledged everyone's ideas, leaving room for diverse interpretations of the artwork.

For three of the artworks, students were further prompted to imagine the paintings from the perspective of the painter. What feelings did they think the painter was expressing? Students wrote or drew their ideas on sticky notes and added them to the gallery for everyone to see. In this way, Kit allowed her students the opportunity to express themselves while also learning that others, including their peers, may have different ideas than they themselves do. Kit reflected:

> *I was surprised how vast their imaginations were and how they could see such different things when looking at a painting. The children were very accepting of other children's opinions and were interested to hear what they were saying.*

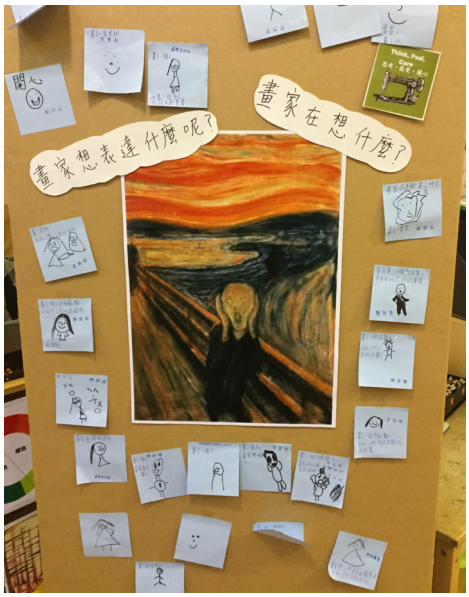
IMAGINING A PAINTER'S PERSPECTIVE

Next, Kit collaborated with her partner teachers to help students explore the complexity of painters' perspectives. Because her school is trilingual, the three classroom teachers sometimes explore the same subject in three different languages in order to make the content accessible to all students while at the same time building vocabulary and language fluency. In this case, each teacher took a different painting from the gallery and used it to lead students through the *Think, Feel, Care* thinking routine in a different language.

Students look at their peers' interpretations of painters' perspectives.

Students imagined what the painter of each image was thinking as they created their artwork. The students had lots of ideas to share. When looking at Edvard Munch's *Der Schrei der Natur (The Scream)* and discussing the painter's possible intentions, one student thought that

the painter wanted to draw a monster, while another student thought that the painter must have enjoyed playing with Mr. Potato Head and wanted to draw one. Just as before, Kit welcomed and documented all student ideas.



Students' interpretation of Munch's thoughts, feelings, and intentions in *The Scream*.

Students then used the *Think, Feel, Care* thinking routine to imagine what feelings the painters were trying to express. When looking at a reproduction of one of Wassily Kandinsky's colorful canvases, some students imagined the painter was feeling excited, while others thought he was feeling happy. This helped students realize that different people have different interpretations of various pieces of art.

After students had discussed each painting with the teachers, Kit decided to document everyone's ideas in a class book to show that different people had different ideas. Her students could look at the book during reading time and review everyone's ideas, giving them another opportunity to learn from each other during a time when they typically are learning from published authors, which further validated her students' ideas in the classroom.

RECREATING *THE SCREAM*

As part of this unit of inquiry, Kit had taught her students about the primary colors and how artists can mix them to create new colors. She had planned for students to use this knowledge to find opportunities to recreate one or two of the paintings that they had analyzed. Her students took this idea further by suggesting that they make a giant reproduction of *The Scream* with a hole where the head should be. "What do you mean, a hole?" asked Kit. "Why? How?" She had an idea of what the children were thinking but wanted to give them the chance to express it themselves. "We need to make a hole like at Disneyland or Ocean Park," they said. "You can cut a hole and I can go in the back. You can see my face and then everyone can play!"

Students painting a recreation of *The Scream*.

True to the spirit of student-centered learning, Kit gave students the time and materials they needed to put their plan into action. The students used what they knew about primary colors to mix their own colors and paint a giant version of *The Scream*. This took quite a bit of time, but Kit found a way to use this project to support her curricular goals around emotional literacy.

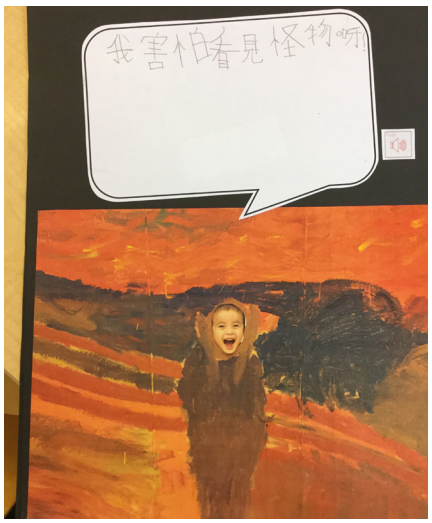
After the backdrop was finished, Kit reminded children that, when they first saw the painting, they had decided that the painter probably wanted to paint a scary picture. She asked her students, "What is something you are afraid of?" Students wrote or drew something that they thought was scary. Then, they worked with their peers to "become the painting" by placing their head into the backdrop they made and to make video recordings of each other. Some students even taped their drawing to the backdrop to visually show what they were afraid of—and what was causing them to scream. Kit didn't view the recordings as final products, instead, she saw them as an excellent learning tool as they encouraged children to share their ideas and to learn from their peers' experiences in an engaging way.

A student places his face through a cutout of *The Scream* recreation and shares what he is afraid of.

BRINGING IT TOGETHER

To conclude this learning experience, Kit wanted students to make a final product to build on the capacities of looking closely, exploring complexity, and finding opportunity that they could share with their families. To begin, Kit held a group discussion in which students shared what they were afraid of with the class, and then had their classmates join them in screaming. For example, when one child shared, "I am scared when I see a spider on the grass," the entire class listened and then they all screamed together, "Ahhhhhh!"

Next, students audio-recorded themselves explaining what they were afraid of. They then had the challenge of writing out their transcript on a speech bubble. Some children were able to write all the Chinese characters, while others decided to cut out characters and then pasted them onto their speech bubbles. Kit's students wanted to write as many characters as they could, and they only cut and pasted characters onto their speech bubbles if they were really struggling to write one. In this way, Kit ensured that students weren't limited by their writing abilities. They could say what they wanted to say.



A page from the class book featuring a student's annotated description of what they are afraid of and an interactive Ting Pen link to an audio recording of the student.

When they were finished, the students pasted their speech bubbles onto a photograph of themselves standing behind *The Scream* backdrop. To top it off, Kit included an interactive icon next students' speech bubble and used a Ting Pen, an audio recording pen, to record students' thoughts. When a reader touched the Ting Pen to the icon pasted to the page, they could hear the audio of the student saying what they were afraid of and then screaming – "ahhhh!" Kit then compiled these pages into a class book that the children used to explore a unit on self-expression, emotion, and art. The book of screams was particularly meaningful as it contained children's own work and ideas.

CONCLUSION

Throughout Kit's experience incorporating maker-centered learning into her classroom practice, two themes emerged related to empowerment and student-centered learning.

1. It is helpful to give young learners opportunities to learn from their own experiences and those of their peers.

For example, instead of limiting her student's thinking by telling them the motivations of the painters under study, Kit gave her students the chance to explore the complexity of the painting and their own emotional responses to imagine what the painter might have been thinking and feeling. This enabled students to draw from their own experiences while also learning from each other as they recognized that different people had different perspectives on each painting.

2. It is helpful to give young learners engaging and appropriate ways to document their thinking so they can easily share their ideas with others and add to the class' knowledge base.

Even though Kit's students were all roughly the same age, they displayed a large range in their cognitive and social emotional abilities and had different life experiences. It was valuable to give

them opportunities to learn from each other. Using audio and video recording tools helped Kit's students share their ideas even though their writing and drawing abilities were limited.

Within an early childhood classroom, taking a student-centered approach towards learning gives students more opportunities to pursue their own questions and form their own understandings about a particular topic of inquiry. This results in students feeling more empowered because they are directly involved in their learning experiences. In reflecting on incorporating maker-centered learning into her classroom, Kit shared:

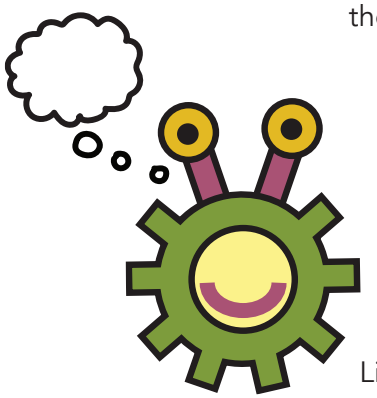
我覺得親身嘗試是十分重要，因為學習的過程是很重要的，這樣的學習才能有鞏固的記憶，日後才能運用已有的經驗再進行不同的探索學習，我們應要給予足夠的時間和機會讓幼兒親身去經歷不同的學習外，也應該有足夠的時間給幼兒去進行反思自己的作品、與同伴分享自己的作品或給同伴意見及再設計作品，這樣幼兒的學習會顯得更有意義。

[translation] *I believe that learning by experience is crucial because the process of learning is very important. Learning through experiences helps build a concrete foundation, so that as we continue on with our journey in learning and exploration, we can draw on the strong foundation we have built. As teachers, we need to provide sufficient opportunity and time for learners to experience different things and ideas, but also carve out enough time for them to reflect on their own products, share with one another, provide feedback for others, and improve their own products. This process will allow students to have meaningful learning experiences.*

TAKING DIFFERENT PERSPECTIVES THROUGH SYSTEMS THINKING

As part of her work with the Agency *by* Design: Early Childhood in the Making project, Ms. Lisa Golds explored systems thinking with her K3 (ages 5-6) students. She found that, by experiencing and reflecting on systems, her students were able to reflect on other people's perspectives and to recognize that a supposed improvement in a system does not necessarily impact everyone involved with the system in the same way.

Systems thinking is a core concept of the Agency *by* Design framework for maker-centered learning. Through systems thinking, students explore the parts, people, and interactions in any given system, with the goal of understanding the layers of complexity that exist. There is some disagreement in the broad early childhood community about whether preschool-aged students can/should think about the complex nature of systems. Lisa found that, by scaffolding systems thinking using the Agency *by* Design thinking routines, her students were able to understand the complexities associated with the Mass Transit Railway (MTR) system in Hong Kong and to consider the different perspectives of the people involved in this system.



Lisa has been an early childhood educator for ten years and speaks passionately about her young, enthusiastic, and inquisitive students. Her favorite part about teaching young students is figuring out how to support them in pursuing their unique interests while at the same time leading them through an inquiry-based learning process. When reflecting on the importance of systems thinking for her students, she wrote:

> *As a strong believer in conceptual-based learning and teaching, systems thinking fits neatly into my teaching pedagogy. In contemporary education, we need to teach children more than knowledge and skills—they need to understand the application of that knowledge in real life situations, and understanding the "who" and the "why" of the different systems and concepts that they encounter every day is a big part of that.*

PARTS, PEOPLE, INTERACTIONS

As part of a unit called "How We Organize Ourselves," Lisa's students learned about various transportation options in the city. They took a field trip using a bus, a cross-harbor ferry, and the

MTR. They then rated each form of transportation on their value for money, comfort, and efficiency. Upon returning to the classroom, one group of students seemed very interested in learning more about the MTR, so Lisa decided to use this interest as a starting point to help them think about the MTR as a system, using the Agency *by* Design thinking routines.

Lisa began this work by using the *Parts, People, Interactions* thinking routine to guide students as they individually drew a system map of the MTR. Lisa asked her students to consider: What are the important parts of the MTR? Who are the people who are involved? How do the parts and people interact?

Student map of the MTR system.

Lisa found it interesting that, when the students drew their system maps, all of them started by drawing the entrance to the MTR. Lisa realized that it was as if her students were playing out the journey they had recently taken in their minds. After they drew the entrance, they drew the "Octopus lady" who helped them pay for their tickets (in Hong Kong, people often pay MTR fares using an "Octopus" card), then they drew the signs that indicated directions to the underground platform, and so on. As they sketched their systems maps of the MTR, Lisa's students were able to identify all of the parts that were important to them as users of the MTR system. Students were also able to identify several people they felt were necessary for the smooth running of the MTR, including MTR staff members like the "Octopus lady," police officers, passengers, and train drivers. The longer they worked on their maps, the more they were able to talk with each other and remind each other of details they had missed, such as the ticket machine, the turnstile, the arrows on the floor, and the signs that indicate where each train is going.

Lisa was surprised at how thorough and logical her students were when thinking about their MTR systems maps. By drawing their maps as if they were taking a journey, they were able to remember many of the different parts and people that they had encountered during their outing—and whom they were likely to encounter the next time they rode the MTR. Lisa had presumed that they would start by drawing the train, as that is the most obvious part of the system, but they demonstrated far more sophistication when considering the MTR system. She reflected:

The children were so engaged, and the longer they worked on their systems drawings, the more details they could remember. We talked about the necessity of all the parts and people. They understood that by taking away any of the integral people or parts from the system, the MTR would not run smoothly.

THINK, FEEL, CARE

Next, Lisa wanted her students to think about how the experiences and needs of the various people involved in the MTR system might differ. She felt that this would prepare them for designing an improved MTR system later. She decided to use the *Think, Feel, Care* thinking routine which is designed to engage students in considering the perspectives of the various people who are associated with a system.

To begin, Lisa had her students revisit the systems maps they created. They chose two people they felt were important to the system: the train driver and a passenger. They then used the *Think, Feel, Care* thinking routine to talk about those peoples' roles, emotions, and motivations when engaging with the MTR system.

During the conversation that followed, students agreed that the train driver would feel happy that so many people were following the rules on the MTR, but that the driver might feel tired after driving the train along the same route so many times in a row. In an attempt to consider the train driver's prior experiences and motivations, they even speculated that the train driver probably wanted to drive trains as a young child.

