TAKING MAKING INTO CLASSROOMS

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A TOOLKIT FOR FOSTERING CURIOSITY AND IMAGINATION

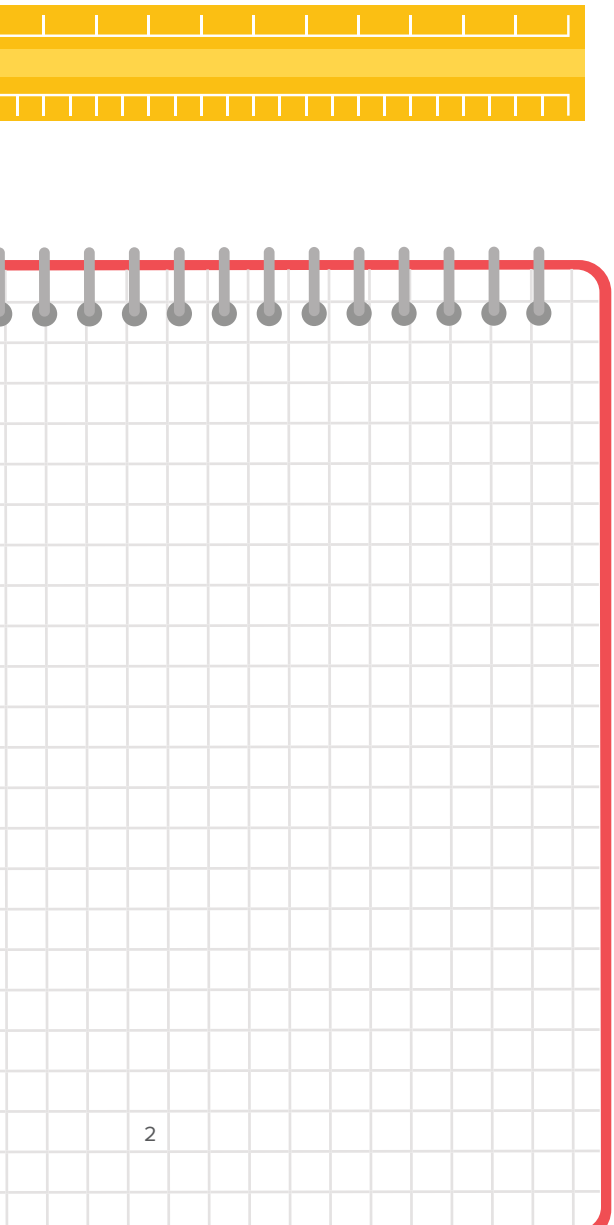
WHY *TAKING MAKING INTO CLASSROOMS* MATTERS

"Designing makes my head hurt, in a good way."

–Teacher & Maker Day Participant

"The goal is to teach in such a way as to produce the most learning from the least teaching."

–Seymour Papert



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Welcome

Since 2013, colleagues associated with the Innovative Learning Centre (ILC, **https://education.ok.ubc.ca/tag/innovative-learning-centre/**) have been pleased to provide toolkits on a range of topics. *Taking Making into Classrooms* is the fifth toolkit in this series, in preparation for Skills Exploration Days. It is accompanied by examples of tested design challenges.

Overview

Common to all the Innovative Learning Centre (ILC) toolkits is a belief that individuals can learn with an open process that supports design thinking, tinkering, and purposeful play. Our goal is to assist educators and community members as they take up and implement cross-curricular learning initiatives that are grounded in experiential, constructionist approaches.

1. ***Maker Day Toolkit V2*** (**https://media.royalroads.ca/owl/media/takingmakingwordpress/makerday-2-toolkit.pdf**) forms the foundation for *Taking Making into Schools*, the research-informed immersive professional learning (RIPL) events. The purpose of these events has been to help educators and community organizers facilitate new ways of engaging their constituent groups in sustained, effective and efficient professional learning. As of August 2016, these events have been offered to over 3,000 educators globally. Since its launch in 2013, the *Maker Day Toolkit* has been available in print, ePub, and PDF formats. The ePub has been viewed over 16,000 times. Thanks to funding from the Industry Training Authority of British Columbia (ITA BC), the *Maker Day Toolkit* has a series of videos that help to unpack the content in the toolkit. (**https://www.youtube.com/watch?v=QRNWw2--aUs**). Additional videos are available that share experiences from various Maker Day events (**https://skilledtradesbc.ca/events/maker-day**).
2. ***The unConference Toolkit*** (**https://commons.royalroads.ca/takingmaking/unconference-toolkit/**) was developed with in collaboration with the Digital Opportunity Trust (DOT, **https://www.dotrust.org/**). As a Canadian-based NGO, DOT operates economic, education, and leadership programs globally and develops the capacity of youth to become agents of change. Based on the central belief of youth empowerment, we believed the very structure of conferences and seminars needed to be reimagined. This reimagining enables the voice and active engagement of the most marginalized and novice participants, regardless of race, gender, religion, ability, and/or culture. The *unConference Toolkit* provides facilitation tips and shares conference structures with documentation proceedings using graphic recording. This toolkit is available as an ePub or downloadable PDF file.
3. ***The Toolkit for Challenging Contexts*** (**https://commons.royalroads.ca/takingmaking/toolkit-for-challenging-contexts-english/**) was developed in collaboration with Dr. Lilian Vikiru, formerly with Aga Khan University, Institute of Educational Development (AKU, IED), and teachers in rural Tanzania. The toolkit situates making within the context of rural schools in challenging contexts—schools with few or no education resources, access to the Internet, or stable electricity. The toolkit provides an introduction to making, active student learning, and professional learning. It forms the basis for a new program being offered by AKU, IED for primary educators and is available in print and as an ePub, in both English and Kiswahili, the official language of much of East Africa. This toolkit was funded as part of a Canada-Africa Reaching Exchange Grant (CAREG).
4. The ***Coding and Microcontrollers in Design Thinking Toolkit*** was developed by Maria Royston and Bill Latta. Completed January 2016, it builds on the first *Appropriate Technologies Maker Day* co-facilitated by Women in Trades Training at

Okanagan College. This toolkit introduces users to the world of simple microprocessing and coding without relying on expensive recipe driven kits.

5. Building on the ideas developed for the first *Maker Day Toolkits*, ***Taking Making into Classrooms: A Toolkit for Fostering Curiosity and Imagination*** was developed in response to classroom teachers who want to know more about introducing making to their students. Two versions were created to assist teachers design and develop classroom learning opportunities.

    5.1 ***Taking Making into Classrooms: A Toolkit for Fostering Curiosity and Imagination*** which draws from the British Columbia Applied Design, Skills and Technologies (ADST) framework. This toolkit has companion courses for credit or non-credit self study.

    5.2 ***Taking Making into Classrooms: Fostering Curiosity and Imagination in Alberta Classrooms*** which integrates classroom learning activities with a learn-a-skill event sponsored by Skills Canada Alberta and draws from the Alberta Career and Technology Foundations (CTF) program.

2016 Acknowledgements

The Japanese proverb states, “None of us are as smart as all of us.” Therefore, it is with a great deal of humility and thanks that we acknowledge friends and colleagues who contribute to the success of these publications.

- Erin Johnson and colleagues at Industry Training Authority in British Columbia (ITA BC)
- Nancy Darling and colleagues at Women in Trades Training (WITT) at Okanagan College
- Skills Canada Alberta (**http://www.skillsalberta.com/skills-exploration-days**)
- Ministry of Education, British Columbia
- Open School BC (**www.openschool.bc.ca**)
- All the wonderful educators who have contributed to our learning

We agree with Margaret Mead when she said, “Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it’s the only thing that ever has.”

