SECTION 5

HONOURING THE PARTS THAT MAKE THE PROCESS WHOLE

Introduction

As explained in Section 3, we have conceptualized a four phase approach to *Taking Making into Classrooms*. Each part is critical in fostering the intentional mindset that embeds making within existing curriculum and embodies it in pedagogical orientation. As stated previously, the design thinking process used in *Taking Making Into Classrooms* modifies the five step approach honed at Stanford's d.School (Figure 5-1).

By using a design challenge as a prompt and extending the amount of time for tinkering and thinkering, students experience the four phase model shown in Figure 5-2.

Figure 5-1: Stanford's d.School Design Thinking Process

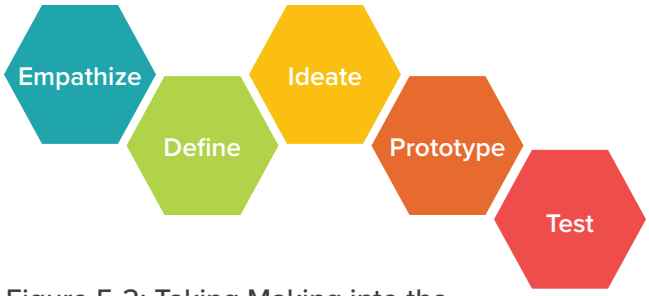
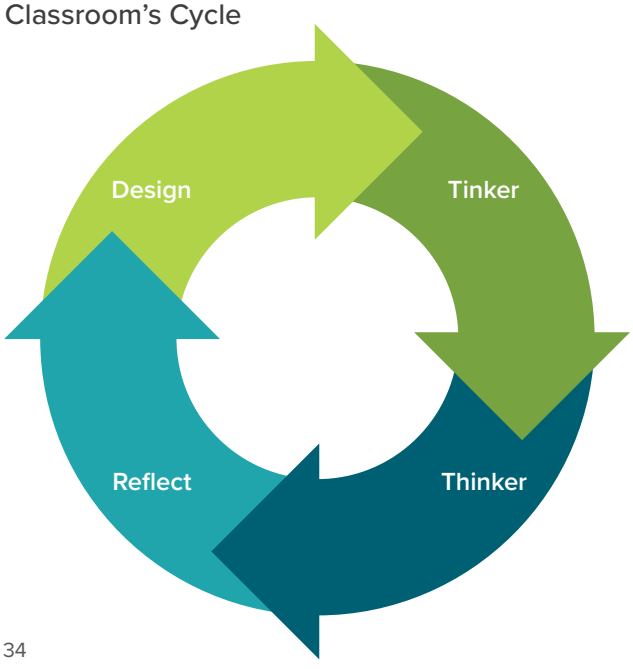


Figure 5-2: Taking Making into the Classroom's Cycle



1. **Design** – helps students gain empathy through questioning, interviewing and primary source research. It helps students to see the value of adopting a human-centred approach to problem finding.
2. **Tinker** – supports making, testing, refining, failing, modifying, and trying again as part of an iterative process.
3. **Thinker** – encourages the observation of the work of others and the use of that understanding to tinker further, and modify and adjust one's initial ideas.
4. **Reflect** – provides time to consider what was done, what could be done, and to muse about the process/product/next steps. Reflection is the prompt for iteration and is essential to understanding that design thinking is a process (journey) not merely a product (destination).

The design challenge (see Section 3) is the prompt or provocation for the *Taking Making into Classrooms* design process. Students consider the challenge by slowly engaging in a facilitated design process rather than rushing to tinker or explore materials and tools.

Design[2]

The design phase helps the students to consider a challenge from a variety of perspectives and to gain empathy for why the challenge is important. Through empathy, the students discover why the challenge is worth spending time problem finding and why an obvious solution might not be the best answer. Design thinking supports a human centred approach, positioning empathy and understanding ahead of solutions and results.

2 We define design as a problem finding experience that uses the design thinking process and is typically promoted by a design challenge. Design precedes making (tinkering).

Through the design phase, students come to understand the importance of design in our world. John Maeda, an artist and professor of design at MIT, noted that while design is integral to the business of technology and job growth (Maeda, 2016), it is also essential in our lives; it helps us to improve our life experiences by using our capacities and creating possibilities, and it helps us to make meaning by helping us to see relations and make connections.

As a process, design thinking encourages students to develop an optimistic stance toward complex problems. When we introduce students to design thinking, it provides them with a way to see how things might be different and to feel that there is a way to make things and then make those things better (Hatch, 2014).