Students disagreed, though, when they discussed the thoughts and feelings of the passenger. Most of the students said that they felt happy when riding the MTR, and reasoned that the passenger would feel happy, too, but one child said that sometimes he didn't feel happy on the MTR, because he got dizzy when the train went around corners too fast. This activity of reflecting on different participants in a system gave the students the opportunity to take another person's perspective and to understand that not all passengers experience the MTR in the same way. Lisa reflected:

The children showed interest and empathy towards this child as he talked about his experiences on the MTR. It was interesting to see the children assimilate this new knowledge into their own perception of the MTR. It showed them that different people can feel differently about the same experience — and even that the same person can feel differently about the same experience at different times. It was a really deep conversation for the children and it was so interesting to be able to watch them as their understanding and their own thinking evolved.

IMAGINE IF…

To wrap up the inquiry on the MTR, Lisa decided to have students use the *Imagine If…* thinking routine to invite her students to consider how to improve this system. This thinking routine prompts students to reflect on the motivations and needs of the people involved in a system as they imagine how they might change that system. Lisa felt that this was a natural conclusion to the work students had done exploring the complexity of the MTR system, and also could serve as a meaningful summative assessment in which Lisa could learn more about how they thought about systems.

Lisa gave the students photocopies of their original systems maps. She asked them to think about the discussion they had about the train driver and the passenger, and to remember all of the other people they had included in their maps. "How might you change the MTR system to make it better for these people?" she asked.

To indicate the changes students wanted to make in the system, students added color to the parts of their maps that they wanted to change. One student added a comfortable chair for the "Octopus lady." The issue of safety had come up in previous conversations, so children added additional video monitoring systems and signs to help provide even more safety in the MTR station. Originally, some students wanted to add a reclining seat for the train driver, but after discussion with other students, they realized that this might cause problems in the system if the driver fell asleep.

Student map of the MTR system indicating changes in color.

Students also brainstormed how they might change the train. For example, one child suggested adding extra chairs to the train—one chair for each passenger. The idea was that each passenger would be more comfortable. This suggestion prompted an interesting discussion in which the students realized that adding extra chairs would restrict the amount of people who could ride the train at one time. A counter-suggestion was to add more chairs but make the train faster so that it could return more often and then continue to shuttle as many passengers as possible during a shorter amount of time. However, the students remembered what their classmate had said the day before about feeling dizzy when the train went around corners too fast. They were concerned that a faster train would mean more passengers would

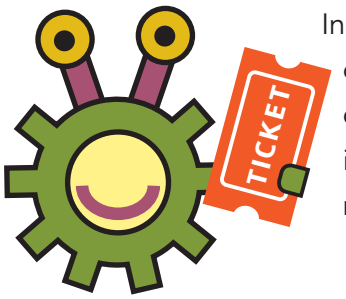
feel dizzy, so they decided to leave the speed and seating as is. Lisa reflected:

This kind of discussion led the children to consider compromises that they previously would not have thought of. It allowed them to see the MTR from the point of view of multiple users, and was an introduction to the idea that 'best' has to be best for everyone, not just for them.

CONCLUSION

Over the course of Lisa's systems thinking work, three themes rose to the surface.

1. Young learners can explore the parts, people, and interactions within systems, but it's important that they have experience with the system.



In Lisa's example, students had gone on a fieldtrip of various transportation options in their city and had a recent experience to refer to as they considered the MTR system. Whether working with tangible or intangible systems, having direct experience helps make the abstract notion of systems accessible to young learners. Lisa explained:

It really helped that the system was one that the children had physical experience with. If this had been an abstract thought process then I do not think that they would have been so successful. Giving them the opportunity to have a hands-on 'interaction' with the system allowed them to think more fully about it.

2. Young learners can learn to take other people's perspectives by drawing from their own experiences and the experiences of others within their communities.

To support this skill, it is necessary to give children the opportunity to reflect on their own experiences and listen to and learn from each other. Lisa wrote:

I think that it was crucial that while each child drew their own systems map, the children were sitting in a small group and had the opportunity to discuss their ideas together. This was the only way to open up the discussion of multiple perspectives.

I think that as the children heard other opinions from the people who held them, it made that understanding far stronger. They trusted their peers, and were able to develop empathy far easier than if I had just told them that other people have a number of differing opinions.

3. Young learners can imagine how to change real-world systems to benefit not just one person, but a broader community of people.

Given the opportunity to experience and reflect on the perspectives of individuals in different systems, young learners can be supported to imagine how to improve systems to address the needs and motivations of others. Lisa explained:

> *This is important as it is often thought that young children cannot see past their own motivations and needs. I think that for 6-year-olds to engage in these kinds of thought experiments shows how capable they are of conceptual understanding and systems thinking. By engaging in maker-centered learning this early in life, they will have the cognitive and social-emotional tools needed to collaborate with others throughout their lives.*

Reflecting on the entire experience, Lisa noted:

> *It was so exciting to see the children engaged in this kind of critical thinking. This was not an exercise that we had tried with the children before and I was amazed at the maturity and logic that they possessed. When I first encountered the [Agency* by *Design] thinking routines, I was not sure if our young students would be able to grasp them, but they showed me within a week how they could consider other people's points of view, and understand a large system within their own society.*

LOOKING CLOSELY BY JUXTAPOSING AND TAKING APART

Over the course of the 2018-2019 academic year, Ms. Shannon Chung explored how to use take apart activities to develop the maker capacity of looking closely with her 4-5-year-old students. She found that, through looking closely with peers and juxtaposing their experiences and insights, her students learned to look at objects and systems from different perspectives. This process led them naturally into exploring the complexity of the parts and purposes of objects and systems.

During this study, Shannon was a K2 Cantonese teacher at Victoria (Harbour Green) Kindergarten. Shannon has been in the field of early childhood education for 18 years. She described her school's curriculum as one that encourages students' learning in a way that cultivates excellence in reading and writing, develops critical thinking, nurtures creativity, and builds problem-solving skills.

Looking closely is one of the three core capacities of the Agency *by* Design framework for maker-centered learning. As Shannon described, "everything, every lesson, it should be look first. Look is the first step." Shannon believed that, in addition to observing and exploring the systems around them, looking closely could also encourage students to learn from one another. Shannon planned looking closely experiences in which she encouraged students to be curious about each other's work and to learn from one another, which connects to the Agency *by* Design framework's concept of co-inspiration.

To engage her students in looking closely, Shannon drew from the "juxtapose" and "take apart" making moves to create her own activities that invited students to look closely at different objects, their own lives, and their communities.

A student's daily routine wheel.

LOOKING CLOSELY: JUXTAPOSING DAILY ROUTINES

To enhance a unit in which students were discussing their responsibilities at home, at school, and in their community, Shannon invited students to look closely at how they spend their time each day. What do they do as part of their daily routine? Shannon had students bring in photographs from home depicting them engaged in each of the activities they

did each day. Then, each student sorted their photographs chronologically, and then made a "Daily Routine Wheel" that displayed their activities using a layout similar to that of a clock.

After everyone had made their Daily Routine Wheels, Shannon had students work in pairs to juxtapose their daily routine with one another. They explained to their peer what they did as part of their daily routine, using the photographs as a guide.

Student A: In the morning I wake up early in the morning, and I brush my teeth by myself. After breakfast, I will go to school.

Student B: During holiday, I will attend a lot of interesting classes and my parents play with me on Saturday and Sunday.

Two students share their daily routines with each other.

Students were excited to share their experiences, but they were equally interested to look closely at their peer's daily routine and to ask questions about each other. In this way, students explored the complexity inherent when two people have different experiences and perspectives.

Shannon observed that, throughout this activity, there was a high level of discussion among students. They were happy to discuss their daily routines with peers and could do so without adult support. Shannon felt that, as a result of this activity, her students understood that everyone has a different daily routine and, therefore, a different perspective. She felt that this activity helped students develop a deeper understanding of their world because they were able to learn from one another.

LOOKING CLOSELY: TAKING APART CLOCKS

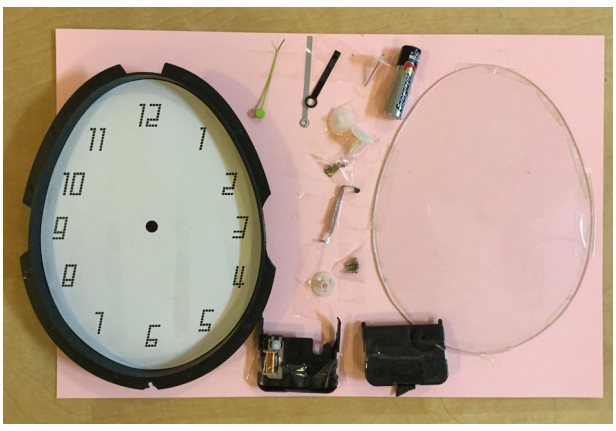
Shannon wanted to build on her students' experiences with looking closely to begin exploring the complexity of objects. Shannon decided to take apart a clock because she realized that students' daily routines were closely related to time, and she saw the opportunity to engage her students in understanding the concept of time by exploring how we use clocks to mark time. To do so,

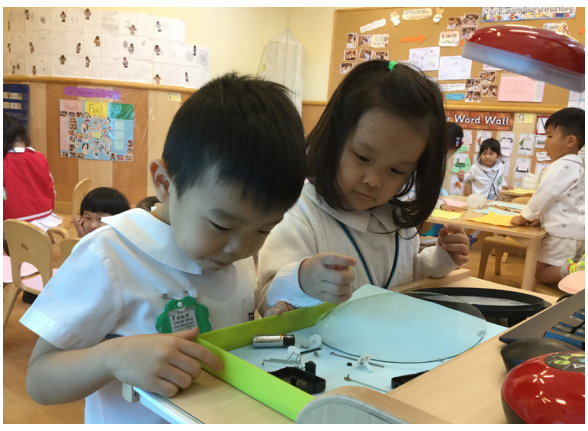
Shannon led her students through a Take Apart activity in which they dismantled a clock, looked closely at its parts, and explored how the parts interacted with each other.

Students make an observational drawing of the clock.

Students made observations of the clock before it was taken apart, and after, through observational drawings. Before they took the clock apart, the class predicted what was inside the clock and what the different parts of the clock might look like. The students then took apart the clock and explored its components using tools like screwdrivers and magnifying glasses. As they did, they discovered the different parts that made up the inside of the clock. As a class, they explored the clock's complexity by discussing how each part of the clock was important and had a purpose.

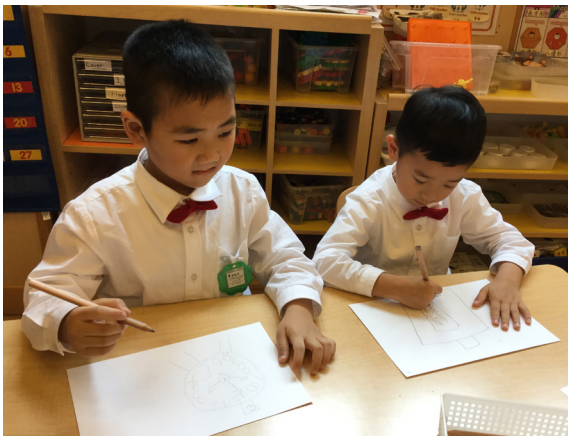
Throughout the process of taking apart a clock and making observational drawings, students had multiple opportunities to share their work with one another. They learned that a clock is made up of different parts which are all needed in order for the clock to function. They were able to look closely at details and share with one another what they noticed. Shannon recognized that there were some limitations to taking apart objects with her students. With the lack of refined motor skills at this age, students often had difficulties using tools like the screwdriver to unscrew the smaller screws inside the clock. For that reason, Shannon felt that teacher support was essential with this group of young learners.





Students look closely at the parts of the clock.

As students gained an understanding of the parts, purposes, and complexities of the clock, they shared that they wanted to make clocks for the classroom. Shannon led a discussion about the appearance and the function of different clocks to help students understand that not all clocks are the same. She also had her students do some research on real clocks, paying attention to how they worked and what they looked like. Recognizing the importance of providing opportunities for students to learn from each other, Shannon had students work in small groups to make their clock.

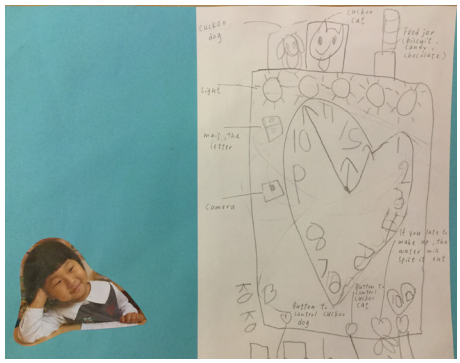


Students brainstorm the design of the new class clock.

First, students sketched ideas, borrowing some ideas from clocks they had observed during their research. One group, for example, inspired by the cuckoo in the cuckoo clock, designed a clock featuring lots of different animals. Students worked well together throughout this process and were proud of their work as a group. They respected their peers' ideas, and they enjoyed sharing their clock designs with the class. Students' sense of maker empowerment became evident when they were able to hack existing clocks to make them reflective of their own designs.

Shannon's experience in her classroom demonstrated the importance of teachers providing students with opportunities to look closely and to engage with each other's work. She reflected:

> *This is really unexpected. They are just four years old and can draw with a lot of detail. When they're recording, when they're looking closely before and after, when they're taking apart things. For me, this is so amazing.*



One student's design of the class clock.

Shannon shared that the early childhood classroom should be built upon an environment of positive appreciations. Shannon strongly believed that everyone's ideas were creative and unique and that we must respect and appreciate each other—which fosters deeper thinking and the creation of new ideas.