Thanks for joining us in this journey to change the ways we invite children into design, making and learning!

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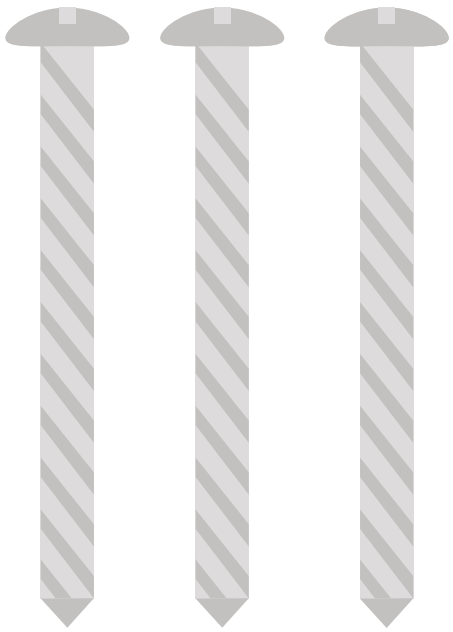


SECTION 1

THE MAKER MOVEMENT AND ITS PLACE IN NORTH AMERICAN LIVES

Introduction

The Maker Movement allows us to celebrate the best gifts of humanity—the ability to think wisely, tinker creatively, and share generously. The maker movement is often described as an "umbrella term for independent inventors, designers and tinkerers. A convergence of computer hackers and traditional artisans, the niche is established enough to have its own magazine, *Make*, as well as hands-on Maker Faires that are catnip for DIYers who used to toil in solitude. Makers tap into an American admiration for self-reliance and combine that with open-source learning, contemporary design and powerful personal technology like 3D printers. The creations, born in cluttered local workshops and bedroom offices, stir the imaginations of consumers numbed by generic, mass-produced, made-in-China merchandise." (ADWEEK, March 17, 2014, http://makermedia.com/wp-content/uploads/2015/02/The-Maker-Movement_media-kit.pdf)

Deepen Your Understanding

Mark Hatch is often described as a contemporary leader of the maker movement. His book, *The Maker Manifesto*, and his involvement with Tech Shop have enabled a generation of condo-dwelling urbanites without garages or spaces for house tools, materials, and projects to come together to tinker and make. As Hatch says, making things allows us "to collectively use our goodness and opportunity to address issues in our civil society and make the world just that little bit better... Now, with the tools available at a makerspace, anyone can change the world" (Hatch, 2014). For more on Hatch's ideas, please read the first chapter of *The Maker Manifesto* (**https://www.oreilly.com/library/view/the-maker-movement/9780071821124/**).

The current maker movement is generally recognized as officially starting in 2006 in Menlo Park, California with the development of the first Tech Shop—membership supported, community makerspaces. For a more detailed history, please read *Making It: Pick up a spot welder and join the revolution* (**https://www.newyorker.com/magazine/2014/01/13/making-it-2**).

Cities that Drive the Maker Movement shares examples of urban approaches to making (**http://techcrunch.com/2016/03/10/cities-drive-the-maker-movement/**).

The BBC has developed some fascinating videos that support the global impact and potential of the maker zmovement:

- *Head to head: Potter versus 3D printer* explores the origins of Ceramics and introduces 3D Jewelry making (**http://www.bbc.com/news/magazine-29941354**). The video asks the questions:
  - Should we think of 3D printing as a new branch of arts and crafts?
  - Does it have any right to be considered a craft at all?
- *Making digital butterflies from old phones* explores the question of "Is This Good?" It explores a digital creative arts collective (**http://www.bbc.com/news/magazine-28106467**)
- *Alternative prosthetics that 'speak from the soul'* explores the work of Sophie de Oliveira Barata, who started her career making realistic-looking artificial limbs for amputees and has now added artistic components to reflect the person's personality and imagination (**http://www.bbc.com/news/magazine-30551860**).
- *The Indian town where cricket bats are made* is the story of a town that is home to factories that produce 1000s of cricket bats a day. It illustrates the use of machines and handcraft to produce excellence (**http://www.bbc.com/news/magazine-35817492**).

We prefer to think of the Maker Movement as an artisan social movement fueled by a fundamental human need to use "our hands and imaginations together to make things and then make those things better," (Hatch, 2014). These makers are empowered by open source technologies and virtually unrestricted access to information through the Internet.

Now more than ever before, North Americans are coming together in makerspaces. Whether in schools, libraries, or community centres, makers marry the notions of art, craft, design, innovation and entrepreneurship. In makerspaces, makers create a collective experience by sharing ideas, traditional/digital tools, and expertise to make things and tinker with ideas and resources. While they might seem to be a new phenomenon, makers have deep historical, cultural, and social roots in North American society.

Historical Roots

During a Maker Day at the Kainai High School in southern Alberta, Canada, an Aboriginal elder explained to the secondary students the importance of embracing the Maker Movement as a way of remembering traditional ways of being on the land. She linked making with traditional ways of knowing and living in the world.

Canadian immigrants were makers by nature and need. Nowhere is making more evident than on prairie farms and ranches where residents planted gardens, preserved food, repaired and maintained equipment, and made their way in foreign environments. Immigrants bring unique skills from their homelands and reposition themselves by drawing on traditions and local resources. Making shapes the way they live and work.

Traits like self-reliance, curiosity, and resourcefulness were common to most early (and often rural) Canadians, Indigenous or immigrant.

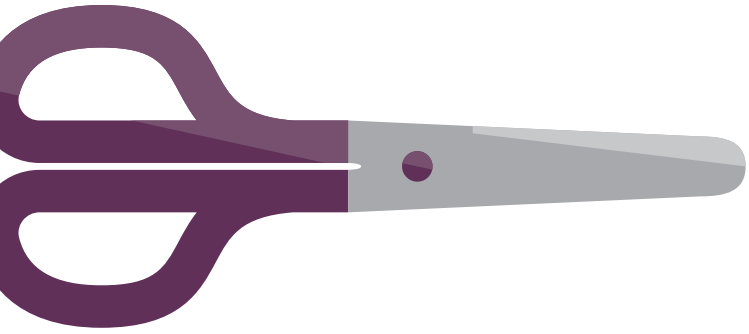
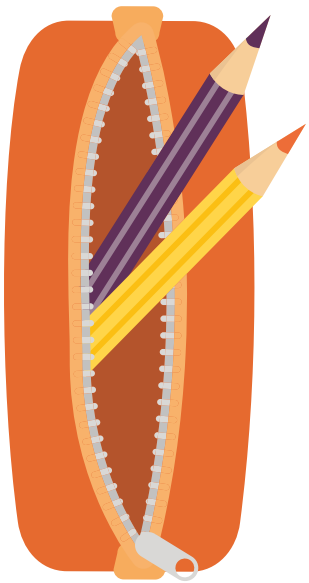


Table 1-1: Evolution of North American Makers

Type	Description	Source of Information
Maker 1.0	Indigenous and Traditional Ways of Knowing	Cultural practices, Local knowledge, Community
Maker 2.0	Back to the Land—Counter Culture	Whole Earth Review; Early Internet
Maker 3.0	Contemporary maker culture, Advanced manufacturing/ agile innovation	DIY sources; Make Magazine; Internet; Internet of Things

Cultural Roots

The maker culture emphasizes "informal, networked, peer-led, and shared learning that is typically motivated by fun and self-fulfillment" (*Maker Culture*, chapter in Innovating Pedagogy 2013, p. 34 The Open University. Retrieved 2014-01-09). As Wikipedia notes "the maker culture encourages novel applications of technologies, and the exploration of intersections between traditionally separate domains and ways of working including metal-working, calligraphy, film making, and computer programming," (**https://en.wikipedia.org/wiki/maker_culture**). We view making on a continuum from personal enjoyment to marketable items; making can range from a lifestyle and a hobby to a way of community building to industry sponsored innovation.