Intentionally positioning design and making in schools supports Javis' view (2007) that "Learning is essential—indeed, like food and water are essential to the growth and development of the body, learning is an essential ingredient to the growth and development of the human person; it is one of the driving forces of human becoming and enriches human living." To design is both to learn and to proactively personalize learning through an intentional process!

Deepen Your Understanding

Learning to think using a design process helps students develop an optimistic stance to life and to build resilience. Design thinking supports divergent, lateral thinking—thinking that supports problem finding rather than mere problem solving. Using design thinking, you come to realize it is possible "to creatively attack the world's greatest problems and meet people's most urgent needs" (Hatch, 2014). Sites like Open IDEO.org share wonderful projects that people have tackled—all in the service of the public good. Tackling problems worth tackling is liberating and inspiring.

As US President Obama said recently, "...our greatest strength right now is the fact that our young generation—the millennials—is also the biggest, most educated, most diverse and most digitally fluent generation in our history. And one thing my daughters have taught me about their generation is that they're not going to wait for anyone else to build a better world; they're just going to go ahead and create that world for themselves...

The world we want for our kids—one with opportunity and security for our families; one with rising standards of living and a sustainable, peaceful planet; one that's innovative and inclusive, bold and big-hearted—it's entirely within our reach. The only constraints...are the ones we impose on ourselves... our destiny isn't decided for us, but by us. And as long as we give our young people every tool and every chance to decide the future for themselves, I have incredible faith in the choices they'll make," (Obama, 2016, par. 1 & 5).

We view the design thinking process as an essential tool for teachers and students as they personalize learning and make change in their actions, world view, and sense of selves. Increasingly, we know empathy is an essential component in the development of emotional intelligence and resilience. Once familiar with making with empathy and design thinking, we have seen people approach problems differently.

One example of thinking differently about problems was shown recently in response to the refugee crisis. People turned to *Do-It-Yourself Aid* (Palet, 2016), and provided simple, local solutions to global problems. In this instance, refugees used personal cell phones for emergency relief. They did not call the coast guard when they were in trouble; instead, they phoned a small, Berlin-based humanitarian startup that initiated a timely, non-political response. It used ordinary citizens who were connected via social media and were ready to provide personal, grass roots responses.

How You Might...

...Facilitate Design Thinking

As you consider how you might facilitate all of the phases included in a design thinking, intentional learning experience, please consider drawing on our suggestions listed below. The timing suggested in the following guide supports a full day maker experience, but recognize you can stop the process at any point to support research, exploration, prototyping, etc. As you become more comfortable facilitating this process, you will want to modify our suggestions, remembering we modified the process suggested by Stanford's d.School (**https://dschool.stanford.edu/groups/designresources/wiki/ed894/The_GiftGiving_Project.html**). We believe modification is the most sincere form of flattery, and we are grateful to d.School for leading the way. The ability to modify and share resources is one of the many reasons both Stanford and we offer our thinking through Creative Commons Licensing.

Table 5-1: Facilitator's Guide to the Design Thinking Process

Step	Facilitating the Design Thinking Process	Student Groupings	Time
1	**Introduction** Tell participants this activity takes 60 minutes and there should not be interruptions once the design thinking process starts.	All	5 minutes
2	**Organization** Organize students into small groups—4 students per group is perfect. Even numbers are essential.	All	10 minutes
3	Give each group a copy of your Design Challenge (Section 3 and Section 12). Ask someone in each group to read it aloud to the other group members.	All	10 minutes
4	Hand out copies of the Design Activity Worksheet. Please note: There were multiple versions of this worksheet modified for a variety of age levels and purposes. This version works well with adults, older students, or participants familiar with a design thinking process. Alternative: A placemat and napkin approach works well with younger students or participants requiring a few more prompts throughout the design thinking process. Here is an example using sample Design Challenge 28: *Inclusive Playgrounds*, in Section 12. Participant Placemat-Inclusive Playground and Participant Napkin-Inclusive Playground. Make sure everyone has a pencil.	All	5 minutes