CONCLUSION

Throughout Shannon's work on looking closely, two themes emerged:

1. Looking closely through juxtaposing and taking apart activities is appropriate for young learners.

Shannon's 4-5-year-old students engaged in the maker capacity of looking closely with minimal adult support. Using techniques such as juxtaposing with peers or taking apart a physical object worked well with this age group and led them into exploring the complexity of how things work and the complexity of different perspectives.

2. Peer-to-peer learning supports student learning as they look closely.

Shannon gave students time to share with one another, first in small groups, then in larger groups. These reflective moments promoted an environment where Shannon's students could admire each other's work—so that when they engaged in the next making activity, they could build on each other's ideas.

我的後感：

認識Project Zero有一年多的時間了，由開始學習的至今，我覺得個人思想意識成長了，對課程課程思維更清晰，喜歡它的思維模式（Thinking routines）；喜歡它多角度觀看事物，喜歡它將系統牽引著學習者對各持份者在系統中的關係進行分析，以致學者會思考系統中不同持份者的觀點和關愛不同層面的人；喜歡它帶領學習者由外而內深入探討，以致微細了解物件的每一部分及其功用，讓學習者了解部件與組件中的關係；喜歡它能富予學習者空間想像成設計師，怎麼能令物品設計更完美、給人帶來方便；更喜歡它能讓學生作為主導，他們能自主計劃、設計以致動手製作作品，這一切的得著都確實令我和我的學生成長了。

對於4–5歲年齡層學生，開始的時候宜運用較簡單的仔細觀察（Looking closely）思考模式，讓他們了解，並於平常鼓勵學生運用這個思維模式從不同的角度對物件進行觀察物件的特徵和結構，使他們明白仔細觀察的意思，待幼兒懂得運用仔細觀察的技巧對物件進行觀察後，可嘗試與學生一起拆解物件以了解組件和內部結構，當中能讓學生部件的重要性和部件之間的關係，進一步延伸可深入探討物件的複雜性和如何利用設計去優化物件，使之更美觀、更有效、和更具功能性。不過，教師在讓學生明白理解他人感受和系統之間的關係時，由於學生的年齡發展尚未成熟，他們難於明白他人（第三者）的感受，需要透過圖像和遊戲幫助學生明白較概抽象的概念，所以教師在教導學生

明白系統和了解他人感受時在適時需加上協助。

從推行的過程中，可見學生透過觀察、記錄、匯報、分享的過程中，他們對課題有更深入的了解，學習時更投入、更主動和自信，當中，他們透過伙伴合作中能夠學習到不同範疇的知識，例如：從發表中認識到不同人有不同的意見，從分享中認識到自己與他人不同的思維，從聆聽中吸取到不同人的意見，獲得經驗的累積，使之在學習創作的過程中更具能動性，希望學生在往後的學習旅程中能激發更多的新思維。

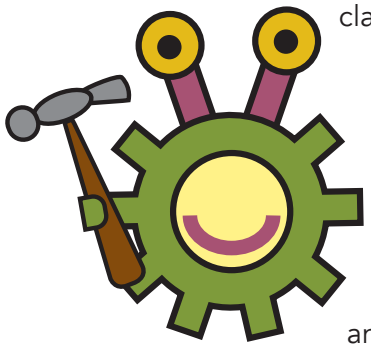
[translation] *From the beginning of this learning journey with Project Zero to now, I see the growth in my personal thinking and knowledge, especially around the framework and ideas of maker-centered learning. I like the thinking routines of maker-centered learning. I like the way that this framework encourages you to look at multiple perspectives when observing an object or person. I like that maker-centered learning uses systems to lead learners into a deep analysis of the intricacies within our designed world, and from that, to think about the different roles and perspectives one holds within a system. I like that this framework leads learners from the outside to the inside, as they look closely at every part and its purposes and from that, understand the connections between them. I like that this framework provides the space for learners to be designers and think about how they can make designed objects more beautiful and more convenient. I like that this framework allows learners to be the main directors of their learning and provides them with agency to develop and design, and from that, make for others. I am convinced that engaging with maker-centered learning has provided me and my students growth in our learning.*

Two students work together to decorate their clock according to their design. Together, the class created several different clocks.

For learners aged four and five, I found that using looking closely with them initially encouraged them to observe objects from different perspectives. Looking closely eased younger learners into looking at an object's parts and purposes, which helped them understand what it means to look closely. As young learners got acquainted with skills to look closely, I found that taking apart the objects with students allowed students to understand the importance of each of the parts and how they are all connected. Taking apart objects provides a step into a deeper investigation of the object's complexities—further prompting young learners to think about how they can make the object more beautiful, more effective, and more efficient.

As we were implementing maker-centered learning, I saw that students had a deeper understanding of the topics we were learning about as they learned to observe, document, discuss, and share. I discovered that students are more involved in their learning, and they showed agency and confidence. Within all of that, I saw that peer-to-peer learning elevated their learning experiences. From sharing with one another, students learned that different people have different opinions. From this understanding, they learned that they also have very different ways of thinking than others. From listening to others, they were able to absorb a wide array of opinions, accumulate experiences, and develop agency through this journey of learning and creating. I hope that my students are able to continue with their learning and thinking in various arenas!

TOOLS AND RESOURCES



The teachers had lots of cool ideas for adapting maker-centered learning into their classrooms—from using child-friendly language to express complex ideas to creating entire sociodramatic play areas to foster perspective taking. In this section, the research team shares some tools and resources inspired by the work of their teacher colleagues. You can use these tools and resources as they are—or hack them and make them your own!

NEW (AND ADAPTED) PEDAGOGICAL TOOLS AND RESOURCES

Developing new tools and strategies for educators who work with young learners was one of the core objectives of the Agency *by* Design: Early Childhood in the Making project. Throughout the Agency *by* Design: Early Childhood in the Making pilot study, we collaborated with our teacher colleagues in Hong Kong to test the thinking routines and resources developed through the original Agency *by* Design project. While teachers appreciated the original thinking routines and other pedagogical resources, they also found that amending certain aspects of these tools could better suit their young learners, as well as the cultural context of Hong Kong.

As a result, many teachers from the cohort started adapting and hacking the original resources to make them more suitable for the young learners in their classrooms. We then worked closely with the teachers to develop the tools presented in this section. These tools include adaptations of the original Agency *by* Design thinking routines, Chinese translations of the original thinking routines, tools to support role play and systems mapping, and a planning tool designed to support educators in hacking and tinkering with other existing Agency *by* Design tools.

The structure for most of these pedagogical tools and resources is similar — the first page of the tool outlines the resource in broad strokes, whereas the second page of each tool offers additional information about the purpose of the tool, along with tips about when and how to use that tool. Each tool indicates which of the three maker capacities the tool was designed to support.

Though these pedagogical tools and resources have been carefully developed through an iterative process, they are also meant to be modified, adapted, and tweaked to suit each educator's unique students and educational setting.

PARTS, PURPOSES, COMPLEXITIES

LOOKING CLOSELY

Parts

Purposes

Complexities

Choose an object or system and ask:

What are all of its parts?

Why do we use the object or system? What does it do? What does each part do?

How do the parts work together to make something happen? What would happen if a part were missing or changed?

PARTS, PURPOSES, COMPLEXITIES

What Kind of Thinking Does This Routine Encourage?
This routine encourages learners to slow down and make careful, detailed observations as they look beyond the obvious features of an object or system and think about how it works. This thinking routine can help foster curiosity as children notice details, ask questions, make connections, and identify topics for future inquiry.

When and How Can I Use This Routine?
You can use this thinking routine to explore any object or system. You may choose to introduce the entire routine at once, or you may choose to break it down into parts over multiple occasions.

- This routine provides an opportunity for children to make their thinking visible. Children can show their thinking through drawings, photos, role play, and/or writing.

- If you are using this thinking routine with young learners, consider having them explore an object or a system they have direct experience with. This way, all children can apply and build upon their prior knowledge in meaningful ways. We suggest you start with objects or systems in your classroom or community that students use regularly.

- Help children develop their language and literacy skills by encouraging them to work together and to discuss what they notice with a partner. Consider creating a class word wall of descriptive language that the class can use and add to over the course of the school year.

- To encourage children to deepen their understanding of the parts, purposes, and complexities of the object under study, have them take apart the object. Then, repeat the thinking routine while looking closely at the separate parts.

- You may realize, as you engage with this thinking routine, that the system you have selected is more complicated or abstract than you originally thought. This is okay. Help students look closely at the parts that they are interested in, and feel free to help them seek more information by asking each other, by using books or the internet, or by consulting with community members. It is okay if students have unanswered questions about the system. Consider documenting these questions to revisit if the opportunity presents itself later on.

Note: This thinking routine is adapted from the Agency *by* Design *Parts, Purposes, Complexities* thinking routine.

PARTS, PEOPLE, INTERACTIONS

EXPLORING COMPLEXITY

Parts

People

Interactions

Choose a system and ask:

What are the parts? What do they do?

Who are the people? What do they do?

How do the parts and people work together? What would happen if a part (or a person) were missing or changed?

PARTS, PEOPLE, INTERACTIONS

What Kind of Thinking Does This Routine Encourage?

This routine encourages learners to slow down and look closely at a system. It helps them notice that there are different people who participate in the system and that they participate in different ways. It also encourages students to explore how one change in a system can impact the rest of the system. This thinking routine can help foster curiosity as children notice details, ask questions, make connections, and identify topics for future inquiry. It also helps children practice systems thinking.

When and How Can I Use This Routine?

You can use this thinking routine to explore any system. You may choose to introduce the entire routine at once, or you may choose to break it down into parts over multiple occasions.

- If you are using this thinking routine with young learners, consider having them explore a system they have direct experience with. This way, all children can apply and build upon their prior knowledge in meaningful ways. We suggest you start with systems in your classroom or community that students use regularly.

- Systems are made up of subsystems, and are themselves parts of broader systems. In order to avoid going down the rabbit hole of "everything is connected to everything," it may be helpful for you to encourage your students to define the boundaries of their system.

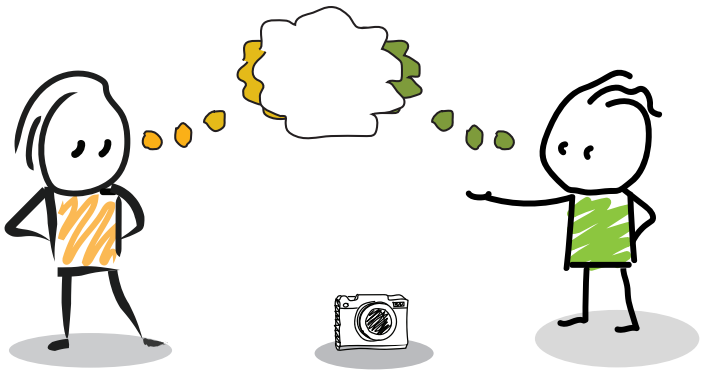
- This routine provides an opportunity for children to make their thinking visible. Children can show their thinking through drawings, visual mapping, photos, role play, and/or writing.

- You may realize, as you engage with this thinking routine, that the system you have selected is more complicated or abstract than you originally thought. This is okay. Help students look closely at the parts that they are interested in, and feel free to help them seek more information by asking each other, by using books or the internet, or by consulting with community members. It is okay if students have unanswered questions about the system. Consider documenting these questions to revisit if the opportunity presents itself later on.

Note: This thinking routine is adapted from the Agency *by* Design *Parts, People, Interactions* thinking routine.

MY PERSPECTIVE, OTHER PERSPECTIVES.

EXPLORING COMPLEXITY



Choose an object or system and ask:

My perspective

Have you ever used this? Why did you use it?
What do you like about it? Why?
What do you dislike about it? Why?
How would your life be different if you couldn't use this?

Other perspectives

Who else uses this? Why do they use it?
What do you think they like about it? Why?
What do you think they dislike about it? Why?
How would their life be different if they couldn't use this?

MY PERSPECTIVE, OTHER PERSPECTIVES

What Kind of Thinking Does This Routine Encourage?
The routine helps students explore complexity by encouraging them to consider that people may have different experiences with and perspectives on the same object or system. This routine also encourages students to think more carefully about how the object or system impacts their lives and the lives of others.

When and How Can I Use This Routine?
You can use this thinking routine to explore any object or system. You may choose to introduce the entire routine at once, or you may choose to break it down into parts over multiple occasions.

- This routine provides an opportunity for children to make their thinking visible. Children can show their thinking through drawings, photos, role play, and/or writing.

- If you are using this thinking routine with young learners, consider having them think about an object or a system they have direct experience with. This way, all children can apply and build upon their prior knowledge in meaningful ways. We suggest you start with objects or systems in your classroom or community that students use regularly.

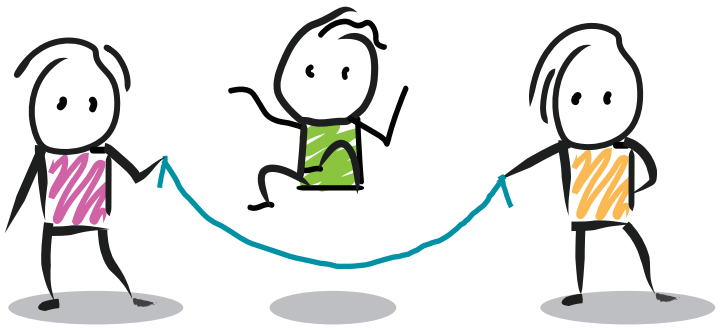
- When possible, encourage students to gather information about other people's perspectives. For example, students might conduct interviews of people who use the object or system, observe people using the object or system, or use the internet or books to research specific perspectives.

- Consider using this thinking routine along with the *Think, Feel, Care* thinking routine to help children practice taking other people's perspectives.