Deepen Your Understanding

Not all making has to be done in makerspaces, nor does it have to lead to innovation and entrepreneurship. Some instances of making are fun and whimsical. Eyebombing is one example. Started in Copenhagen, "the idea is to stick removable googly eyes onto objects like parking meters and pipes, so they almost seem human. Eyebombing is now gaining popularity on social media with the aim of trying to bring a little light relief to the world... Ultimately the goal is to humanize the streets and bring sunshine to people passing by."

Simply put, Eyebombing is using googly eyes to bring objects to life. For more information, please check out **https://www.bbc.com/news/av/magazine-25449223**.

Social Roots

We are increasingly engaging in an interdependent and globalized economy. The rise of opportunities such as Airbnb, Car2go, community gardens, etc. suggests a shift to collaborative consumption and shared ownership, which confirms the need for makerspaces to support making. As Morozov (January 13, 2014) suggests, "digital natives are starting to hunger for life beyond the screen. Making something that starts virtual but quickly becomes tactile and usable in the everyday world is satisfying in a way that pure pixels are not."

Photo: **Skills Canada Alberta**

How You Might...

...Host Guest Speakers

Invite local makers/crafters into your classroom (for example, craftspeople who participate in local farmers' markets, make items for sale in local hospital gift shops, DIY car buffs, etc.). Ask them to share how they became interested and skilled in their particular area. Invite them to do hands-on workshops with your students, stressing the sourcing of materials, initial design ideas, and production techniques of their craft.

...Explore Projects for Social Justice

A number of social good projects are offered in Section 1. Spend time talking with your students about social justice and the need to contribute to the social good.

Explore how the projects illustrated in Section 1 address a social need. Discuss how the projects came into being and how the developers determined that there was actually a need for their products.

Explore the issues facing your community. Consider inviting a local philanthropist, social activist, and/or politician into your class to discuss the concerns facing your community. Often, we can be surprised by the needs that exist right in our own contexts.

Remind students that it is okay to think globally and act locally to make change in the world.

Adaptive Design – Cardboard furniture
http://www.adaptivedesign.org/
http://www.cerebralpalsyafrica.org/equipment/

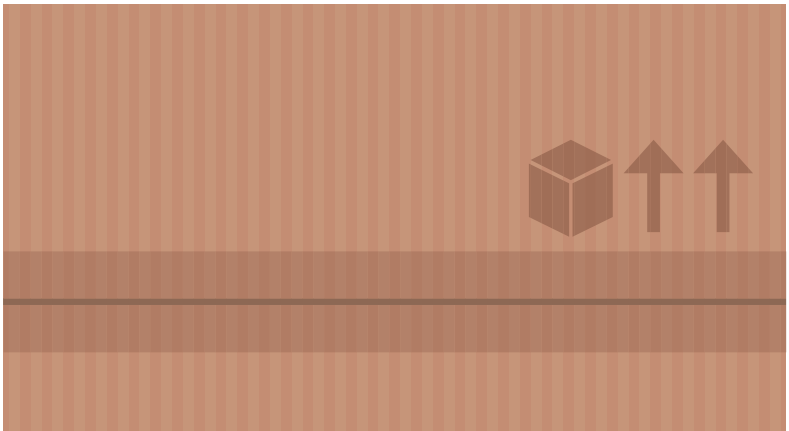
Recycled Orchestra of Cateura – Musical Instruments
http://www.cbsnews.com/news/the-recyclers-from-trash-comes-triumph

15 Below Project – Outerwear
http://agency.taxi/work/client/taxi-the-15-below-project/

Bionic Knee Brace – Prosthesis
http://www.theglobeandmail.com/report-on-business/small-business/sb-growth/the-challenge/bionic-knee-brace-puts-a-spring-in-the-step-of-two-inventors/article29980792/

...Reach out to Community Members

Invite interesting members of your community into your class to share alternative ways of doing things (i.e. recent immigrants, members of specific cultural groups, older members of your community, Aboriginal elders, etc.). Ask them to share traditional ways of knowing and doing, elaborating how those traditions came to be and how they might be useful now. However, be mindful of the potential for stereotyping and cultural appropriation (**https://en.wikipedia.org/wiki/Cultural_appropriation**).



Deepen Your Understanding

Making things for the social good sometimes leads to unintended entrepreneurial opportunities. An example of this is Zach Rotholz, who had a long time love affair with cardboard and apprenticed with Adaptive Design, a nonprofit that makes assistive furniture for children with various physical abilities (**http://www.adaptivedesign.org/**). Eventually, Rotholz opened his own business, Chairigami, to create a line of foldable furniture using sturdy corrugated cardboard (**http://www.chairigami.com/**).

Other groups building with cardboard and utilizing adaptive design within the non-profit sector include Cerebral Palsy Africa, a British NGO that runs training and support programs in a number of African countries. They describe their NGO as a new social enterprise that makes furniture from recycled paper and cardboard using Appropriate Paper-based Technology (APT) techniques. Their volunteers are setting up a mini factory to pilot a larger scale production of customized paper furniture because APT aims to create a social enterprise with saleable products for the UK market. Their UK Volunteers also benefit from an outlet for their practical talents and creativity. The lessons learned in APT production will be useful for people in challenging contexts who are establishing sustainable production units that manufacture assistive equipment aids (**http://www.cerebralpalsyafrica.org/equipment/**, par. 3).

Work Roots

Hatch (2014) suggests we are actually entering a new industrial revolution as we embrace the changes brought by our current Conceptual Age. If the first industrial revolution was powered by steam and the second by electricity, our new age is powered by unlimited access to information through the Internet. With this ubiquity and interconnectivity comes the rapid development of reasonably priced, powerful tools, as well as the ability to obtain a range of globally sourced materials with which to make things and then make those things better. Recognizing the Maker Movement has steadily evolved (See Table 1-1: Evolution of North American Makers), Hatch describes the current Maker Movement as an "Internet of Physical Things" (p. 3). He claims the Maker Movement is actually bigger than the Internet because it includes physical objects connected via sensors to the Internet.

The Internet of Things is a simple concept that is enabled by seemingly endless possibilities and options (**http://postscapes.com/internet-of-things-examples/**). Imagine adding components and additional functionality to the most ordinary, everyday objects. For example, what if we added sensors to road surfaces so they could tell drivers if the highway is slippery—we can! What if the cap of your pill bottle glowed when you had forgotten to take your daily dose—it can (**https://www.medgadget.com/2009/08/internet_connected_bottle_caps_help_remember_to_take_your_pills.html**). What if you could determine your physical activity during a day and track it in relation to your heart rate—you can with wearable fitness trackers (i.e. FitBit or many others). The Internet of Things (IoT) requires us to think differently and to consider real problems as complex and multiple faceted. Once we begin to think beyond simple solutions, we can begin to add value, functionality, and combine amazing ideas together to create human centred, empathic responses to vexing situations. However, a willingness to be passionately curious is central to creative ideas. For those of you new to IoT, here are seven things to know (**https://library.educause.edu/resources/2014/10/7-things-you-should-know-about-the-internet-of-things**).