Step	Facilitating the Design Thinking Process	Student Groupings	Time
NOTE	Steps 5 to 21 refer to the Design Activity Worksheet. Here is a Facilitator Guide for the placemat and napkin approach.		
5	**Design** Ask students to find **#1 Interview Notes** (Empathy) on their worksheets. Tell them to pick a partner within their group and to stay with that partner throughout the design thinking activity. Ask them to interview their partner to find out the topic that they find most challenging. Encourage them to ask lots of questions in order to gain empathy for what their partner knows or thinks about that topic. Tell them to record their interview notes on #1 of their worksheet. Monitor the groups to make sure one person is doing the interviewing and recording. Set your timer for 4 minutes for this step.	Partners	4 minutes
6	When the timer goes off, ask the students to switch roles with their partners and to begin the interview/note taking process again. Set your timer for 4 minutes for this step.	Partners	4 minutes
7	Ask students to review their notes and then interview their partners again, asking for more details, stories, examples about with the design challenge. Start the interview process again, starting with the first interviewers from Step 5. Tell them to record their notes on **#2 Detailed Interview** (Empathy). Set your timer for 3 minutes for this step.	Partners	3 minutes
8	When the timer goes off, ask the partners to switch roles and to begin the interview/note taking process again. Set your timer for 3 minutes for this step.	Partners	3 minutes

Step	Facilitating the Design Thinking Process	Student Groupings	Time
9	Ask students to locate **#3 Defining the Issue** on their worksheets. Working individually, they need to determine what their partner's goal and wishes are. What is their partner trying to do to help his/her learners? Also, record any insight they have gained. Did they learn something new about the problem or the learners' challenges? Set your timer for 3 minutes for this step.	Individually	3 minutes
10	Ask students to sketch 5 ideas to help their partner with their challenge. Use **#4 Sketch 5 Ideas** on their worksheets. Encourage students to sketch rather than use words to illustrate the ideas. Set your timer for 10 minutes for this step.	Individually	10 minutes
11	Ask students to share their 5 sketches with their partners. Tell them to record their partner's feedback and suggestions on **#5 Gain Feedback From Your Partner**. Set your timer for 5 minutes for this step.	Partners	5 minutes
12	When the timer goes off, ask the partners to switch roles and repeat the process. Set your timer for 5 minutes for this step.	Partners	5 minutes
13	Based on the feedback from their partners, ask the students to use **#6 Redesign Your Idea Based on Feedback** to redesign their ideas. It can be a combination of all the ideas, a new idea, or a modified idea based on their partner's feedback. Again, stress the need to sketch their ideas. Set your timer for 5 minutes for this step.	Partners	5 minutes
14	Ask partners to share their **#6 Sketches** within their small groups. Remind groups of the design challenge parameters. Ask each small group to select one sketch to prototype. This will require negotiation, sharing and collaboration.	Groups of 4	Time will vary by group

Step	Facilitating the Design Thinking Process	Student Groupings	Time
15	Once each group has selected a design to prototype, ask them to draw it on **#7 Sketch Your Group's Idea**. Once this sketch is completed, the group can explore the makerspace and use the tools and materials that are available to make their prototypes. Once groups have completed their drawings on #7, you can give them their participant kits.	Groups of 4	Time will vary by group
16	**Tinkering** Help groups to use the makerspace tools and materials. Introduce safety concerns. Encourage groups to push for details and to test out their prototypes.	Groups of 4	2 hours or time available
17	Once groups have begun to finish their prototypes, encourage them to begin to clean up their areas and return the tools to the makerspace. Encourage recycling and reuse of the materials. Count all the tools and make sure everything has been returned.	Groups of 4	15 minutes
18	**Thinkering** Explain the design charrette/gallery tour process. Clear of the tables and prepare prototypes for display	All	15 minutes
19	Design charrette/gallery tour: Ask 1 member of each group to stay at their table and explain their work to the other groups. Other group members can wander the room talking with the representative from each group. Remind groups to take turns staying at the table. Remind participants to ask insightful and respectful questions of each group's representative. This is an opportunity for idea sharing, iteration, and professional learning.	All	30 minutes Time depends on degree of interest

Step	Facilitating the Design Thinking Process	Student Groupings	Time
20	**Reflection** Ask participants to return to their groups and share what they have learned. Ask them to complete **#8 Reflection** on their worksheets.	Individually	10 minutes
21	**Assessment** Please refer to Section 4 for Assessment suggestions.		

Tinker[3]

Tinker is the second phase of the *Taking Making into Classrooms* cycle. It is through tinkering that students begin to make their thinking visible (Eisner, 1998). Tinkering or prototyping is done once the initial design has been sketched and negotiated. Typically, we encourage students to work in groups of four through the design thinking process, but that is an educator's decision—individual work or group work. We recommend that students work within their groups to refine their sketches and add essential details and descriptions. As they do that, they begin to think aloud about the ideas and find different sources of the initial problem. Thinking aloud basically allows them to talk through the design process. When students engage in thinking aloud within a group, their classmates can engage with them as critical friends and offer timing supports, ideas, and modifications. Thinking aloud forms a link between tinkering and thinkering in the design thinking cycle as it bridges initial ideas with more iterated, developed plans.