Note: This thinking routine is adapted from the Agency *by* Design *Parts, Perspectives, Me* thinking routine.

THINK, FEEL, CARE

EXPLORING COMPLEXITY



Think

Feel

Care

Choose a system that involves several people. Select one person from the system and ask:

What does this person do in the system? How do you know?

If you were this person, how would you feel? Why would you feel that way?

If you were this person, what would you care about? What would be important to you?

To help children think about different perspectives, choose a different person from the system and ask the questions again.

THINK, FEEL, CARE

What Kind of Thinking Does This Routine Encourage?

This routine encourages students to consider the diverse perspectives that different people within a particular system may have based on their role in the system. This routine fosters perspective taking and can help children generate new questions and/or ideas about the system, how it works, and how it might be improved.

When and How Can I Use This Routine?

You can use this thinking routine to explore the perspectives of anyone within a system. You may choose to introduce the entire routine at once, or you may choose to break it down into parts over multiple occasions. Though you can use this thinking routine on its own, we suggest you use it in combination with other Agency *by* Design thinking routines that encourage students to look closely and carefully explore the parts and purposes of the system they are working with.

- If you are using this thinking routine with young learners, consider having them think about a system they have direct experience with. This way, all children can apply and build upon their prior knowledge in meaningful ways. We suggest you start with systems in your classroom or community that students use regularly.

- You may also use this routine to explore the interactions presented in a fictional story. Children can explore the different perspectives of the characters based on their different roles in the story.

- Consider having children engage in this routine through role play, with each student portraying a different person in the system. Once students portray someone one way, have them try to portray the same person in a different way. This can help children understand that, even within particular groups of people, there is no one set perspective, but rather an array of possible perspectives.

- Students will likely draw on their assumptions about the various people in their system. Consider discussing where these assumptions come from. You can encourage students to challenge their assumptions by asking them what they really know about someone else's perspective, and what they could do in order to find out more about someone else's perspective. For example, they could conduct interviews with someone in that role, seek out more information using the internet or books, or even find ways to experience that role themselves.

- Encourage students to notice that not everyone in a system feels the same way or cares about the same things. Have them talk about this. Why might different people have different perspectives? What problems might arise because of this? What might be some benefits of this?

Note: This thinking routine is adapted from the Agency *by* Design *Think, Feel, Care* thinking routine.

IMAGINE IF...

FINDING OPPORTUNITY

Choose an object or system. Ask questions such as:

How could you make it **more effective?** *(work better)*

How could you make it **more efficient?** *(easier to use; faster to use)*

How could you make it **more ethical?** *(better for the community; easier to share; safer; more fair)*

How could you make it **more beautiful?**

How could you make it _____?

IMAGINE IF…

What Kind of Thinking Does This Routine Encourage?
This routine encourages divergent thinking by prompting students to think of new possibilities for an object or system. It can also encourage convergent thinking by giving students a basis from which to narrow down their ideas so they can redesign or hack an object or a system. Ultimately, this thinking routine is about finding opportunity and pursuing new ideas.

When and How Can I Use This Routine?
You can use this thinking routine to explore any object or system. Though you can use this thinking routine on its own, we suggest you use it in combination with other Agency *by* Design thinking routines that encourage students to think more deeply about the object or system they are working with.

- This routine provides an opportunity for children to make their thinking visible. Children can show their ideas through drawings, role play, and/or writing.
- If you are using this thinking routine with young learners, consider having them think about an object or a system they have direct experience with. This way, all children can apply and build upon their prior knowledge in meaningful ways. We suggest you start with objects or systems in your classroom or community that students use regularly.
- Help children develop their language and literacy skills by facilitating class discussions and/or by encouraging them to brainstorm and share ideas with a partner.
- This thinking routine asks students to imagine how to make an object or system "more ethical." You will likely need to define "more ethical" for young learners by narrowing the scope of the term (for example, replacing "more ethical" with "better for the community" or "better for the environment"). When doing this, consider drawing upon your school community for guidance to ensure that you are focusing student thinking in ways that support the ethical behaviors that your school community is working to promote.
- To prepare children for using this thinking routine, consider using the *Think, Feel, Care* thinking routine. This will help children think about the desires and needs of people within the system, which will give them the background they need to imagine ways to improve the system for these people.

Note: This thinking routine is adapted from the Agency *by* Design *Imagine If...* thinking routine.

“深入拆解”的思考模式

仔細觀察

選擇一樣物品或者一個系統，然後提出以下問題:

組件

它的組成部分是什麼？

它有哪些不同的部分和組件？

用途

它有什麼用途和作用？

每個組件的用途是什麼？

關聯性

它們之間的關聯性是什麼？

細心觀察它的組件和功能，兩者之間有怎樣的聯繫？

“深入拆解”的思考模式

這個思考模式鼓勵的是什麼思考元素？

這個思考模式通過讓學生慢慢、細心地觀察物件和系統中的細節，鼓勵他們不止觀察物件的表面特徵，更重要的是了解其內部運作。這個思考模式可以激發學生的好奇心，鼓勵他們勇於提出問題，並且能做更深入的研究。

這個思考模式什麼時候使用？

這個思考模式可以用於探討物件或者系統。它可以單獨使用，也可以結合其他一起使用。以下是一些使用這個思考模式的具體用法:

- 這個思考模式讓學生通過畫出物件和系統不同的組件及組成部分、建立清單、說明設計理念以及其中的複雜性，而使思維變得更清晰。你可以同時使用三個要素，也可以每次只使用一個。

- 如果學生選擇要研究的是一件具體可見的物品，學生可能不需要太多的背景知識。但是，如果學生要探究的是一個系統，比如：“民主”，那學生有可能要多做一些背景調查，老師也可以給學生機會反思他們和這個系統互動的經驗，這樣會對學生的研究有所幫助。

- 如果想把這個思考模式發展到更深層次，在學生思考部件、用途和複雜性之後，讓學生真的把物件拆開，然後繼續觀察其中的部件、用途和關聯性，並且用不同的顏色標註出來。

- 你也可以將“關聯性”換成更容易理解的用語，比如難題、未了解的地方或“我想知道的事情”。

“深入拆解”的思考模式是翻譯及改編自Agency by Design的 Parts, Purposes, Complexities思考模式。

“聯系互動”的思考模式

探究系統內部的關聯性

想像代入任何一個系統然後提問以下問題：

組件

這個系統有什麼**組成部分**？

人

這個系統是由有哪些相關的**人**聯繫著？

互動

系統裡的人是如何和其他人**互動**，而這些人如何和系統中各個組成部分產生互動和交流？

當系統裡其中一個元素出現變化，這變化會如何影響到系統的各個部分和人物？

“聯系互動”的思考模式

這個思考模式鼓励的是什麼樣的思考？

這個思考模式鼓勵學生能夠慢下来，仔细觀察其中一個系统。通過這樣幫助學生更好地認識具體系統裡無論是直接或間接相關的人物，學生也會注意到系统裡任何一點變化，也许都會有意無意地影響到系统的其它方面。當開始思考系統裡的组件，人物以及其中的互動時，學生會開始注意到系统裡面其實也有多個副系统。這個思考模式幫助激發學生的好奇心，提出問題，明確下一步研究的方向，以邁向系统性的思考。

這個思考模式可以在何時，怎麼使用？

這個思考模式可以用來探索任何系统。它可以單獨使用，也可以结合其它思考模式一起使用。以下是一些使用這個思考模式的具體例子：

- 在開始使用這個思考模式前，先带领學生清楚地理解什麼是系统。提供系统書面上的定義雖然會有幫助，但如果可以舉一些具體的例子會更有效，例如：地鐵系統，居住地區的回收系统和学校里的午餐排队系统等。

- 為了使用這個思考模式，學生需要確定一個他們要探索的系统。其中一個方法是讓學生選出一個物品並思考與其相關連的系统。比如，一張郵票可以與一個郵政系统聯繫起来，一個自行車頭盔可以和交通系统聯繫起来。

- 鼓勵學生說出他們想要探索的系统名稱。對於有些學生來言，要具體說出他們想要探索的系统可能有些難。老師可以借此機會重新讓學生對系统定義、或者關於系统的具體例子達成共識。隨後，再問學生他们定義的系統是不是符合前面談到的那些條件。

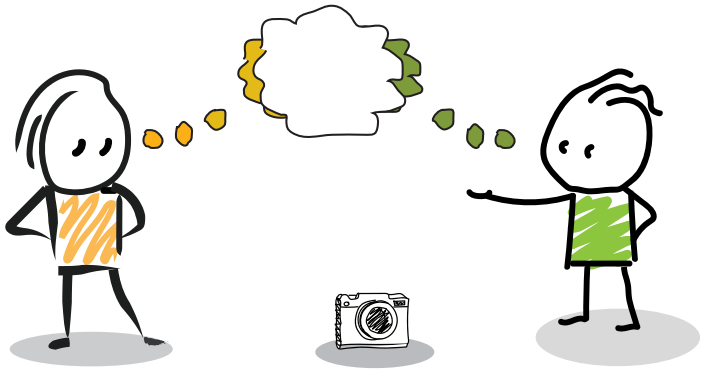
- 系统是由很多副系统组成的，同时他們也是屬於更大的系统的一部分。為了避免鑽進牛角尖，鼓勵學生定義系统的範圍會對運用這思考模式有幫助。

- 可以讓學生分组，列出一個系统裡所有组件和人物的清單，然后在圖纸上畫出這個系统，讓系统裡所有组件和人物之間的互動變得更具體。

“聯系互動”的思考模式是翻譯及改編自Agency by Design的 Parts, People, Interactions 思考模式。

“另眼相看”的思考模式

探究系統內部的關聯性



想像代入任何一個系統角色或物件本身然後提出以下問題：

組件

這個系統或物品有什麼組成部分？
它有哪些不同的部分和組件？

觀點角度

你可以從什麼角度來觀察它的組成部分？
嘗試用不同的使用者的角度去觀察此系統或物品。

我

你跟這個系統或物品有什麼關聯？
你跟系統或物品有什麼聯繫？

Early Childhood in the Making | Agency *by* Design
Adapted from the Exploring Complexities Project
Project Zero | Harvard Graduate School of Education

“另眼相看”的思考模式

這個思考模式鼓勵什麼樣的思考呢？

這個思考模式通過幫助學生近距離觀察某個物品/系統的細節，考慮不同的使用者和利益相關者不同的觀點角度，以反思自己和這個物品/系統的關係來探究其中的關聯性。

這個思考模式可以用於什麼地方？

它可以用於任何物品/系統。尤其適用於有很多組成部分並且可以進行拆解的物品，以及有很多不同的角色參與的系統，比如提供資源或管理資源的系統、社會系統、組織系統、交通系統或政府統治系統等。這個思考模式的三個要素可以在同一時間介紹給學生，但每個步驟會鼓勵不同類型的思考模式，因此清楚解釋每一個步驟的思考模式會對學生有幫助，同時，也允許學生在每個步驟中花時間琢磨和鑽研。

對探究組件的步驟，有沒有一些建議？

給學生足夠的時間去看或者去體驗物品或系統。如果是面對一個具體的物品，學生可以對其進行現場素描，或者畫個示意圖。如果可以的話，他們還可以動手將其拆開，然後仔細觀察其中的各個部件。（動手拆解物品–從門的把手到舊的家用電器到玩具–　都是幫助學生近距離觀察物品的有效做法。）

對探索觀點與角度的步驟，有沒有一些建議？

鼓勵學生從不同的角度去看，比如拉近看，拉遠看，或者採用鳥瞰視角。鼓勵學生發揮想像，思考不同角色會如何與這個物品/系統產生關聯；什麼樣的人參與了製造？什麼樣的人會受其影響？什麼樣的人關心它？如果可能的話，鼓勵學生收集其它人的觀點，比如去採訪一些人或者做研究。

對“你跟這個系統或物品有什麼關聯？”的步驟，有沒有一些建議？

鼓勵學生思考自己或者認識的人的生活跟該物品或系統有什麼樣的接觸，鼓勵他們考慮任何相關的感受、假設、關係、信仰、態度或者任何學生能想到的關聯。

當使用這個思考模式的時候，學生的思考過程如何可以更明顯可見？

從寫下組件的名字開始，學生可以通過創造清單，素描，製作圖表的方式讓思維可見。

“另眼相看”的思考模式是翻譯及改編自Agency by Design的 Parts, Perspectives, Me 思考模式。

“換位思考”的思考模式

探究系統裡縱橫交錯的關係

想像代入任何一個系統

選擇在同一個系統裡的不同人物或事物，從不同的角度去觀察系統的各部分，然後嘗試代入系統中的角色去理解系統中不同角色的感受以及對價值觀的關心。

思考

思考：這個人物或事物會如何理解這個系統，他/她/它在系統裡的角色是什麼？

感受

感受：這個人物或事物在系統裡的角色會有什麼樣的感受？

關心

關心：這個人物或事物在系統內的價值觀是怎樣的，他/她/它存在的重要性和行為目的是什麼？站於這個人物的角度來看，有什麼是重要的？

“換位思考”的思考模式

這個思考模式鼓勵的是什麼思考元素？

這個思考模式鼓勵學生在一個特定的系統裡思考不同人物的觀點。其目標是幫助學生理解系統裡的不同角色，他們會用什麼形式去表達感受以及對系統裡其他人物和事物的關心。這個思考模式引導學生從多角度去提出問題並表達觀點。

這個思考模式什麼時候使用?