Supporting our current industrial revolution and the Internet of Things is "the largest untapped human resource on the planet... the space time, creativity, and disposable income of the creative class," (Hatch, p. 52). Richard Florida, in *The Rise of the Creative Class,* suggests the creative class is an "amalgamation of engineers, artists, lawyers, programmers, designers, and others who have the educational or professional propensity to create," (Hatch, p. 52). This class is fostering the majority of contemporary innovation and is moving into advanced manufacturing, which in turn is supporting an economic recovery, new employment options, and the rapid growth of the Maker Movement.

Deepen Your Understanding

We use the term "challenging contexts" rather than "developing world" or "third world" as a way to describe settings in which individuals have limited, unreliable, or no access to modern day conveniences such as electricity, running water, health care, mobile computing, broadband, and related emerging technologies due to a variety of circumstances, conditions or environmental constraints.

In 1916, John Dewey said, "If we teach today's students as we taught yesterday's students, we rob our children of tomorrow." We recognize that contextual challenges occur globally, varying only in their scope, cause, duration, geography, and potential permanence. Teachers in challenging contexts have a daunting task. The challenges they face include, among others: large class sizes, diverse learner abilities in a class, low literacy levels, lack of resources, serious underfunding, and lack of professional learning opportunities.

Globally, countries struggle to make lasting, substantial educational reform. Initiatives such as the United Nations Millennium Goals (**http://www.un.org/millenniumgoals/**) have encouraged universal primary education and classroom changes that are student-centred, evidence-based, and that encourage active and participatory learning. For instance, in Tanzania, teachers are called upon to show "big results now," which is central to that country's education reform initiatives. However, teachers have not been given adequate professional development opportunities to show them how to turn their objectives into actual classroom practice.

Excerpt from *A Toolkit from Challenging Contexts: Taking Making into Schools* (**https://commons.royalroads.ca/takingmaking/toolkit-for-challenging-contexts-english/**). This toolkit provides examples of classroom resources developed by teachers from Turiani, Morogoro Region, Tanzania.

Deepen Your Understanding

In Section 6, we discuss why we believe it is essential for our students to engage in design thinking and, more importantly, to become design thinkers. The world of work is changing significantly. In a globalized and increasingly technology-assisted world, many jobs are being outsourced, are being replaced by automation or robotics, or are changing in significant ways that require a different skill set. An interesting site developed by Oxford University and Deloitte can tell you if a robot will take your job (**http://www.bbc.com/news/technology-34066941**), suggesting that 35% of the existing jobs in the UK will be gone in 20 years.

During August 2016, we witnessed a significant loss of jobs in Canada, which impacted younger workers and those in the natural resource sector the hardest (Younglai, Aug. 6, 2016 Retrieved from http://www.theglobeandmail.com/report-on-business/economy/jobs/canadas-july-employment-figures/article31286881/). However, some sources predicted that the private sector might add jobs, because job creation happens in the private sector as entrepreneurs create new work, products, services, and imagine different economic opportunities. This is an instance of how creativity, imagination, design thinking, and the Internet of Things can create opportunities that were previously unimaginable. With social media and online seed capital options like Kickstarter, amazing products and opportunities are surfacing. BuzzFeed, for example, offered a glimpse into "27 Genius New Products You had No Idea Existed" (**https://www.buzzfeed.com/peggy/genius-new-products-you-had-no-idea-existed?utm_term=.saM6O84Pq#.dglpgaZ7K**).

The bottom line is that Einstein was probably correct when he defined insanity as doing the same thing again and again while expecting different results. If we train students for jobs that may be obsolete by the time students are ready to apply for them, we are creating an impossible situation for young people, for our economy, and for our future.

How You Might...

...Open a Conversation About Universal Design

When we talk about assistive tools and technologies, it is important to remember that there are universal principles that guide design. Design is typically defined as the capacity to plan and produce desired outcomes that meet human needs. Universal design is the capacity to design outcomes that meet the needs of "extreme users" (Bruce Mau, cited in Berger, 2009, p. 114), who are users in the most challenging of conditions or situations. The interesting thing is that the general user often benefits from the design as well. A good example of universal design are the curb cuts on sidewalks that have become commonplace in North America. Originally intended for enhanced wheelchair access to sidewalks, people pushing strollers, skateboarders, and bike riders have also benefited.

A great example of universal design in product design are the OXO Good Grips (**https://www.oxo.com/we-are-oxo/aboutus**). The story goes that Sam Farber was watching his wife struggle to peel carrots because of the increasing arthritis in her hands. He started observing the ergonomics and usability of existing peelers and started asking important questions, such as:

- How does the existing design and form affect us?
- How might the design/form be different?
- How might the change in design matter?

The result of Farber's observation about carrot peeling resulted in a hugely successful product line—OXO Good Grips. It took multiple attempts, shapes, and adaptations (e.g. addition of ridges to the grips, more squeezable fins in the rubber, a better shape), but a better grip benefits us all!

Using the principles of universal design, identify instances of good design in your everyday items, classroom furnishings, or school environment.

An example of an individual turning a hobby into a social enterprise is Favio Chavez, an environmental technician in Paraguay who made trash into musical instruments for the impoverished children in his community. Please read the full story and hear the results of the project at **http://www.cbsnews.com/news/the-recyclers-from-trash-comes-triumph/**.

Another example of a company using good design to address a social issue is the story of the *15 Below Jacket Project*. TAXI, a small company whose mantra is "Doubt the Conventional," decided it wanted to give back to its community on its 15th anniversary by attempting to address homelessness. The result was the development of the 15 Below Jacket. Please check out their website for details (**http://agency.taxi/work/client/taxi-the-15-below-project/**).

These examples are only a few among the many that we offer to illustrate the scope / range of making activities. The scope and range of activities illustrated in Table 1-2 is consistent with the K–12 curriculum in the Applied Design, Skills and Technologies framework (**https://curriculum.gov.bc.ca/curriculum/**).

Table 1-2: Scope and Range of Maker Activities

Zero to Maker	Maker to Maker	Maker to Market
• Inspiration to invent • From consumer to having a hand in making	• Collaboration & access to the expertise of others • Need to unleash the innate desire for self-expression & creation	• Invention and innovation • Knowledge flows & concentrates
Skills Needed		
• Ability to learn & access to means of production	• Desire to improve and share with others	• Capacity to scale • Appeals to market beyond self, family, & friends

Photo: **Skills Canada Alberta**

SECTION 2

MAKING THE CONNECTION: DESIGNING, MAKING, AND A NEW CULTURE OF LEARNING

Introduction

Locally and globally, from Ministries of Education to non-governmental organizations (NGOs) like UNESCO, educators recognize the need to make learning more authentic, engaging, and experiential. We know the maker movement has a significant role to play in these educational reforms. *Taking Making into Classrooms* fosters curiosity, imagination, and active learning. It aligns beautifully with new curriculum initiatives.

Teachers have often commented to us that they want to introduce design thinking and making into their classes and classrooms. They felt they lacked the language to advocate for it and struggled to find the academic fit for making within an already overcrowded curriculum. The intent of this section is to help with both concerns. Making is a pedagogical orientation as well as subject for study.

Pedagogical Orientation

Our research and experience tells us that Papert (1980) was right—when we give children powerful tools to think with, there is no limit to learning! All too often we ask too little of our students and give them too little time to uncover all the exciting things there are to explore and learn. As a pedagogical orientation, the roots of making can be found in John Dewey's call for experiential learning. In his book *The School and Society*, Dewey (1899) suggests that every school must support "an embryonic community life, active with types of occupations that reflect the life of the larger society and permeated throughout with the spirit of art, history and science. When the school introduces and trains each child of society into membership within such a little community, saturating [a student] with the spirit of service, and providing [a student] with instruments of effective self-direction, we shall have the deepest and best guarantee of a larger society which is worthy, lovely and harmonious," (p. 44).