Thinker[4]

Thinker is the third phase, and it helps groups to share their learning and to embrace the way that multiple points of view can result in divergent, ambidextrous thinking. Realizing that everyone started with the same design challenge and sample materials, tools, and resources, thinkering during a gallery tour (or design charette) brings a forced stop to the tinkering and invites each group to summarize its activities—process and products. It requires all participants to become critical friends and to learn to ask good, fair minded, open questions. Students need time to learn to be critical friends, but there are support materials available (i.e. *Critical Friend Toolkit*, n.d.). The development of critical friends is part of developing a safe, risk-taking environment in which innovation and creativity are encouraged. We value the use of the revised Bloom's taxonomy questions as a way to introduce students to the types of questions that open conversations and encourage iteration (**https://www.cloud.edu/Assets/PDFs/assessment/revised-blooms-chart.pdf**). Tinkering and thinkering are related to Papert's concept of hard fun.

Learning to ask good questions (Section 4) is an essential outcome of design thinking. People working in the fields of coaching and leadership (Whitworth, Kimsey-House & Sandahl, 1998; Payne & Hagge, 2009) suggest that powerful questions support open discussion and sustained dialogue. We have modified their suggestions on the following page.

3 We define tinkering as the actual hands-on making of things based on a design. Tinkering produces a tangible but not necessarily final prototype, model or metaphor of a solution to a design challenge.

4 We define thinkering as the viewing of other design solutions. Viewing is similar to a Design Charette where peers observe and comment on the work of other peers.

Opening Questions

- What is your intention?
- What impact might this have?
- What are some other possibilities?
- What other ideas do you have about it?

Clarifying Questions

- What do you mean? Please tell me more.
- What concerns you most about this?
- What concerns do you still have?
- What more can you tell me?

Probing Questions

- Can you give me an/another example?
- What have you tried so far?
- How did that work?
- What might be missing?

Options

- What are other possible solutions?
- What would you like to see happen next?
- What else could you do?
- What other opportunities are there for this?

Action Questions

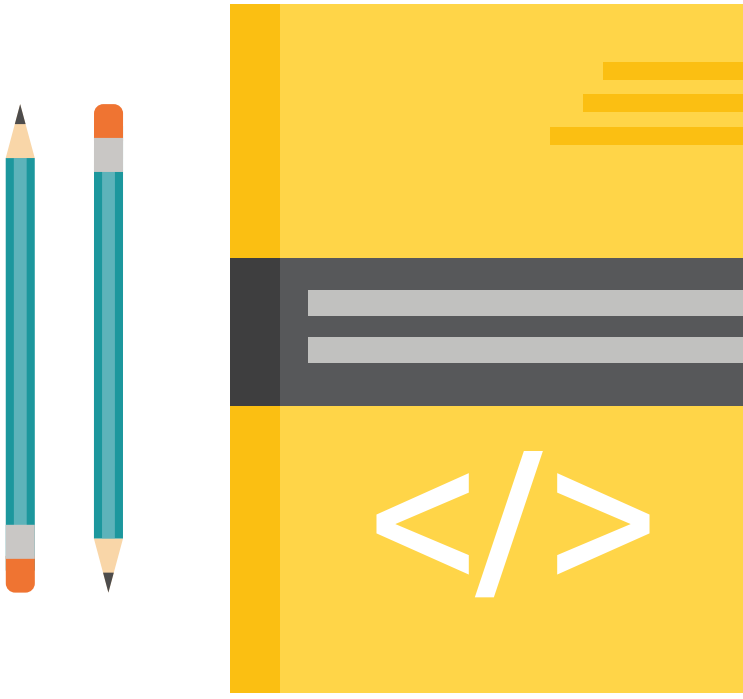
- What are your next steps?
- What are you willing to do to refine this?
- What strengths do you see with this?
- What would be helpful in assisting you?

Blocks

- What got in the way?
- What if this doesn't work, initially?
- What's your backup plan?
- Are you prepared to take this further?

Reflect[5]

The reflect phase can be seen as the final phase of the design cycle or the start of iteration and re-design. It is a natural extension of the thinkering process. We encourage both group reflection (part of the preparation for the gallery tour) as well as individual reflection, which is the fourth stage of the design cycle. Reflection helps students to make their thinking visible (Eisner, 1998) and consider what they have learned and when they need to learn. It can be used as part of formative assessment. It helps students to document their own learning, recognizing they can often be so busy in the process they forget what they actually learned. Reflection also helps with closure to a design challenge and can be used to inform the next steps in personalized learning. However, the most important thing reflection can do is to provide thinking time: time to consider what was done and why, what were the contributions, what could be better next time, etc. Reflection is essential for iteration because it helps inform what could be done next. In terms of the design process, reflection helps students see what they designed and then make decisions as to how that design could be better.