這個思考模式可以用來探索系統裡任何一個人的觀點與角度。它可以單獨使用，也可以結合其他思考模式一起使用。以下是這個思維模式的一些具體用法。

- 以個人或小組的形式，讓學生通過情景設計演繹系統裡面不同的人物和角色。學生可以代入系統中的任何角色去表達不同觀點及視角。

- 在學生描繪系統裡的一個角色後，老師可以建議學生用另外一種方法來表達這個角色。目的是讓學生了解即便是一群人，也有多於一個觀點和角度。

- 老師可以鼓勵學生們理解系統裡每一個人的思考模式，比較有何異同。當不一致的時候，系統裡的人可以用什麼方法解決矛盾以獲得平衡。關於系統裡不平等的權力結構可能會在討論中出現。

- 雖然這個思考模式鼓勵學生代入別人的觀點和視角，可是也需要提醒學生們，我們無法完完全全地了解別人的想法。當使用這個思維模式的時候，學生應該代入具體人物的真實生活經驗來去除個人偏見。鼓勵學生去演繹具體的人物（比如茱莉，一個外科醫生；約翰，一位小學數學老師；馬丁，一位環保人士）而不只是某種類型的人物。

- 採取某種觀點的時候，學生有可能會偏向設想系統裡不同類型的人物而將人物不必要的定型。當你察覺學生開始有這樣的討論，你可以帶領學生討論這些假設性的根據，並鼓勵學生們去挑戰自己的假設。老師可以通過提問學生作出假設的原因，讓學生反思到人物不同的觀點和需求，務求讓學生將不必要的假設刪掉。

“換位思考”的思考模式是翻譯及改編自Agency by Design的 Think, Feel, Care 思考模式。

“推進創新”的思考模式

尋找機會

選擇一個物品或系統：

思考它的組成部分和用途，還有與它互動的人或系統，然後提問：

這個物品/系統怎麼可以被設計得**更有效能**？

這個物品/系統怎麼可以被設計得**能提高工作效率**？

這個物品/系統怎麼可以被設計得**更美觀**？

這個物品/系統怎麼可以被設計得**更有道德和人性化**？

這個物品/系統怎麼可以被設計得**更切合人民社會的需求**？

“推進創新”的思考模式

這個思考模式鼓勵我們怎麼思考？

這個思考模式鼓勵學生從多方面思考，為一件物品/系統思考各種新的可能性。然後再鼓勵學生把新想法融合起來，決定一個有效率的方法去完善，重新設計，和拆解物件/系統。最終，這個思考模式是用於尋找新的設計機會以及實施新的想法的。

這個思考模式可以在何時，怎麼使用？

這個思考模式可以被用於探索實驗、改造、完善任何物品/系統的可能性。雖然這個思考模式可以單獨使用，但我們強烈建議它與其他Agency by Design 的思考模式一併使用，這樣可以更完整地讓學生了解改善具體的物品/系統的方法。當使用這個思考模式時，可以參考以下幾點建議：

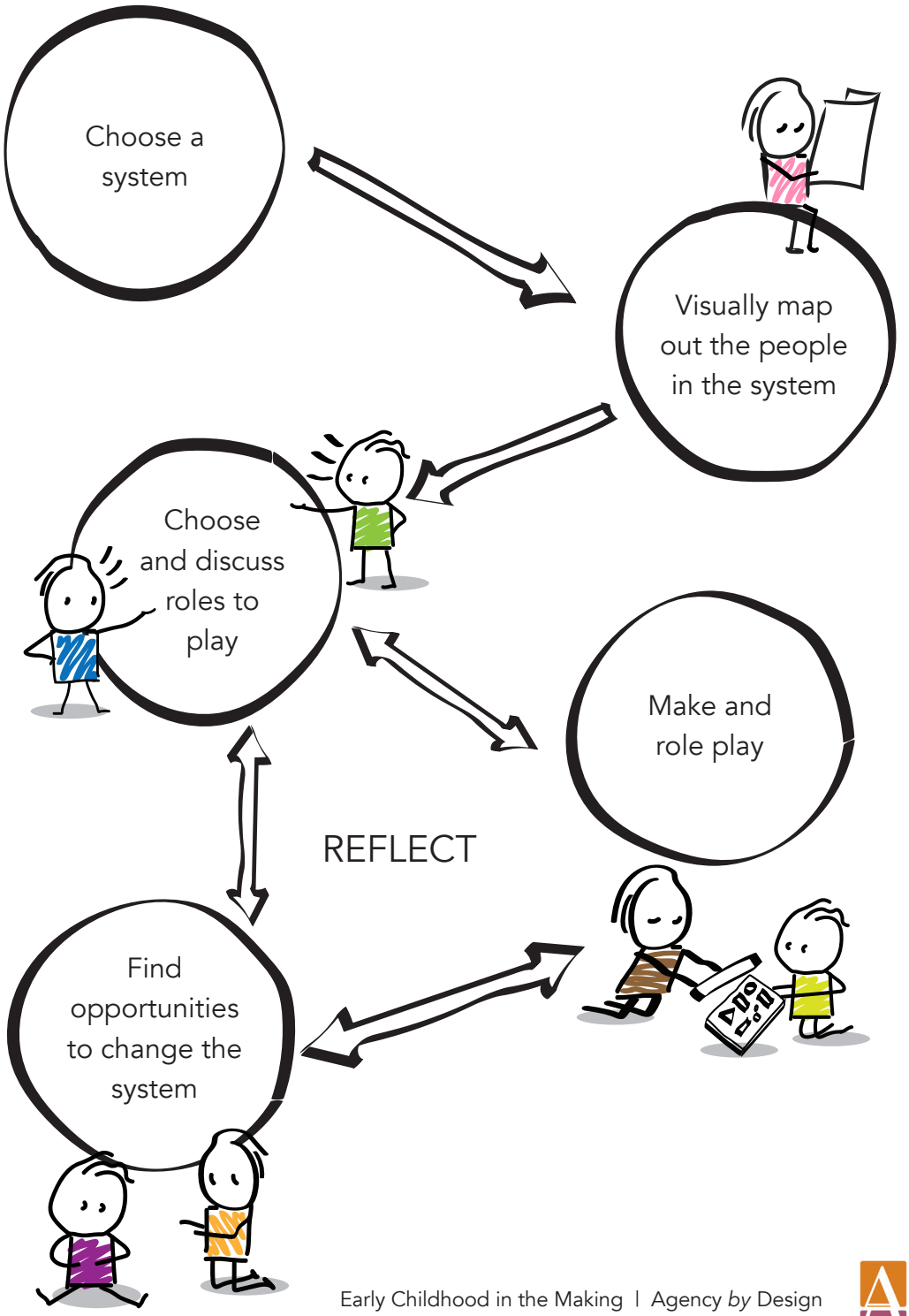
- 這個思考模式讓學生透過四種不同的角度來想像新方法去改善一個物品或系統。具體來說，可以通過就這個物品或系統提問：例如，它如何可以被設計得更有效，提高效率，更符合社會規範或者更美觀。雖然這四個角度會幫助思考，但我們也鼓勵你和你的學生能從其他的角度去思考。

- 當使用這個思考模式的時候，老師們可能會很自然的告訴學生，想像是無限制的。事實上，雖然讓學生天馬行空地想像很重要，但如果能給想像加上一些創造性的限制，對學生可能會更有幫助。例如，給學生提供特定的工具和材料，提供一些具體功能的條件，或者界定具體的人群或者使用者。比如，在一個椅子的設計活動中，學生可能被告知他們只能使用紙板或者文件夾，新的椅子模型要能夠支撐教師的重量，以及他們的椅子是為了地鐵的乘客使用而設計的。

- 當思考如何改造或者重新設計一個物品或系統時，看見學生發揮無窮的想像力是讓人很興奮的事情，但讓學生對他們設計的物品或系統保持設計上的敏感度也是很重要的。我們建議老師讓學生回想Agency by Design其他的思考模式，在過程中學生們可尋找新的可能性。同樣地，如果學生在產生新想法時猶豫不決，學生可回想Agency by Design 其他的思考模式，這樣也可以幫助他們找到新的機會和新的可能性。

“推進創新”的思考模式是翻譯及改編自Agency by Design的 Imagine If 思考模式。

PLAYING AROUND WITH ROLES



Early Childhood in the Making | Agency *by* Design
Project Zero | Harvard Graduate School of Education

PLAYING AROUND WITH ROLES

Engaging young learners in exploring complexity and finding opportunities to make systems better requires perspective taking and empathy. Role playing can be a powerful approach to support learners in taking others' perspectives when exploring the roles, ideas, and feelings of different characters in a system. Here we offer a few thoughts on how to leverage children's natural desire to play and how to employ different thinking routines to foster perspective taking and empathy. This tool is intended as a starting point and does not need to be followed step by step or happen all at once. We suggest that points 3-5 below be iterative. Teachers should feel free to adjust this tool to meet their needs and the needs of their students.

1. **Choose a system that is familiar to the learners.** Children are able to draw from their own experiences to imagine someone else's experiences and perspectives. Therefore, using a system that is familiar to them can be an effective way to invite their perspective taking and empathy. For example, if your students have daily experiences with public transportation, you might select the local transportation system.

2. **Visually map the system.** Visual representations are helpful for young learners to keep the different parts, members, and interactions of the system in mind and serve as a reference point during their role-play. You can use the *Parts, People, Interactions* thinking routine or facilitate an open conversation with learners to identify the specific parts, people, and interactions within a particular system. You can also use the *Mapping Systems Experiences* tool. The important thing is to make it visual. For example, if representing a transportation system, students can draw a transportation hub and visually identify the trains, passengers, conductor, ticket sellers, etc.

3. **Choose and discuss roles to play.** Assign or allow students in small groups to choose a member of the system they will play. In their small groups, they can discuss the different activities, experiences, and perspectives of each individual. For example, they might discuss that passengers usually sit or stand in a train, read a book or sleep, etc. You might ask questions to facilitate the conversation; for example, "where are the passengers headed?" Try to help your students explore the complexity of the different individuals by helping them go beyond superficial characterizations and stereotypes.

4. **Make and role play.** Give students time to create their own props with materials available in the classroom and act out their roles. Provide them with opportunities to guide their own play, but don't be afraid to offer guidance. You might support their role play by offering other materials and props, such as a conductor's hat, a newspaper, or train tickets you've collected from families. You can offer challenges or puzzles that learners can work out during their play. You can also prompt them to switch roles.

5. **Find opportunities to change the system.** Invite learners to think about how they can change the system to make it better. You can use the *Imagine If…* thinking routine to help students generate ideas for changing the system. Then, encourage students to incorporate those ideas into their next role play session by changing or adding new roles, making new props, and/or adjusting the ways they interact with each other within the role play. This can be extended to think about how changes can be made in the system in real life.

A note about reflection: Throughout the role play, especially points 3-5 above, engage students in conversations about the thoughts, feelings, and motivations of members in the system. You can use the *Think, Feel, Care* thinking routine and introduce vocabulary to expand children's descriptions of what individuals in the system think, feel, and care about. You can use documentation from role-play sessions, diagrams, or other forms of visual representation to capture children's thinking and expand the play scenario.

MAPPING SYSTEMS EXPERIENCES

LOOKING CLOSELY AND EXPLORING COMPLEXITY

This tool guides young learners to look closely at a system and explore its complexity by directly experiencing the system and reflecting on that experience. This is particularly helpful when working with very young students who may struggle to conceptualize a complex system without direct experience. In addition, this tool provides suggestions for making student thinking visible by encouraging students to share their ideas and learn from each other.

1. Choose a System

Guide students in choosing a system that they are already familiar with, such as:

a classroom object (a clock, a ball point pen, a board game, etc.)
a classroom system

(an arrival or dismissal routine, a lunch time routine, classroom roles and responsibilities, etc.)

a community system (a local transportation system, checking out books at the library, grocery shopping, etc.)

2. Experience the System

Have students directly experience the system. This could take the form of a looking closely activity, a take apart activity, and/or a field trip if the system is located outside of the learning environment. As students experience the system, encourage them to look closely at how it works. Have students document what they notice using tools such as drawing paper and pencils, audio recorders, and/or cameras.

For example, if students are exploring a clock as a system, they might take photographs of the clock as they take it apart. If students are exploring the local subway system, they might visit the subway station and describe their journey through the station and onto a subway car by using an audio recorder.

3. Remember and Document the System

Give students time to document what they remember about their experience of the system. Students might individually draw pictures of all of the parts of the system they remember, or you might hold a group discussion in which you scribe student ideas on a class chart.

Prompt students to remember what they did first, what happened next, and what they noticed at each stage of their experience. Encourage students to revisit any drawings, photos, or recordings they made as they experienced the system to help them remember the many parts and processes involved.

4. Map the System

Have students make a visual representation of the system that highlights the parts, people, and interactions involved. Students might draw a picture that shows an interaction between some of the parts and people in the system, make a booklet detailing a journey through the system, and/or reconstruct their experience of the system through role play.

Encourage students to work together, as this will give students the opportunity to learn from each other and contribute to each other's understanding of the system.

5. Reflect on the System

Use one or more of the Agency *by* Design tools to guide students to think more carefully and critically about the system:

Parts, Purposes, Complexities—Use this tool to explore the parts of a system, their purposes, and how they interact.

Parts, People, Interactions—Use this tool to explore how people interact with the various parts of a system.

Think, Feel, Care—Use this tool to explore the thoughts, feelings, and motivations of people within the system.

Imagine If…—Use this tool to consider ways to improve the system.

THE MCL HACKER HELPER

A TOOL FOR TEACHERS TO ADAPT MAKER-CENTERED LEARNING RESOURCES TO BE BEST SUITED FOR THEIR STUDENTS AND CONTEXT

What?

What maker capacity would you like to support through your teaching practice? **What** tool, protocol, or thinking routine might you use to foster this capacity?

How?

How might the maker resource you would like to use be difficult for your students to work with? **How** might it be helpful to them?

Who?

Who are your students and what do you assume to be their strengths and limits as learners in a maker-centered environment?

Hack.

How might you **hack**, tweak, or adapt this maker resource to be most suitable for your students?