By taking making into their classrooms, teachers draw upon a rich, research-informed literature of constructionist learning, dating from Dewey to Papert to contemporary work out of the Lifelong Kindergarten group at MIT (**https://llk.media.mit.edu/**).

Deepen Your Understanding

We would be remiss to not pause here and celebrate the life and many significant contributions of Seymour Papert. As we were writing this toolkit, Dr. Papert passed away after a long health struggle following a motorcycle accident in Hanoi where he was attending a conference. He is one of the pioneers of artificial intelligence and a true believer that children should have access to powerful tools to think with. His work influenced our careers and thinking and brought us to computing through his wonderfully curious turtle interface—LOGO. Dr. Papert embodied purposeful play and curiosity. He will be sorely missed!

Papert's theory of constructionism states that the best way to construct knowledge and understanding is through the construction of something that is shareable outside of the student's head (Papert & Harel, 1991). Papert suggests that by using creative and critical thinking, students can work collaboratively to explore materials, use tools and equipment, design, build, develop processes, and communicate the merits of their work in unique and exciting ways. The Lifelong Kindergarten group at MIT continues Papert's work and, among other things, developed SCRATCH—the object oriented programming software for children (**https://llk.media.mit.edu/**). For more on coding and the use of appropriate technologies in making, please see Section 10.

Deepen Your Understanding

Crawford (2010) brings a contemporary lens to the idea of meaningful work in society by questioning the thinking behind turning everyone into a knowledge worker. Crawford suggests that we cannot and should not separate thinking from doing by creating a binary of working with one's hands (the trades/applied skills) and working with one's mind (white collar work/academic studies). His best selling book, *Shop Class as Soulcraft: An Inquiry into the Value of Work* is a must read (**https://www.penguinrandomhouse.com/books/301618/shop-class-as-soulcraft-by-matthew-b-crawford/**).

Domain of Study

In British Columbia, the Applied Design, Skills, and Technologies curriculum (Carpentry to Home Economics, Information Technology to Business Education, etc.) has been renewed as Applied Design Skills and Technologies (**https://curriculum.gov.bc.ca/curriculum/adst/goals-and-rationale**).

"The Applied Design, Skills, and Technologies curriculum builds on students' natural curiosity, inventiveness, and desire to create and work in practical ways. It harnesses the power of learning by doing, and provides the challenging fun that inspired students to dig deeper, work with big ideas, and adapt to a changing world. It provides learning opportunities through which students can discover their interests in practical and purposeful ways.

"Applied Design, Skills, and Technologies includes skills and concepts from the disciplines of Business Education, Home Economics, Information Technology, and Technology Education, as well as rich opportunities for cross-curricular work and space for new and merging areas, such as Media Arts".

We believe making supports exploration and meaningful play while helping students to foster creativity and a capacity for risk-taking. We have observed that students need time to be autonomous and work on authentic problems that require problem finding as well as problem solving. Our work suggests a design thinking process (Sections 5 and 6) helps students to explore problems using a human-centred approach, which encourages thinking about the common good and potential unintentional consequences. This process leads to extraordinary solutions for seemingly ordinary problems. The design thinking process helps to sustain inquiry and action by teaching students to ask good questions and then even better questions rather than settling for simple answers.

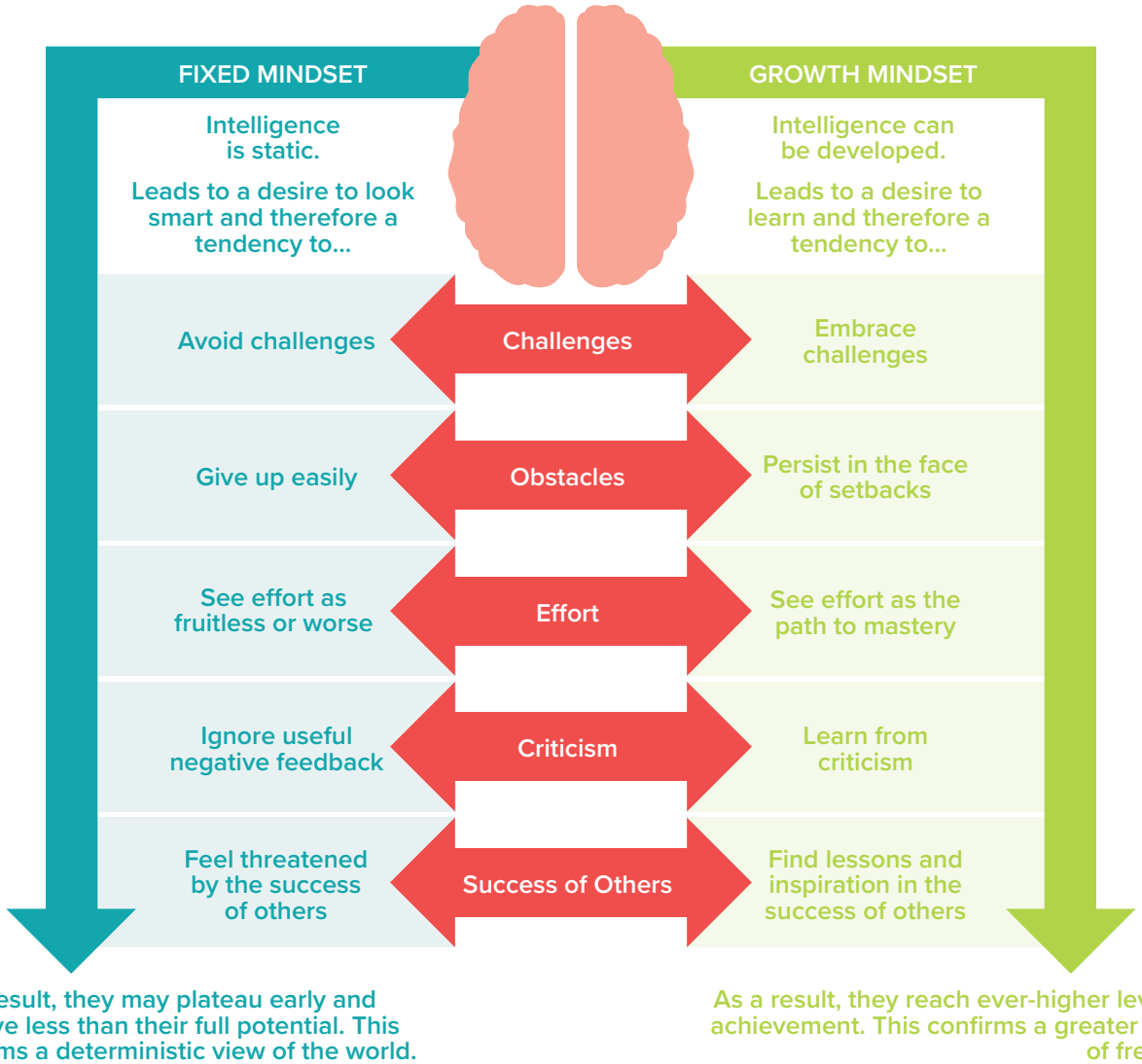
New Culture of Learning

Contemporary research from Stanford University suggests that when we tinker with complicated and engaging tasks, make mistakes, and encounter failure, we do the intellectual wrestling that fosters the development of brain synapses, which build brain plasticity and intelligence. Jo Boaler, in her work with students to build mathematical understanding, has learned that effort and practice grow the essential brain

plasticity that supports deep learning. You can explore her work at **http://www.youcubed.org/** and **https://www.youcubed.org/think-it-up/mistakes-grow-brain/**.