5 We define reflect as the personal pause to consider one's work in light of other solutions and ideas. It is a necessary stop in the action before moving on to either a re-design or the next design challenge. It should play a significant role in the assessment process.

Honouring of the Process

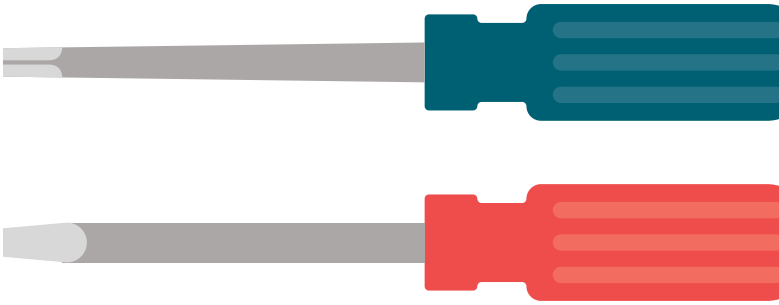


Table 5-2 aligns the *Taking Making into Classrooms* phases and activities with other design processes. Please note, each of these phases can contribute significantly to the assessment process as each contains evidence of student learning.

Table 5-2: Mapping Phases and Activities to d.School and BC Education Processes

Taking Making into Classrooms Phases	*Taking Making into Classrooms* Activities	d.School Design Thinking Process	BC Process http://cuebc.ca/cue/w-content/uploads/2016/01/Introduction-to-ADST-PASS-3.pdf
Design Phase	• Introduction to the design challenge • Facilitated human-centred design thinking process	Empathize Ideate	Developing empathetic understanding
Tinker Phase	• Collaborative prototyping • Collaborative problem finding • Idea negotiation within groups	Ideate Prototype	Creating insights and solutions by defining, ideating and prototyping
Thinker Phase	• Design charrette (gallery tour) • Engagement with classmates as critical friends	Prototype Test	Thinking critically to analyze fit solutions to contexts by testing and making
Reflection Phase	• Individual reflection • Group reflection • Reflection on process, process, and iteration of next steps	Reflect	Communicating by sharing

Fostering Habits of Mind

We have found that by honouring all the phases of the design thinking cycle, students begin to gain competency in each of the six activities and learn to play hard. Through this purposeful play, students begin to develop habits of mind (Costa & Kallick, 2000) which include "16 problem solving, life related skills, necessary to effectively operate in society and promote strategic reasoning, insightfulness, perseverance, creativity and craftsmanship. The understanding and application of these 16 habits of mind serve to provide the individual with skills to work through real life situations that equip that person to respond using awareness (cues), thought, and intentional strategy in order to gain a positive outcome."

Figure 5-3: Habits of Mind

Persisting Stick to it! Persevering at task through to completion, remaining focused. Looking for ways to reach your goal when stuck. Not giving up!	**Thinking about your Thinking: Metacognition** Know your knowing! Being aware of your own thoughts, strategies, feelings, and actions and their effect on others.
Striving for Accuracy Check it again! Always doing your best. Setting high standards. Checking and finding ways to improve constantly.	**Thinking Flexibly** Look at it another way! Being able to change perspectives, generate alternatives, and consider options.
Questioning and Posing Problems How do you know? Having a questioning attitude, knowing what data are needed and developing questioning strategies to produce those data. Finding problems to solve.	**Responding with Wonderment and Awe** Have fun figuring it out! Finding the world awesome, mysterious, and being intrigued with phenomena and beauty. Being passionate.
Thinking and Communicating with Clarity and Precision Be clear! Striving for accurate communication in both written and oral form; avoid over-generalizations, distortions, deletions, and exaggerations.	**Creating, Imagining, and Innovating** Try a different way! Generating new and novel ideas, fluency, originality.
Managing Impulsivity Take your time! Thinking before acting; remaining calm, thoughtful and deliberate.	**Remaining Open to Continuous Learning** Learn from experiences! Having humility and pride when admitting we don't know; resisting complacency.
Listening with Understanding and Empathy Understand others! Devoting mental energy to another person's thoughts and ideas; make an effort to perceive another's point of view and emotions.	**Thinking Interdependently** Work together! Being able to work in and learn from others in reciprocal situations. Team Work.
Applying Past Knowledge to New Situations Use what you learn! Accessing prior knowledge; transferring knowledge beyond the situation in which it was learned.	**Taking Responsible Risks** Venture out! Being adventuresome; living on the edge of one's competence. Try new things constantly.
Gathering Data through all the Senses Use your natural pathways! Pay attention to the world around you. Gather data through all the senses; taste, touch, smell, hearing, and sight.	**Finding Humor** Laugh a little! Finding the whimsical, incongruous, and unexpected. Being able to laugh at one's self.