Do.

What will you **do** in your classroom to test out your adaptation of this maker resource?

THE MAKER-CENTERED LEARNING HACKER HELPER TOOL

Just as the broader Agency *by* Design framework for maker-centered learning encourages people to be active creators of the designed world, the Hacker Helper Tool invites educators to view the breadth of educator resources associated with the Agency *by* Design framework as malleable. This tool provides prompts to support educators as they "hack" existing Agency *by* Design tools, practices, and thinking routines to work better for their learners.

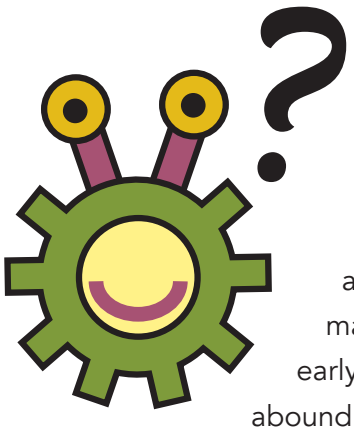
When and How Can I Use This Tool?
You can use this tool to hack and adapt any pedagogical resource associated with the Agency *by* Design framework to better meet the needs of your learners. For example, if you work with young learners, you may wish to adapt the language and visuals associated with a particular tool to support their engagement with the ideas embedded within the tool.

- This tool is most suitable for educators experienced with the Agency *by* Design framework as it requires an understanding of the maker capacities and a familiarity with the existing pedagogical resources.

- When considering an Agency *by* Design tool to use in your classroom, consider the origins of that tool and the social and cultural assumptions that may be embedded into that tool as a result. If the tool offers a particular approach to practice or suggests certain benefits for learners, you may ask yourself According to whom? (who created it?) and For whom? (who was the intended audience?). Consider how you may hack or change the tool to be specific to your learners and your learning environment.

- When adapting an existing tool, take the opportunity to step back and check to see whether the new tool still meets the goals you have set. You may go back and forth between the original tool and the new version, modifying the language and the overall approach until you find something you feel will meet your goals and the needs of your learners. It's okay if the resulting tool is different from the original or satisfies different goals; don't be afraid to invent!

LOOKING AHEAD



This pilot study has been a great starting point for thinking about how maker-centered learning can be applied in early childhood education. But new questions abound! In this section, the research team reflects on this first phase of study and shares ideas for future research.

WONDER, SURPRISE, AND POSSIBILITY

In a school bright with color from books, making supplies, and the artifacts of student work, Justin, a K1 teacher from Victoria Nursery (Harbour Heights), explains a maker moment with his students:

> *The children received a letter in the mail from the security guard at the zoo from the story* Goodnight, Gorilla*. The security guard explained that his flashlight fell and broke into many pieces and he was unable to fix it. He asked for our help because he heard that we knew how to make things. We talked about how to make a flashlight… we didn't know how. So we asked an expert—Bob the Builder! We sent Bob a letter asking for help. He wrote back to us stating that he had never built a flashlight before so he could not tell us how, but he could share what he does when he builds other things: First, he looks closely at all of the parts he needs and he draws a picture to help him remember. Then, he figures out how it will work before he begins to build. Next, he builds, and when he's finished, he tries to make it even better.*

This example from Justin's K1 classroom illustrates how maker-centered learning in early childhood brings together creativity, collaboration, prototyping, and problem solving in ways that are playful and purposeful, not just for the students but for the teacher, as well. It shows how teachers can use stories and pretend play to support students' complex thinking. It further describes the connections that students and teachers make—and the imagination that they express—when learning is centered on making.

While many highly regarded approaches to early childhood education exist today, educators and families around the world have voiced a growing interest in maker-centered approaches to early years learning. As we have shared in this playbook, the Agency *by* Design: Early Childhood in the Making pilot study explored the prospects of incorporating maker-centered learning into the early childhood classroom through a collaborative inquiry with educators from the Victoria Educational Organisation in Hong Kong.

Teachers found that incorporating maker-centered practices into their work with young learners fostered agency and independence; cultivated systems thinking; promoted perspective taking; and encouraged peer-to-peer learning. Throughout this study, our teacher colleagues used visuals and manipulatives, role play and storytelling, and variations on the Agency *by* Design thinking routines, making moves, and other tools and strategies to support students in engaging with maker-centered learning. The results of our teacher colleagues' valuable work are illustrated in the Lessons Learned, Pictures of Practice, and Tools and Resources sections of this playbook.

While our colleagues in Hong Kong have found that maker-centered learning has benefitted their young learners, we have also discovered that incorporating the practices of maker-centered learning into their work has profoundly impacted how they see and understand themselves as educators. Over our two-year engagement with them, our teacher colleagues came to notice that they were naturally stepping back and letting their students lead their own learning. At first, the idea of stepping back and letting young people lead their own learning was uncomfortable for some of our teacher colleagues, but eventually they found themselves re-directing authority, encouraging students to take ownership over their own learning, and allowing their young students to find their own paths, rather than feeling the constant need to lead the way. These educators came to understand that there was much expertise and many sources of knowledge in their classrooms, schools, and communities, and that they did not need to bear the burden of being the sole providers of knowledge and information for their students. As they became more confident in their maker-centered learning practice, the teachers in this study also developed a hacker mindset that allowed them to approach instructional challenges as makers, figuring out how to adapt and modify tools and resources according to the goals of their lessons and the needs of their students.

These may seem like radical mindset shifts for educators—but they were necessary shifts our teacher colleagues felt they needed to make. In fact, it is not an exaggeration to say that one of the most powerful impacts of this work has been our colleagues' newfound understanding that the benefits of maker-centered learning do not separately accrue to either teachers or students, but rather the individual and collective agency that developed in their classrooms was a shared experience between themselves and their young learners. This shared experience of individual and collective agency was made possible by the schools' leadership—both the school network's administration and the individual school principals—who supported teachers in this learning and experimentation process by providing the time, space, and opportunity for them to explore new approaches to practice and share with one another.

MULTIPLE PERSPECTIVES ON MAKER-CENTERED LEARNING IN EARLY CHILDHOOD EDUCATION

In many ways, it should be no surprise that the Agency *by* Design framework for maker-centered learning is applicable to early years learning. The original study that inspired this framework included the contributions of pre-K–12 educators working in a variety of contexts in Oakland, California. Throughout this first inquiry educators of young children were key players in the development of this work. Since then, early childhood educators working in many different learning environments—including formal and informal settings in the greater Pittsburgh, Pennsylvania and Washington,

DC metropolitan areas in the United States—have incorporated maker-centered learning into their work with very young students. We have learned much from these pioneering educators as they have either directly reached out to us to share their work, or more informally shared documentation of maker-centered learning in action on a variety of social media platforms.

Beyond the United States, the Agency *by* Design framework for maker-centered learning has been introduced into early years classrooms in many different cultural contexts, largely through the influence of the *Thinking and Learning in the Maker-Centered Classroom* online course. This popular primer for the Agency *by* Design framework continues to serve as an introduction to maker-centered learning for educators and school administrators working on six of the world's seven continents. While many educators of young children who enroll in this course may initially feel skeptical about the applicability of maker-centered learning to their work, they consistently report being surprised at how adept their students are at learning through making.

As has been the case with our teacher partners in Hong Kong, we have further heard how maker-centered learning complements—rather than contradicts—many popular inquiry-based approaches to early years learning. Educators applying the International Baccalaureate Primary Years Program, Reggio Emilia approaches, and Montessori approaches to early years learning have all found resonance between maker-centered learning and the frameworks and philosophies they apply in their classrooms. Beyond such specific approaches to inquiry-based early years learning, we have also come to understand from educators around the world that young students are natural makers, and that the practices of maker-centered learning are applicable within most any pedagogical structure.

FUTURE DIRECTIONS FOR MAKER-CENTERED LEARNING IN EARLY CHILDHOOD EDUCATION

Building on the findings from this pilot study, one of the most exciting outcomes of this project has been the new questions it has surfaced for our research team. Amongst these questions are:

- What are the prospects for leveraging maker-centered learning as a tool to support social and emotional learning for young students?

- What is the relationship between making and culture—and how might maker-centered learning support the development of cultural competency?

- What is the potential of maker-centered learning to support the development of language, vocabulary, literacy skills, and early reading?

- In what ways might maker-centered learning be incorporated into sociodramatic play to support young people in becoming more sensitive to design and empowered to shape their worlds?

- What might be the affordances of both analogue and digital tools and technologies in developing the maker capacities of looking closely, exploring complexity, and finding opportunity?

- What role do families, caregivers, and broader communities play in supporting young learners as empowered makers?

- What structures and supports do the educators of young children need to most effectively incorporate maker-centered learning into their work—and what additional pedagogical strategies, tools, and materials can facilitate the integration of maker-centered learning into their classrooms?

As exciting as they are on their own, all of these questions further exist within the context of the Agency *by* Design community's greater commitment to access and equity in education as it pertains to learners with special needs and special rights, children of all genders and gender identities, and children from a wide breadth of socioeconomic, cultural, and racial backgrounds—amongst many others.

Just as the above list of questions suggests, there is still much to be learned about the role and impact of maker-centered learning in the early childhood education space. As has been shown by the excellent work of our teacher colleagues at the Victoria Educational Organisation, maker-centered learning offers many possibilities for empowering young learners—and the people who teach them—as makers and agents of change.

While our first chapter of investigation into the promises, practices, and pedagogies of maker-centered learning in the early years classroom may be coming to a close in Hong Kong, we are eager to begin all of the next chapters that lie ahead—still waiting to be discovered, still waiting to be written. When we think of embarking on the next chapter of this work, three words stand out as possible places to start: *wonder, surprise, and possibility.* We are inspired by the *wonder* that maker-centered learning has sparked in young learners and the educators they work with; we are intrigued by the *surprise* that has been expressed by many teachers when they realize just how much their young students are capable of doing, learning, and exploring through making, and; we are ever

curious about the *possibility* that maker-centered learning offers classrooms and communities—especially the possibility for supporting early childhood educators and their students in becoming empowered to shape their worlds.

It is with these three words in mind, and the questions we have articulated above, that we look forward to pursuing the next phase of the Agency *by* Design: Early Childhood in the Making project—whether in Hong Kong, in our hometown, or anywhere else in the world.

AFTERWORD

When my colleagues at Victoria Educational Organisation and I were told that, as a teacher cohort, we had the exciting opportunity to work with Project Zero to discover how maker-centered learning could be used with our students in the early years, we initially had mixed feelings. Of course, this was an honor, and an incredible experience for us, but at the same time we had questions. Was it safe to let such young children use analogue tools? How would this work fit into our already busy days? And how would children as young as three, four, five, and six-years-old be able to grapple with concepts such as *design, systems, and empathy*? The answers that we found to these questions were beyond anything that we could have anticipated—and the depth of change that we have seen in lesson planning, teaching, and learning has been truly inspiring.

As the Head of Curriculum Studies for Victoria Educational Organisation, I was extremely excited to be a part of this initiative. Having worked in early years education for over a decade, I have come to understand that young children are capable of so much more than they are often given credit for. Walking into any room full of preschoolers, I have witnessed thought-provoking conversations at the snack table, feats of daring engineering in the construction area, and the foundations of empathy and collaboration being fostered in the playground. The idea that maker-centered learning allows students to see the designed world around them really appealed to me. Young children are always asking "why?" They are hungry to know how the world works—and maker-centered learning is a framework that can help them find the answers to many of their questions.

I had the additional good fortune to be the project liaison between our staff in Hong Kong and the team at Project Zero. This experience allowed me to facilitate our cohort meetings—and to get a view of what was happening in each classroom, in every year level. My colleagues and I knew from the start that maker-centered learning would not look the same in a classroom of three-year-olds as it would in a classroom of six-year-olds—and we learned a great deal from both the similarities and differences in the ways that maker-centered learning was applied and received across classrooms. Regardless of the year level, being able to follow the progression of each teacher who took part in the research initiative was an exciting part of the role for me.

Our journey with maker-centered learning started as participants in the *Thinking and Learning in the Maker Centered Classroom* online course. As a cohort, we learned how to use the thinking routines that had been designed by the Agency *by* Design team to support students' learning in the classroom. As we encountered new thinking routines from one session to the next, we often puzzled amongst ourselves, "this is complicated, this is for older students, surely our kids can't

do this," but then after giving it a go we would come back together, amazed at the critical and creative thinking skills that our students were able to demonstrate. As a teacher in the classroom, I loved using the thinking routines with my five and six-year-old students. I also loved to see them collaborate and think about issues that might usually be deemed too *complex* for them. Through maker-centered learning, my students were able to consider multiple points of view when listening to stories, to talk in detail about what the concept of "design" meant to them, and to talk about the various systems that were involved in queuing up at the ice-cream truck or in visiting the library.

Like many early years programs, hands-on inquiry has long been a vehicle for teaching and learning at our schools. This meant that incorporating the concepts of maker-centered learning into what we already did in the classroom felt, for the most part, straightforward. Nonetheless, some challenges presented themselves throughout the process. Many of the teachers found that engaging in abstract thought (e.g., systems thinking, taking the perspectives of others, empathy, etc.) became an even more difficult activity for our students if the children did not have any lived experience of the situation they were trying to think about. And as our students are so young, lived experience is not yet something they have in abundance; nor have they had the luxury of spending lots of time finding out about other cultures or systems through various entertainment media. However, by engaging our students in ideas that they were familiar with, we were able to elicit creative thinking, perspective taking, and the desire to take action. At the same time, we saw our students developing a sense of agency in their classrooms. To hear students telling their teacher that she could join their maker station but only if she was dedicated enough to come every day with new ideas, just as they did; to see children attribute emotions to the artists behind a famous work of art; and to see groups work together to break down problems into parts, people, and interactions in a bid to solve them as concisely as possible, were true testaments to the work that was being carried out in the classroom.