A growth mindset differs from the more traditional idea of a fixed mindset. A fixed mindset suggests there are things that we can and cannot do well. A growth mindset suggests we can grow our capacities by wrestling with problems worth thinking about and by continually learning. Carol Dweck researches the notion of a growth mindset and her TED Talk explores how "we can grow our brain's capacity to learn and to solve problems," (**https://www.ted.com/talks/carol_dweck_the_power_of_believing_that_you_can_improve?language=en**). In her TED Talk, Dweck mentions a school in Chicago that did not issue failing grades for students; rather, it recorded the grade as "not yet." This assessment suggests students may achieve success in time and with more learning. As Popova (2014) describes: "At the heart of Dweck's research, and what makes the 'growth mindset' so winsome, is a student's passion for learning rather than a hunger for approval. Its hallmark is the conviction that human qualities like intelligence and creativity, and even relational capacities like love and friendship, can be cultivated through effort and deliberate practice. Not only are people with this mindset not discouraged by failure, but they don't actually see themselves as failing in most situations—they see opportunities for learning," (par. 4, **https://www.brainpickings.org/2014/01/29/carol-dweck-mindset/**).

Figure 2-1: Two Mindsets



Neural plasticity and growth mindsets align with Yong Zhao's message concerning 21st century learning: we must support uniqueness, foster creatively, and support entrepreneurial thinking. To do this, Yong Zhao and others say that schools must create more time for students to explore and engage in purposeful play in order for them to build confidence in their ability to learn and find their passions.

Developing a growth mindset, fostering creativity, and engaging in design thinking are all components of a pedagogy of promise: one that is optimistic, seeks the good in situations, and encourages the positive development of individual capabilities. The International Society for Technology in Education (ISTE) recently revised their skill and knowledge standards for digital age students (**https://www.iste.org/**), identifying seven skill and knowledge areas. Section 10 suggests ways in which these skills and standards can be attended to when teachers take making into classrooms.

Making enables the type of learning environment suggested by the OECD (Organization for Economic Co-operation and Development), an international organization founded to stimulate economic progress and world trade. OECD suggests that learning environments must be:

- learner-centred,
- structured and well-designed,
- profoundly personalized,
- inclusive, and
- social.

These learning environments are consistent with the Conference Board of Canada's call to provide learning experiences that are focused on developing

- creativity, problem-solving, and continuous improvement skills;
- risk assessment and risk-taking skills;
- relationship-building and communication skills; and
- implementation skills.

The core literacies required to fully participate in these new learning environments include what Trilling and Fadel (2009) identify as:

- critical and creative thinking,
- problem finding and problem solving,
- authentic learning, and
- collaboration.

Together, the alignment of a growth mindset with making in these types of learning environments helps teachers to come closer to Einstein's description of education—"It is not the learning of facts, but the training of the mind to think."

Intentional Mindset

We suggest that by taking making into their classrooms, teachers may foster an intentional mindset that includes designing, making, engagement and curiosity. *Maker Day Toolkit V2* (**https://www.newyorker.com/magazine/2014/01/13/making-it-2**) offers suggestions for facilitating immersive professional learning experiences for teachers.

Once teachers are comfortable with making, they can introduce similar immersive experiences to their students, which will help them to develop intentional mindsets. By embedding making across curricular areas, teachers create opportunities for students to experience making, which nurtures innovative and creative thinking through design and tinkering.

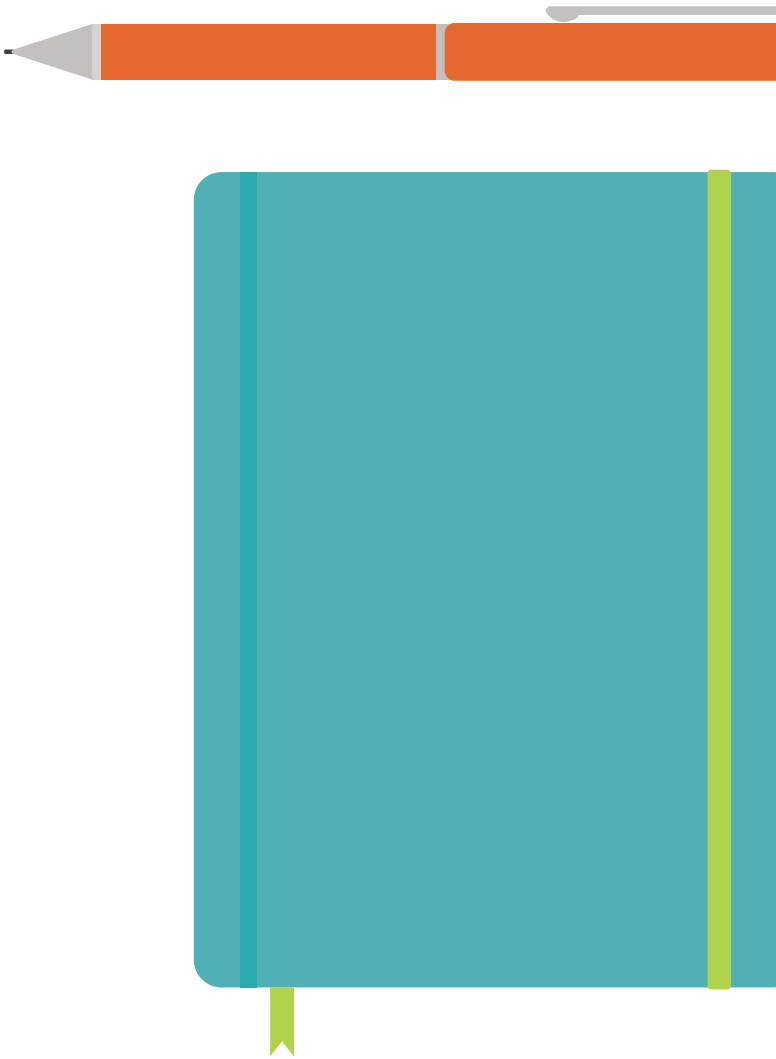
By introducing students to a design challenge and then facilitating them through a design phase, students are encouraged to nurture innovative, divergent, and creative thinking. Design thinking prompts curiosity: it helps students to think laterally and to find connections amongst ideas generated by others. The thinker phase helps students become empowered by their ideas; it supports students' confidence in their ability to design, make things, and then collaborate to make those things better. Figure 2-2 illustrates the recursive nature of experiences needed to build an intentional mindset.

Deepen Your Understanding

Making allows us to create signature learning experiences that can be intentionally designed in schools to foster lasting memories of deep, personally significant learning. Hernandez suggests that signature learning experiences are memorable because they fill unmet needs and typically take place outside of schools. For more on signature experiences, please read **https://www.edsurge.com/news/2016-03-15-signature-experiences-the-moments-we-fall-in-love-with-learning**.

Figure 2-2: Fostering an Intentional Mindset

Section 3 shares our approach to fostering an intentional mindset for *Taking Making into Schools*. Design challenges link making as a pedagogical orientation, a subject of study, and an integrative component of the mandated curriculum. Design challenges draw on students' previous learning, topics/concepts within the curriculum, and the use of the design thinking process. Please see Section 3 for details.



How You Might...