(Classroom Habitudes: Teaching 21st Century Learning Habits and Attitudes, http://www.angelamaiers.com/2008/10/classroom-hab-2/

Habitudes to Start the Development of Creative Learning

Angela Maiers writes about developing "habitudes" in our classrooms. She suggests a habitude is the combination of habits and attitudes in a classroom context, and it requires teachers to move from a checklist of curricular things to cover to the creation of a learning environment that prompts deep and significant change in students. The following six habitudes identified by Maier are offered as a starting point for your own creative activities.

Habitude 1: Imagination

A cardboard box; a basket of unfolded laundry; an individual blade of grass. To a child, these everyday, unnoticed items become a fort; clothing for a king and queen; a harmonica that plays symphonic music. Imagination is not just for kids. Discovery, innovation, creativity, and learning all begin with imagination. Everyone says imagination is important, but it's something we take away by forcing students to memorize and repeat rather than think and envision.

Habitude 2: Curiosity

Champion learners are curious about everything. They ask questions and get themselves involved in all stages of learning, without worrying about the answer, but relishing in the process. They have learned that by posing questions, they can generate interest and aliveness in the most exciting or mundane situation. This inquisitive attitude fuels their unrelenting quest for continuous learning.

Habitude 3: Perseverance

I think of times in my life that it took more than "I think can" to get me to my goal. Most recently, I completed running in my first half marathon. Without resolve, determination, firmness, and endurance, I know I could not and would not have physically or mentally gone the distance.

Habitude 4: Self Awareness

We all have strengths and weaknesses in regard to our learning performance and capabilities. Knowing yourself, knowing your strength, preferences, and areas of need is a critical characteristic of a successful learner. Yet, self-awareness is more than just recognition of what you can or cannot be, do, have. This innate ability to stay in tune serves multiple purposes. They can foresee problems and use their strengths to overcome difficulties encountered.

Habitude 5: Courage

Courageous learners understand that safe is risky. Success is the byproduct of risk-taking, closing our eyes, saying I will not let fear hold me back, and taking the plunge. I want them to understand that it takes courage to address the voices in your head that echo doubts, questions, or other paralyzing thoughts.

Habitude 6: Adaptability

Adaptability is more than just serving change; it is using change as a growth opportunity. In fact, with anticipation of change, you can control change. This kind of development requires robust adaptively. The world opens up for adaptable learners, as they approach each task, each challenge willing to be a beginner. They approach their learning and life with a beginner's mindset. These learners embrace challenge with openness, flexibility. Those who don't embrace change with adaptability usually get blind-sided by it (Classroom Habitudes: Teaching 21st Century Learning Habits and Attitudes, **http://www.angelamaiers.com/2008/10/classroom-hab-2/**).

We know you will develop more examples of these habitudes that are situationally and culturally relevant in your classrooms and schools. We see a natural link between habits of mind, habitudes, and design challenges, and we believe that together the parts make for an intentional approach to *Taking Making into Classrooms*.

How You Might...

...Map Physical Layout

Before you conduct your first facilitated maker experience, consider the physical layout and affordances of your classroom. What type of maker experience do you want for your students? What is your intent? Please explore Sections 7, 8, and 9 for suggestions and safety tips.

...Introduce Habitudes

Think about Maier's work on Habitudes. Do they provide an interesting way to re-consider your classroom and learning environment? Do they help inform your classroom rules and learning goals?

Photo: **Skills Canada Alberta**

SECTION 6

WHY WE NEED OUR STUDENTS TO BE DESIGN THINKERS

Introduction

The world of work is changing. Factors including globalization, the creation of new jobs and ways of working, and fluctuating resource demands and prices have impacted all of us. Some researchers predict that by 2020, some of the most significant changes will include more freelance opportunities, increased flex-work time, smaller numbers of employees doing existing jobs due to technological innovations, and a major shift in workplace demographics (i.e. age, gender, culture, etc.)