It was also inspiring to see the change in the participating teachers as they planned with renewed vigor for their lessons and activities. The teachers in the cohort often commented that they wanted to plan for "quality, not quantity" ensuring that their students had acquired a deep understanding of the concepts and skills needed, before moving on to a new activity, as well as taking cues from the students about what and how they wanted to learn. They looked at their lesson plans from previous years and put a new spin on them, finding new meaning and purpose for the students. My teacher colleagues have also been incredibly eager to share what they have discovered with their peers, with parents, and with other educators across Hong Kong. As the teachers have become more familiar with maker-centered learning, hearing them talk about their explorations with design and making in their classrooms has been akin to hearing the most confident experts talk about their specialist subject—and has always been a joy.

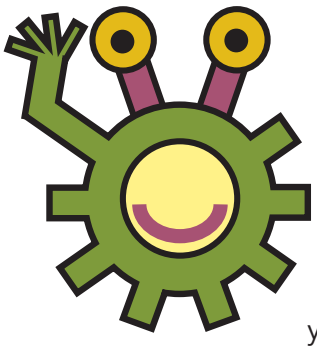
I am excited for the future of this work at the Victoria Educational Organisation. As I see the practice of maker-centered learning spread out to the other campuses in our network so that we are able to engage more of our students in making, I am confident that the cognitive and emotional development associated with this work will benefit students tremendously. I am also excited by the interest that has been shown in the work of other leading schools and educators across Hong Kong. Here in Hong Kong, as with everywhere else in the world, fostering a 'can do' spirit in our students and encouraging them to find new ways to make the world a better place must be our foremost intention as educators, regardless of the curriculum that is delivered in a particular school. It is equally exciting to see how maker-centered learning in the early years will spread across countries and continents; how educators will see that this is not only a framework for older children, but one that can also be used with and by children who are taking their very first steps into the world of formal education.

It has been a pleasure, and an honor, to work with the staff at Victoria (Harbour Green) Kindergarten and Victoria Nursery (Harbour Heights) as they have navigated through this research initiative. The dedication and enthusiasm that they have brought to the project has been the driving force in seeing this work become so successful. Equally, we would not have achieved such success without the Agency *by* Design: Early Childhood in the Making research team from Project Zero, who have supported and encouraged us to push beyond our comfort zones and to always try something new. My colleagues and I are also greatly appreciative of the commitment of the management teams at the Victoria Educational Organisation and the CTF Education Group, whose vision and openness to innovation have allowed us to take part in such an incredible research initiative.

Lisa Golds
Head of Curriculum Studies
Victoria Educational Organisation
Hong Kong, August 2019

This has been such an exciting journey!

I hope you've had as much fun—and have learned as much—as I have. Before I say goodbye, the research team and I want to encourage you to use the lessons learned and pictures of practice presented in this playbook as inspiration for the maker-centered teaching and learning you may do in your own classrooms. One way to get started is by incorporating some of the new and adapted tools the team has developed into your work with young people. As you do, don't forget to document your work and share it with others. One great way to do this is by posting on social media using the @AgencybyDesign Twitter and Instagram handle and the hashtag #MCL. Of course, another way of sharing your work and the work of your students is by displaying it throughout your school.



Being that we're at the end of the playbook, I have to say farewell for now—but I look forward to seeing you around soon! In the meantime, have fun bringing maker-centered learning to your students.

REFERENCES

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, 41(1), 16–25.

Bairaktarova, D., Evangelou, D., Bagiati, A., & Brophy, S. (2011). Early engineering in young children's exploratory play with tangible materials. *Children, Youth, and Environments,* 21 (2), 212-235.

Baynes, K. (1994). Designerly play. Design: Occasional Paper No. 2. Loughborough: Loughborough University.

Bers, M. U., Strawhacker, A., & Vizner, M. (2018). The design of early childhood makerspaces to support positive technological development: Two case studies. *Library Hi Tech*.

Birch, S.A.J., Li, V., Haddock, T., Ghrear, S.E., Brosseau-Liard, P., Baimel, A., Whyte, M. (2017). Perspectives on perspective taking: How children think about the minds of others. *Advances in Child Development and Behavior*, 52, 185-226.

Brahms, L. & Wardrip, P. S. (2016). Learning practices of making. *Teaching Young Children*, 10(1), 26-29.

Brennan, K., Hernández, A. M., & Resnick, M. (2009). Scratch: Creating and sharing interactive media. Proceedings of the 9th International Conference on Computer Supported Collaborative Learning.

Clapp, E. P., Ross, J., Ryan, J. O., & Tishman, S. (2016). *Maker-centered learning: Empowering young people to shape their worlds*. San Francisco, CA: Jossey-Bass.

Copple, C., Koralek, D., Charner, K., & Bredekamp, S. (2013). *Developmentally appropriate practice: Focus on preschoolers*. Washington, DC: NAEYC.

Daly, L. & Beloglovsky, M. (2015). *Loose parts: Inspiring play in young children*. St. Paul, MN: Redleaf Press.

DeLuca, C., Shulha, J., Luhanga, U., Shulha, L. M., Christou, T. M., & Klinger, D. A. (2014). Collaborative inquiry as a professional learning structure for educators: A scoping review. *Professional Development in Education*, 41(4).

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8.

Diamond, J. (2007). Learning about children learning about squirrels. *The New Educator*, 3(4), 303-322.

Doorley, R. (2014). *Tinkerlab: A hands-on guide for little inventors*. Boulder, CO: Roost Books.

Dougherty, D. & Conrad, A. (2016). *Free to make: How the maker movement is changing our schools, our jobs, and our minds*. Berkeley, CA: North Atlantic Books.

Gandini, L., Hill, L., Cadwell, L., & Schwall, C. (2015). *In the spirit of the studio: Learning from the atelier of Reggio Emilia.* New York, NY: Teachers College Press.

Gravel, B., Bers, M., Rogers, C., & Danahy, E. (Eds.) (2018). Making engineering playful in schools: Lessons and stories about making, play, and collaboration from the Tufts-ISB Partnership.

Halverson, E. R. & Sheridan, K. M. (2014). The maker movement in education. *Harvard Educational Review*, 84(4), 495–504.

Hetland, L., Winner, E., Veenema, S., & Sheridan, K. M. (2007). *Studio thinking: The real benefits of visual arts education*. New York: Teachers College Press.

Hoisington, C. & Winokur, J. (2015). Gimme an "E"!: Seven strategies for supporting the "E" in young children's STEM learning. *Science and Children*, 53(1), 44-51.

IDEO. (2013.) Design thinking for educators toolkit. Retrieved from https://designthinking foreducators.com/toolkit/

Jensen, H., Pyle, A., Zosh, J. M., Ebrahim, H. B., Scherman, A. Z., Reunamo, J., & Hamre, B.

K. (2019). Play facilitation: The science behind the art of engaging young children (white paper). The LEGO Foundation, DK. Retrieved from: https://helda.helsinki.fi//bitstream/handle/10138/305924/play_facilitation_the_science_behind_the_art_of_engaging_young_children.pdf

Kegan, R. (1982). *The evolving self: Problem and process in human development.* Cambridge, MA: Harvard University Press.

Krechevsky, M., Mardell, B., Rivard, M., & Wilson, D. (2013) *Visible learners: Promoting Reggio-inspired approaches in all schools*. San Francisco, CA: Jossey-Bass.

Lagemann, E.C. (2002). Usable knowledge in education: A memorandum for the Spencer Foundation board of directors [Memorandum]. Chicago, IL: Spencer Foundation.

Marsh, J., Kumpulainen, K., Nisha, B., Velicu, A., Blum-Ross, A., Hyatt, D., Jónsdóttir, S.R., Levy, R., Little, S., Marusteru, G., Ólafsdóttir, M.E., Sandvik, K., Scott, F., Thestrup, K., Arnseth, H.C., Dýrfjörð, K., Jornet, A., Kjartansdóttir, S.H., Pahl, K., Pétursdóttir, S. & Thorsteinsson, G . (2017) Makerspaces in the early years: A literature review. University of Sheffield: MakEY Project.

Martinez, S. L. & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press.

Mawson, W. B. (2013). Emergent technological literacy: What do children bring to school? *International Journal of Technology and Design Education*, 23, 443-453.

Meeteren, B. V. & Zan, B. (2010). Revealing the work of young engineers in early childhood education. Proceedings from the STEM in Early Education and Development Conference.

Milne, L. (2013). Nurturing the designerly thinking and design capabilities of five-year-olds: Technology in the new entrant classroom. *International Journal of Technology and Design Education*, 23, 349-360.

Mitchell, D. & Forestieri, M. (2018). *Simple STEAM: 50+ science technology engineering art and math activities for ages 3 to 6*. Lewisville, NC: Gryphon House.

Montessori, M. (1914). *Dr. Montessori's own handbook*. New York: Frederick A Stokes Company.

Montessori, M. (1967). *The absorbent mind*. New York: Holt, Rinehart and Winston.

Moomaw, S. & Hieronymus, B. (2002). *More than painting, preschool and kindergarten: Exploring the wonders of art*. St. Paul, MN: Redleaf Press.

Mooney, C. G. (2013). *Theories of childhood: An introduction to Dewey, Montessori, Erikson, Piaget, and Vygotsky*. St. Paul, MN: Redleaf Press.

Moorhouse, P. (2018). *Learning through woodwork: Introducing creative woodwork in the early years*. New York: Routledge.

Oers, B. V. & Duijkers, D. (2013). Teaching in a play-based curriculum: Theory, practice and evidence of developmental education for young children. *Journal of Curriculum Studies*, 45(4), 511-534.

Pappert, S. & Harel, I. (1991). *Constructionism: Research reports and essays*. 1985–1991. Ablex Publishing Corporation.

Parker, R. & Thomsen, B. S. (2019). Learning through play at school: A study of playful integrated pedagogies that foster children's holistic skills development in the primary school classroom (white paper). The LEGO Foundation, DK. Retrieved from: https://www.legofoundation.com/media/1687/learning-through-play-school.pdf

Peppler, K, Halverson, E. R., & Kafai, Y. B. (2016). *Makeology: Makers as learners, volume 2*. New York: Routledge.

Ross, J., & Clapp, E.P. (2018). The Agency by Design inquiry cycle: Documenting inquiry and practice in the maker-centered classroom. Retrieved from: http://www.agencybydesign.org/sites/default/files/AbD%20Inquiry%20Cycle%20Article_30Sep2018.pdf

Sandoval, W. A., & Bell, P. (2004). Design-Based Research Methods for Studying Learning in Context: Introduction. *Educational Psychologist*, 39(4), 199–201.

Seidel, S., Tishman, S., Winner, E., Hetland, L., & Palmer, P. (2007). *The qualities of quality: Understanding excellence in arts education*. Cambridge, MA: Project Zero.

Smedley, S. & Hoskins, K. (2018). Finding a place for Froebel's theories: early years practitioners' understanding and enactment of learning through play. *Early Child Development and Care*.

Thomas, A. (2014). *Making makers: Kids, tools, and the future of innovation*. Sebastopol, CA: Maker Media.

Thompson, R. C. & Compton, M. (2019). Start StoryMaking to join the maker movement. *Teaching Young Children*, 12(3). 16-21.

Tishman, S, & Palmer, P. (2006). Artful thinking: Stronger thinking and learning through the power of art. Final report submitted to the Traverse City Area Public Schools. Retrieved from http://www.pz.harvard.edu/sites/default/files/ArtfulThinkingFinalReport-1.pdf

Topal, C. W. & Gandini, L. (1999). *Beautiful stuff! Learning with found materials.* Worcester, MA: Davis Publications.

Wilkinson, K. & Petrich, M. (2014). *The art of tinkering: Meet 150+ makers working at the intersection of art, science, and technology.* Richmond, CA: Weldon Owen.

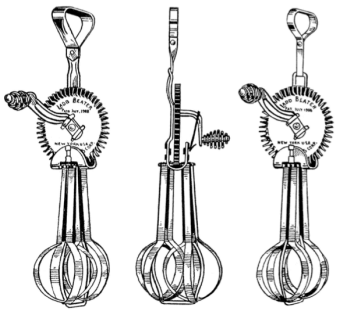
Wong, J. M. S., & Rao, N. (2015). The evolution of early childhood education policy in Hong Kong. *International Journal of Child Care and Education Policy*, 9(1), 3.

Wood, C. (2019). *The literacy of play and innovation: Children as makers.* New York: Routledge.

APPENDIX

PARTS, PURPOSES, COMPLEXITIES

LOOKING CLOSELY



Choose an object or system and ask:

What are its **parts**?

What are its various pieces or components?

What are its **purposes**?

What are the purposes for each of these parts?

What are its **complexities**?

How is it complicated in its parts and purposes,
the relationship between the two, or in other ways?

PARTS, PURPOSES, AND COMPLEXITIES

What Kind of Thinking Does This Routine Encourage?
This thinking routine helps learners slow down and make careful, detailed observations by encouraging them to look beyond the obvious features of an object or system. This thinking routine helps stimulate curiosity, raises questions, and surfaces areas for further inquiry.

When and How Can This Routine Be Used?
This thinking routine can be used to explore any object or system. This routine can be used on its own, or in combination with another routine. Here are some ideas and considerations for putting this thinking routine into practice:

- The routine provides an opportunity to make students' thinking visible through creating lists, maps, and drawings of the parts, purposes, complexities of various objects and systems. You may introduce the three elements of this routine all at once, or you may want to introduce the three elements of the routine one at a time.