...Introduce Design Portfolios

As part of your instructional and assessment strategies, ask your students to maintain their own design portfolios. Design portfolios can be a large envelope or 3-ring binder. Students can keep their design thinking worksheets in their design portfolios and use the portfolios to maintain ongoing sketches and sketch noting.

In terms of sketch noting, you might want to refer to the free download, *Ditch That Textbook,* for tips on sketch noting/graphic note taking (**http://ditchthattextbook.com/**).

A design portfolio allows you to support your students' growth through reflective, formative dialogue. Table 2-1 suggests ways in which you can foster growth through dialogue with and amongst your students. The table builds on the work of Schön (1987) and Svarovsky and D. W. Shaffer (2006).

Table 2-1: Fostering Students' Growth through Reflection and Formative Dialogues

	Description	Example of Opening Dialogue
Reflection-on-action	Comments made about students' actions/activities that have already taken place.	Great start on your thinking. Appreciated the details and descriptions of your sketches.
Reflection-in-action	Comments made about students' current actions/activities or plans that are about to take place or could take place in the future.	Good initial ideas. Wonder what your next steps will be? Who else might you consult with to improve your design idea?
Skill Development	Comments made about students' skill improvement, areas of strength, and areas needing growth.	Good use of perspective and detail in your sketches. Wondering if you have considered other ways of representing your thinking?
Knowledge	Comments made on students' domain expertise.	Excellent demonstration of your growing understanding hydraulics and how hydraulics can make your design more functional and efficient.
Values	Comments made probing students' aesthetics, beliefs and social justice.	Your design suggestion is a wonderful example of simplicity and function in addressing how a homeless person might keep their possessions dry and why that might be problem in the spring weather conditions.
Agency	Comments made about students' proactive thinking and personal problem finding efforts.	Excellent initiative in determining who to need to interview and why their point of view might be important to your design.

...Discuss "Not Yet" Reporting Options

Meet with your colleagues and school administration and discuss how your present reporting options allow for "Not Yet" comments to be included.

...Explore MindSet Kit Resources

Explore the free open resource MindSet Kit (**https://www.mindsetkit.org/?utm_source=Mindset+Kit+Updates&utm_campaign=8efa5e8708-7_11_16_MSK_List_First_Step_Language&utm_medium=email&utm_term=0_fb3a4dfa59-8efa5e8708-85733961**). Amazing collection of lessons, ideas, prompts and research supporting the importance of fostering a growth mindset.

...Apply ISTE Standards for Students

Review the ISTE Standards (**https://www.iste.org/iste-standards**) and use them to develop growth oriented learning opportunities.

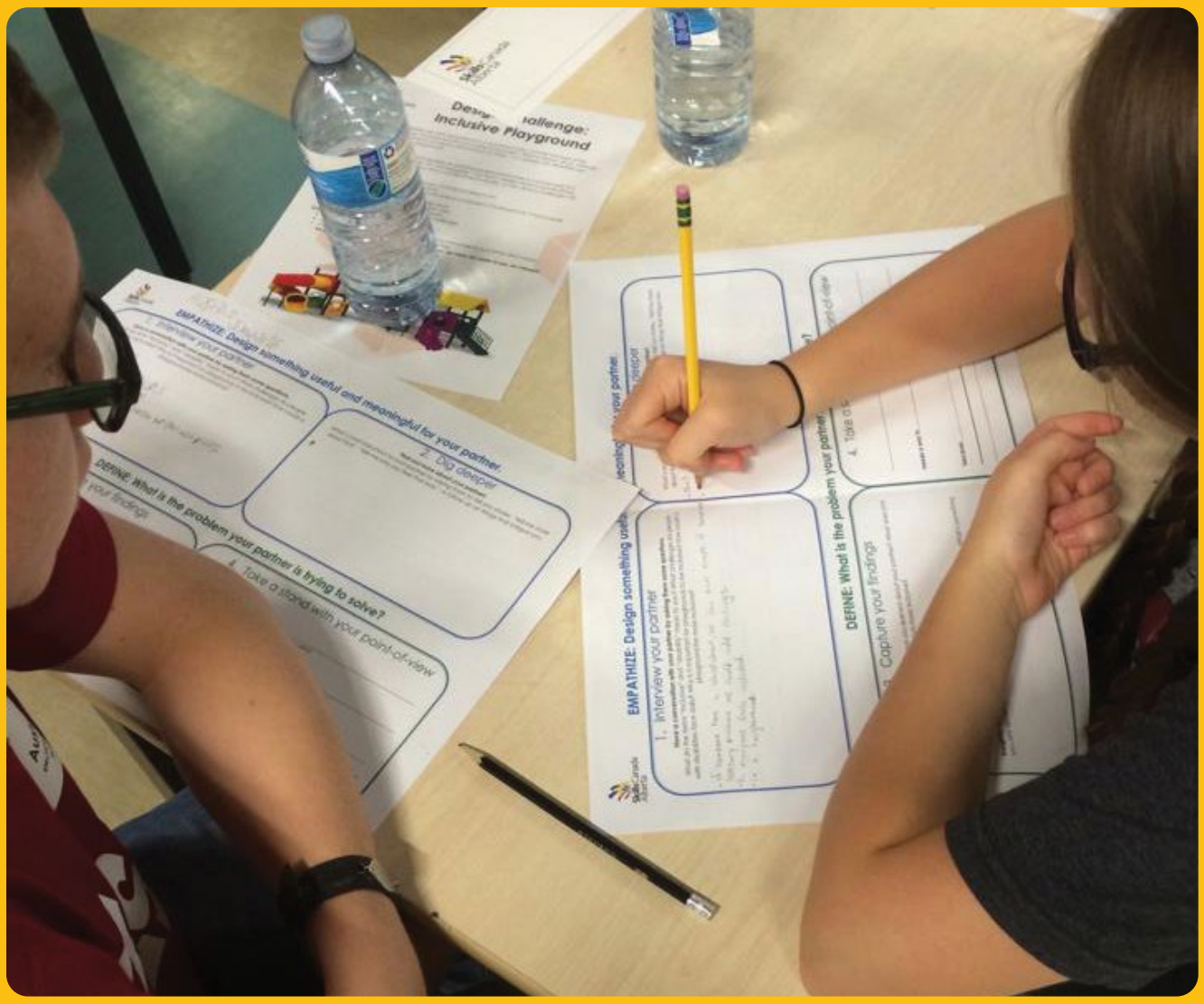


Photo: **Skills Canada Alberta**

SECTION 3

DESIGN CHALLENGES: PROMPTS FOR LEARNING AND HARD FUN

Introduction

Seymour Papert, the MIT educator and innovator who co-developed the computer program LOGO and the pedagogy of constructivism, coined the phrase "hard fun." He came to this phrase after listening to students as they programmed their software turtles using his program LOGO. Students described their initial work as being fun and hard—hence "hard fun." Please see **http://www.papert.org/articles/HardFun.html** for details. *Taking Making into Classrooms* should be hard fun; it should link learning, making and curriculum together in engaging ways.

Using makerspaces (please see Section 9) and participating in Making Faires[1] are also hard fun. They have a place and a value in our informal learning. However, while working in makerspaces and participating in Maker Faires may support curricular goals, the intentionality suggested in Section 2 might be missing. Without an intentional mindset, making risks becoming just another event or an additional thing to fit into an already overcrowded curriculum. Our work suggests that through the creation of contextually relevant design challenges, teachers can take making into their classrooms in intentional, sustainable and meaningful ways.