Deepen Your Understanding

Sara Diamond and Karel Vredenburg write, "There's no innovation agenda without design thinking. It anticipates our needs, creates our experiences and tips the scales in a competitive global landscape," (August 6, 2016 Retrieved from **http://www.theglobeandmail.com/report-on-business/rob-commentary/theres-no-innovation-agenda-without-design-thinking/article31292340/**). They stress that Canadians must increase their capacity to use design thinking to guide their work.

Diamond, the president of the Ontario College of Art and Design, and Vredenburg, the director of IBM Designs and IBM Studios Canada, note that "competitive success is determined by the ability to understand human needs and desires and to deliver richly imagined ways of addressing them. Many organizations recognize the importance of innovation, but they don't know how to achieve it. The answer is design," (para. 1).

Further, they note, "we need to think of innovation clusters as combinatory instead of single-sector. If centred in one location, these can be bound to other talent and innovation sites in Canada through fast-speed Internet, artificial intelligence, Internet of Things capabilities, data analytics and visualization, supply-chain management, export and business know-how, and design," (para. 15).

"To enable an entrepreneurial and creative society, we should encourage provincial jurisdictions to teach art, design and creativity as pathways to innovation. Canada has a strong postsecondary design education system in universities and colleges, from east to west. We have Canadian design expertise in inclusive and accessible design and use—Canada can be exemplary in inclusion and social enterprise," (para 18).

Changes to the British Columbia Applied Design, Skills and Technologies curriculum invite students from K–12 to learn design. Diamond and Vredenburg call on Ottawa to "make design and design-thinking practices foundational elements of its innovation agenda for the country to enable Canadians and Canadian companies to thrive on the world stage," (para. 20).

Shortly after British Columbia launched its BC's Skills for Jobs Blueprint (**https://www.workbc.ca/getmedia/4c54646a-93fa-4566-b148-f43a3f27b240/Booklet_BCsBlueprint_web_140428.pdf.aspx**). critiques both pro and con started. Among the more interesting critiques, Todd Hirsch's commentary *Skilled Workers Are Good, But Adaptable Workers Are Better*, explores this question by asking, "How do you tell a 45-year old heavy equipment operator—trained with tax dollars when he was 25 and given great job opportunities … that work has dried up and now he has to find a totally new career? Too young to retire but too old to easily go back to college, he's in a bind." (2014, par. 6)

Hirsch suggests that knowing how to learn and knowing how to do are complementary skills, not domains belonging to separate fields. Real life is rarely experienced in a binary of one thing or another.

Our experience tells us the unifying process amongst training and academic preparation is design thinking, and we recognize that design is possible when science and art work together. As technologies continue to enhance and augment our lives, we have to think differently about how we work, live, and play. An interesting example to ponder is the impact driverless cars and nimble drones might have on the taxi industry and courier services. And while we might not be able to consider the intended and unintended impact of emerging technologies, we do know that education needs to change to help us address the challenges ahead.

"Cynthia Breazeal, founder of the world's first social robot for the home called Jibo, believes technology and humans can work hand in hand. 'What we're creating [are] robots that really are teammates and complement the services that human professionals can provide but also help empower families in the home.' She also thinks artificial intelligence can play an important role in education. 'Education is absolutely key to remaining competitive in the modern world,' Breazeal said," (Fox, 2015, Retrieved from **http://www.cnbc.com/2015/05/20/dramatic-change-for-workforce-ahead-experts.html**).

A question for educators, K–20, is how to ensure students become full, proactive members of our dynamic future, in which change and iteration will be among the primary constants. We know design thinking and making are essential and can inform both pedagogy and curriculum.

Traits of A Design Thinker

It is not surprising that Tim Brown, CEO of innovation and design firm IDEO (**www.ideo.org**), identified developing the following traits as essential for design thinkers.

- **Empathy** – Ability to image the world from multiple perspectives
- **Integrative thinking** – Exploit opposing ideas and opposing constraints to create new solutions
- **Optimism** – Assume no matter how challenging the constraints of a given problem, at least one potential solution is better than the existing alternatives
- **Experimentalism** – Pose questions & explore constraints in creative ways that proceed in entirely new directions
- **Collaboration** – Complex problems require an enthusiastic interdisciplinary collaborator (Brown, 2008, p. 87, **https://churchill.imgix.net/files/pdfs/IDEO_HBR_DT_08.pdf**)

Design thinking is a human centred design process that seeks to gain empathy for a situation by developing understanding of the concerns, insights, lived experiences, and/or needs of others. The initial step in design thinking is gaining empathy through interviews. At the heart of good interviews are great questions—questions that are open, engaging and politely probing. It is through open questions that the person who is being interviewed can share what they are comfortable sharing and often be engaged in a conversation that is rich and illuminating to both the interviewer and the interviewee.