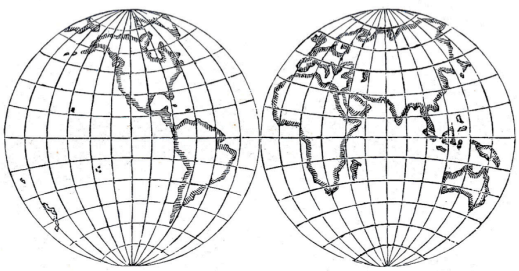
- If an object that students are working with is present and/or physically visible, students might not need a lot of background knowledge. However, if students are working with a system—like democracy—it may be helpful for students to have background knowledge or to give them an opportunity to reflect on their experiences interacting with that particular system.

- To take this routine to the next level, after learners have considered the parts, purposes, and complexities of an object as it is, you may consider having them take apart the objects they are working with—and then continue to identify the parts, purposes, and complexities they notice using different colored markers.

- You may consider swapping out the word "complexities" for more accessible terms, such as puzzles or questions.

PARTS, PEOPLE, INTERACTIONS

EXPLORING COMPLEXITY



Identify a system and ask:

What are the **parts** of the system?

Who are the **people** connected to the system?

How do the people in the system **interact** with each other and with the parts of the system?

How does a change in one element of the system **affect** the various parts and people connected to the system?

PARTS, PEOPLE, AND INTERACTIONS

What Kind of Thinking Does This Routine Encourage?
This thinking routine helps learners slow down and look closely at a system. In doing so, young people are able to situate objects within systems and recognize the various people who participate—directly or indirectly—within a particular system. Learners also notice that a change in one aspect of the system may have both intended and unintended effects on another aspect of the system. When considering the parts, people, and interactions within a system, young people begin to notice the multitude of subsystems within systems. This thinking routine helps stimulate curiosity, raises questions, surfaces areas for further inquiry, and introduces systems thinking.

When and How Can This Routine Be Used?
This thinking routine can be used to explore any system. This routine can be used on its own, or in combination with another routine. Here are some ideas and considerations for putting this thinking routine into practice:

- Before beginning this routine, it may be helpful to lead your students towards a firm understanding of what a system is. Definitions are helpful, but we've found that concrete examples (e.g., subway systems, town recycling systems, the lunch line system at school, etc.) work best.

- In order to engage in this thinking routine, your students will have to identify a system to explore. One way to do this is to have your students situate an object within a broader system. For example, a postage stamp can be situated within the broader postal system and a bicycle helmet can be situated within a broader transportation system.

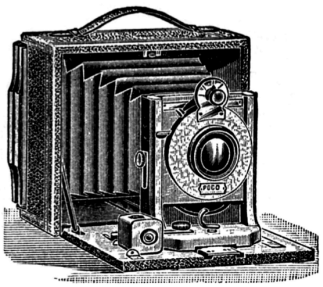
- Encourage your students to name the systems they would like to explore. This can be tricky for some learners and it may be helpful for you to reorient them to an agreed upon definition of a system, or a concrete example that you shared earlier. You can then ask your students if their system meets the criteria for a system you'd discussed previously.

- Systems are made up of subsystems, and are themselves parts of broader systems. In order to avoid going down the rabbit hole of everything is connected to everything, it may be helpful for you to encourage your students to define the boundaries of their system.

- Working in groups, it is helpful for young people to first make a list of all of the parts, and people involved in a system, and then to map out their system on chart paper to make the interactions between all of the parts and people in their system visible.

PARTS, PERSPECTIVES, ME

EXPLORING COMPLEXITY



Choose an object or system and ask:

What are its **parts**?

What are its various pieces or components?

What **perspectives** can you look at it from?

Different users, makers; different physical perspectives.

How are **you** involved?

What connections do you have? What assumptions, interests or personal circumstances shape the way you see it?

From the Exploring Complexities Project
Materials Developed by: Flossie Chua, Karin Morrison, David Perkins, Shari Tishman
Project Zero | Harvard Graduate School of Education

PARTS, PERSPECTIVES, ME: Q & A

What kind of thinking does this routine encourage? The routine helps students explore complexity by encouraging them to look closely at the details of something, considering its various viewpoints, users, and stakeholders, and reflecting on their own connections and involvement with it.

On what topics can this routine be used? It can be used to explore virtually any object or system. It works particularly well with objects that have many parts – and can be taken apart—as well systems that have various roles and users connected to them, such as systems involved in managing or providing resources, social systems, organizational systems, transportation systems or governance systems.

Should the routine be used all at once, or step by step? The three elements of this routine can be introduced all at once, but each of the steps encourages a different kind of thinking, so it is helpful to distinguish the steps from one another, and to give each step time to unfold.

What are some tips for the 'parts' step? Give students plenty of time to look at or otherwise experience the topic in detail. If the object is physically present, students can sketch it, or make a diagram. If appropriate, they can take it apart. (Taking things apart—from doorknobs to old household appliances to toys--is a particularly powerful way to look closely at the parts of something.)

What are some tips for the 'perspectives' step? Encourage students to imagine different physical viewpoints if appropriate, for example by zooming in, zooming out, or taking a bird's eye view. Encourage them to think broadly about how different people interact or are connected to the object or system: who is involved in making it, who is affected by it, who cares about it? When possible, encourage students to gather information about other perspectives, for example by interviewing people or doing research.

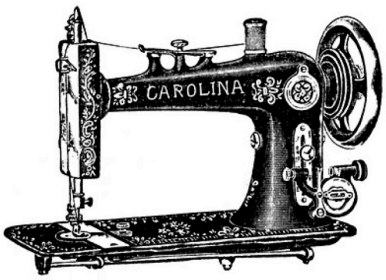
What are some tips for the 'How are you involved?'' step? Encourage students to consider the different ways the object or system touches their lives or the lives of people they know. Encourage them to consider any feelings, assumptions, connections, beliefs, attitudes or associations they have with it.

How can students' thinking be made visible while using this routine? As with the other routines that begin with the naming of parts, students can make their thinking visible by creating lists, sketches, and diagrams.

From the Exploring Complexities Project
Materials Developed by: Flossie Chua, Karin Morrison, David Perkins, Shari Tishman
Project Zero | Harvard Graduate School of Education

THINK, FEEL, CARE

EXPLORING COMPLEXITY



Step inside a system:

Choose a variety of people within a system and then step inside each person's point of view. As you think about what you know about the system, consider what each person might think, feel, and care about:

Think: How does this person understand this system and their role within it?

Feel: What is this person's emotional response to the system and to their position within it?

Care: What are this person's values, priorities, or motivations with regard to the system? What is important to this person?

THINK, FEEL, CARE

What Kind of Thinking Does This Routine Encourage?

This routine encourages learners to consider the different and diverse perspectives held by the various people who interact within a particular system. The goal of this routine is to help learners understand that the variety of people who participate in a system think, feel, and care differently about things based on their positions in the system. This routine fosters perspective taking, raises questions, and surfaces areas for further inquiry.

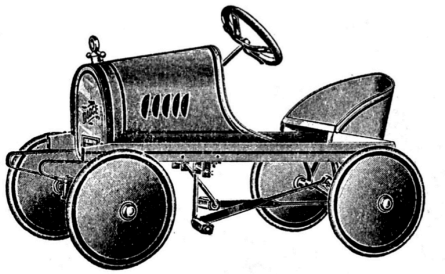
When and How Can This Routine Be Used?

This thinking routine can be used to explore the perspective of any person within a particular system. This routine can be used on its own, or in combination with another routine. Here are some ideas and considerations for putting this thinking routine into practice:

- Working individually or in small groups, it may be helpful for you to have students sketch out a small monologue or scene that contains some of the different people who participate in a particular system. They can then assume the role of various people in their system, and act out the scene, with each student portraying a different person's perspective.
- Once students portray a person in their system in one way, ask them how they might portray the same person in an entirely different way. This will prompt your students to understand that even within particular groups of people, there is no one perspective, but rather an array of perspectives that different and unique people may hold.
- Learners should be encouraged to consider how what people think, feel, and care about may be in alignment within a particular system, or misaligned. When misalignments emerge, ask your students how these tensions are dealt with or negotiated within the system? Discussions about unequal power structures within a system may arise.
- While this routine asks learners to step inside the role of a character and to imagine how they may think, feel, and what they might care about from that point of view, it is important to remember that students can never really know and understand someone else's perspective. When engaging in this thinking routine, it is important for students to push beyond stereotypes and to try to imagine the lived experiences of particular people. Encourage your students to develop specific people to play (e.g., Julia, a migrant worker, John, a used car salesman, and Martin, a Republican senator) as opposed to types of people (e.g., a migrant worker, a used car salesman, and a Republican senator).
- When perspective taking, learners will likely draw on assumptions about the types of people represented in their system. As they do so, you may lead students in a discussion that addresses where these assumptions come from. You can encourage students to challenge their assumptions by asking them what they really know about someone else's perspective, and what they may need to do (e.g., conduct interviews, speak with a grandparent, etc.) in order to find out about someone else's perspective.

IMAGINE IF…

FINDING OPPORTUNITY



Choose an object or system:

Consider the parts, purposes, and people who interact with your object or system, and then ask:

In what ways could it be made to be more **effective**?

In what ways could it be made to be more **efficient**?

In what ways could it be made to be more **ethical**?

In what ways could it be made to be more **beautiful**?

IMAGINE IF...

What Kind of Thinking Does This Routine Encourage?
This routine first encourages divergent thinking, as learners think of new possibilities for an object or system, and then encourages convergent thinking, as learners decide upon an effective approach to build, tinker, re/design, or hack an object or a system. Ultimately, this thinking routine is about finding opportunity and pursuing new ideas.

When and How Can This Routine Be Used?
This thinking routine can be used to explore the possibilities of improving, tinkering with, or tweaking any object or system. Though this routine can be used on its own, we strongly suggest that it be used in combination with other Agency *by* Design thinking routines in order to best inform learners of the ways in which they may improve upon a particular object or system. Here are some ideas and considerations for putting this thinking routine into practice:

- This thinking routine asks students to imagine new ways to improve an object or system by looking at the possibility space around an object or system through four different lenses. Specifically, it asks *in what ways can an object or system be made to be more effective, efficient, ethical, or beautiful?* While we find these four lenses helpful to consider, you and your students are encouraged to come up with others.

- When engaging with this thinking routine one's instinct may be to say to her students "the sky's the limit." While it is important for students to generate ideas within a wide-open possibility space, we've also found it helpful to place creative constraints on people's thinking. You may do this by limiting the variety of tools and materials students have access to, presenting certain functionality criteria, or identifying a particular population or user group. For example, in a chair re/design activity, students may be told they can only use cardboard and document fasteners, their new chair models have to be able to hold the instructor's weight, and their chairs have to be designed for people who commute to work on the subway each day.

- When considering how to redesign or hack an object or system, it is exciting to see students generate a list of wild, blue-sky ideas, but it is also important for students to be sensitive to the design of their objects or systems. To do this, we recommend educators have their students circle back to the other Agency *by* Design thinking routines as they search for new opportunities and brainstorm new possibilities. Likewise, if students get stuck and struggle to generate new ideas, circling back to the other AbD thinking routines may help them find opportunity and see new possibilities for their objects or systems.

ABOUT THE AUTHORS

Edward P. Clapp is a Principal Investigator at Project Zero interested in exploring creativity and innovation, design and maker-centered learning, contemporary approaches to arts teaching and learning, and diversity, equity, and inclusion in education. In addition to his work as a researcher, Edward is also a Lecturer on Education at the Harvard Graduate School of Education. Edward's most recent books include *Participatory Creativity: Introducing Access and Equity to the Creative Classroom* (Routledge, 2017) and *Maker-Centered Learning: Empowering Young People to Shape their Worlds* (with Jessica Ross, Jennifer Oxman Ryan, and Shari Tishman, Jossey-Bass, 2016).

S. Lynneth Solis is a Senior Research Manager at Project Zero at the Harvard Graduate School of Education. Her research investigates the cognitive and social processes by which young children learn about how the world around them works through play and making. She is interested in the role of sociocultural and pedagogical factors that support young children's learning in both formal and informal settings. Her work asks: What are the behaviors, spaces, and opportunities children engage in to develop their understandings of the world? and What is the role of adults, culture, and pedagogy in shaping children's learning experiences? She holds an Ed.D. in Human Development and Education and an Ed.M. in Mind, Brain, and Education from the Harvard Graduate School of Education.

Carolyn Ho is a research assistant at Project Zero's Agency *by* Design: Early Childhood in the Making project. She is interested in cross-cultural and interdisciplinary artistic collaborations, the relationship between the arts and our civic responsibilities, and the ways that artists can connect and work together given the collective transiency we face today. Carolyn has taught in Singapore, Hong Kong and Canada as a music and drama teacher. Carolyn holds an Ed.M. in Arts in Education from the Harvard Graduate School of Education.

Katy Laguzza is a research assistant for the Agency *by* Design: Early Childhood in the Making project. Previously, Katy worked with the Museum of Science, Boston as manager of two national curriculum projects designed to foster an engineering mindset in preschool and kindergarten learners. Katy is particularly interested in inclusive design and accessibility in educational settings.

Since 2012, the Agency *by* Design research team at Project Zero has explored the promises, practices, and pedagogies of maker-centered learning in a variety settings. This initial research produced a flexible pedagogical model that supports young people in becoming sensitive to design and seeing themselves as the creators of their worlds. Beginning in 2018, the Agency *by* Design research team began working with a cohort of early childhood educators in Hong Kong on a pilot study to adapt the Agency *by* Design framework for young learners. The result of this exciting work is the *Maker-Centered Learning Playbook for Early Childhood Education*. This playbook includes lessons learned from the study, pictures of practice, and a host of educator tools and resources designed to support the development of young students' maker capacities while also nurturing other generative cognitive dispositions and habits of mind at this early stage of learning and development.

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