Deepen Your Understanding

Students need opportunities to practice asking open ended questions in order to problem find. Problem finding is different from problem solving. Typically, in problem solving, we have the solution in mind as we start. In problem finding, we are open to the possibility that not only do we not know what the solution might be, but we are willing to consider that we are unclear as to what caused the problem in the first place. In rushing to problem solve, there is always the risk that we might only be treating the obvious symptoms of a deeper problem rather than grappling thoughtfully to find the actual source of the problem.

An actual example of problem solving are the well-meaning programs that provide winter coats for the homeless. These programs address the immediate issues of seasonal clothing for our vulnerable population. However, when the weather improves, the homeless rarely have places to store their winter wear and end up discarding it; thus, they face the same problem when the weather changes again. An interesting alternative is the problem finding approach taken by TAXI and their 15 Below Coat project. As a design firm, TAXI challenged itself to go further and develop an all season coat that is highly portable and adaptable. While neither coat project fixes homelessness, one addresses an immediate concern while the other attempts a multi-seasonal option.

Crafting Open Ended Questions Using Bloom's Taxonomy Question Stems

The art of the interview is truly a learned and perfected skill. When we ask closed questions—questions that evoke a yes/no answer or a response confirming what we already know—it is hard to gain insight into the points of view of other people. As Art Graesser, a professor of psychology points out, we are "to blame for our poor inquiry skills. Kids are naturally curious—why? how? what would happen if?—but teachers don't much encourage such intellectual aimlessness. Instead they want kids to know the answers to who, what, when, where—or so-called grill and kill questions. 'Our school systems have removed curiosity from kids… It's not socially sanctioned to ask the questions that actually matter,'" (Walsh, 2016, para. 4).

We draw on the revised Bloom's taxonomy (**http://www.edpsycinteractive.org/topics/cognition/bloom.html**) with question stems and suggested verbs as a way to help novice viewers come to understand the difference between open and closed questions. Please also refer to the list of powerful questions in Section 5.

An example of a closed question is, "How many eggs are typically in an egg carton?" The answer is 6 or 12 in North America. As a result, the questioning is usually over with that response.

An example of an open question might be, "Do you know of any places in which eggs are not sold in our typical containers of 6 or 12 eggs?"

The answer might be quite different if the respondent was from areas in Asia, where eggs are typically sold in groups of five and bundled in woven grass or reeds.

This openness in the questioning also invites an inquiry into how did we ever come to sell eggs in a dozen—and where did the word "dozen" come from? It also invites an exploration into cultures that prefer odd numbers such as groups or sets of five (**https://www.flickr.com/photos/pcfannet/sets/72157615190490684/with/3355927948/**).

If approached from an environmental perspective, this inquiry opens further questions about:

- access to reeds, grasses, or other suitable materials for packaging;
- whether the use of reeds or grass is more ecological than cardboard or styrofoam; and
- whether the eggs are more or less protected than our way of selling them, etc.

While the Stanford d.School design thinking process appears to be only 90 minutes in duration, you can extend the time and elaborate the process to include library research, online research, interviews with experts, person on the street interviews, etc. The possibilities are as open as your questions!

How You Might...

...Introduce WebQuests

You might want to explore Bernie Dodge's WebQuest structure for ideas on how to expand student inquiry and how to help them conduct research (**http://webquest.org/**).

...Explore Renovated Learning Resources

For extra insights on teaching the design process, consider exploring *Teaching the Design Process in Makerspaces* (**http://renovatedlearning.com/2016/02/08/teaching-the-design-process/**).

...Explore d.School Resources

As stated in the How You Might... tip in Section 5, the design thinking process can be done within 90 minutes as suggested in the d.School Gift Giving Project (**https://dschool.stanford.edu/groups/designresources/wiki/ed894/The_GiftGiving_Project.html**) or extended to support inquiry or problem based learning across a unit of study or a school's annual, community oriented design project.

As Walt Disney said, "It is kind of fun to do the impossible." One of the best gifts we can give our students is a process through which they can actually change the world. Designers do not just make things beautiful, they help to make them work beautifully. By using a design challenge approach to invite your students to learn more, you will be helping them to see the world in new and divergent ways and to become proactive in asking intelligent, open questions that can lead to change.

Photo: **Skills Canada Alberta**