Students can think about design challenges in two ways—first, as an act of design (the what) and second, in the choices of which skills (the how) and technologies (the help) assist in the process of making. As Papert (2005) stated, "You can't think about thinking without thinking about thinking about something." We suggest that it is hard to make something worth making without having a design challenge worth solving. Equally important is a process by which you engage in problem finding, inquiry, tinkering, thinkering, and reflecting to develop a solution.

A design challenge positions making within a particular context, inviting students to collaboratively engage in design thinking as a process to define the problem (problem finding) and to prototype solutions (tinkering). While design thinking is similar to the scientific method, it differs significantly in terms of its focus on empathy and human-centred concerns. For more on the similarities and differences between the design process and the scientific method, please read **http://www.renovatedlearning.com/2016/02/08/teaching-the-design-process/**.

The design thinking process used in *Taking Making Into Classrooms* modifies the five step approach honed at Stanford's d.School into four phases (design, tinker, thinker, reflect). It consists of five activities (design challenge, human-centred design thinking process, collaborative prototyping, design charrette, individual/group reflection), which will be described starting in Section 5.

Design challenges support inquiry and problem based learning. When inquiry and problem based learning are supported by making through a design thinking process, teachers have the potential to encourage problem finding. Teachers can invite students to locate relevant and just in time information while tinkering with ideas, concepts, materials, and information as they prototype a possible solution.

1 Examples include **http://makerfaire.com/; http://ets.educ.ubc.ca/ubc-centennial-maker-faire/**

Deepen Your Understanding

Our experience suggests there are three primary ways to structure a design challenge.

1. As an inquiry question
2. As a problem to be solved
3. As a scenario to play out

Inquiry questions encourage exploration and engagement with curricular topics. For an example of inquiry based learning in mathematics, please explore the site *Looking at Math as Inquiry* **http://karimkai.com/on-purpose/**.

Problem solving is "cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver," (Mayer & Wittrock, 2006, p. 287). They explain learners need five kinds of knowledge to be successful problem solvers:

- **Facts:** knowledge about characteristics of elements or events;
- **Concepts:** knowledge of a categories, principles, or models, such as knowing what place value means in arithmetic or how hot air rises in science;
- **Strategies:** knowledge of general methods, such as how to break a problem into parts or how to find a related problem;
- **Procedures:** knowledge of specific procedures, such as how to carry out long division or how to change words from singular to plural form; and
- **Beliefs:** cognitions about one's problem-solving competence (such as "I am not good in math") or about the nature of problem solving (e.g., "If someone can't solve a problem right away, the person never will be able to solve it").

Problem based learning (PBL) is a student centred approach that positions learning in the form of open questions. Students typically work in groups and are encouraged to share what they already know, pose questions about what they need to know, engage in research, and form a theory or series of ideas about what they have learned. PBL can be used to support making as students can make their learning visible in tangible demonstrations of learning. Please check out the Edutopia resources on PBL available from **http://www.edutopia.org/video/5-keys-rigorous-project-based-learning**.

Scenarios provide information and context in the form of a story or narrative. The purpose of a scenario is to set the scene for a project, introduce learners to a project, and to create a common starting point. A scenario can also set the parameters for the project, outline any limiting factors, special conditions, and time/context constraints. Scenarios are creative ways of imagining a "different future" or an alternative way of doing something. They help the learners visualize the context for the task as they usually cover environmental, social, technical, political, and economic concerns.

Structure of a Design Challenge

We often use scenarios to invite students into the design challenge. Scenarios help students to visualize the context in which the inquiry or problem is situated by creating a story or narrative for student engagement with the challenge.

We have learned there is a simple elegance to drafting a good design challenge. Building on Papert's idea of hard fun, we think a design challenge needs to be open enough to invite multiple perspectives, insights and solutions while structured enough to provide support and initial direction. Design challenges bridge prior learning so existing curriculum, content, and contexts can be situated within challenge components. Table 3-1 describes the parts of our design challenge format. Curriculum links can be introduced in the Overview and Design Rationale. How students are to engage with the challenge can be positioned with the Problem Scenario. Assessment can be explained in the Success Determinants section, while the Parameters

section can be used to scope the learning activities within the possibilities of a specific classroom learning environment (i.e. access to tools, resources, materials, etc.).

Section 12 offers examples of our well-tested design challenge structure. Please see Sample Design Challenge 1: *Designing a Healthy Lunch Experience* on page 73, which links the curriculum areas of health and nutrition with making and design.

Table 3-1: Design Challenge Components and Descriptions

Design Challenge Component	Component Description
Overview	Introduction to the challenge to provide an authentic learning context or situation.
Design Rationale	Short explanation of why the challenge is in fact a challenge worth addressing and links students' prior learning while also providing links to new information. Resources and sources to guide initial inquiry work can be positioned here.
Problem Scenario	Paragraph inviting participants into the challenge and explaining the role/reason for their group's involvement in addressing the problem.
Success Determinants	Usually begins with "Success will be determined by the degree to which your design solution:" followed by criteria for assessment using suggested characteristics/attributes that constitute a good design solution for the challenge.
Parameters	Specific issues, constraints or limiting factors impacting the participants, which should be addressed (i.e. rules, limitations) for the group to negotiate.

A well-crafted design challenge fosters heads-in (content); hearts-among (empathy, curiosity and purpose); hands-on (skill sets) and creates rich, multidimensional/multimodal/multimedia opportunities for students to demonstrate what they know and how they came to know it in deep and personal ways.

For example, *Designing a Healthy Lunch Experience* works well because it positions making in the aid of a complex problem: why the majority of people do not get adequate nutrition during the workday. It might even begin to address the wicked problem of affordable food, childhood obesity, and wellness.

Complex and Wicked Problems

Complex problems are challenges without an easy or obvious solution. The site Citizen Math (**https://www.citizenmath.com**/) shares rich and engaging examples of complex problems positioned with math and science. The site approaches math and science as subjects for inquiry and problem based learning, reminding teachers that when they give students too much information (just-in-case learning), the task for students becomes merely finding the correct answer.

"If you ask teachers to define the purpose of math class, I suspect many would say something along the lines of, 'To help students become better problem solvers.' As a community, we seem to equate learning math with solving problems, where the goal is to illustrate some underlying mathematical concept: proportionality, linearity, etc. Unfortunately, the tasks we've traditionally relied on for this are often so forced as to be caricatures of themselves.

Confronted with problems like these, students frequently ask of math, 'When will I ever use this?' Yet as many teachers have pointed out, this may not be their real question. Instead, 'When will I use this?' may be code for, 'I don't get this and I feel dumb.' Traditional tasks often reveal so much information on the front-end that students interpret their responsibility as to calculate an answer rather than to engage in a problem-solving process," (**http://karimkai.com/on-purpose/?utm_source=EdsurgeTeachers&utm_campaign=096643cdc9-Instruct+215&utm_medium=email&utm_term=0_3d103d3ffb-096643cdc9-292150001**).

Inquiry and problem based learning, supported by design thinking and making, encourage problem finding, locating relevant and just-in-time information, and tinkering with ideas, concepts, materials and information in order to prototype a possible solution. You might want to explore the inquiry based learning resources available from **https://www.learnalberta.ca/content/kes/pdf/or_ws_tea_inst_02_inqbased.pdf**.

Wicked problems are defined as social, cultural or environmental problems that appear impossible to solve because:

- there is incomplete or contradictory knowledge about the problem itself;
- the number of people and opinions involved and the potential large economic burden add additional layers of complexity; and
- the actual problem is interconnected with other problems (**https://www.wickedproblems.com/about.php**).

Wicked problems include issues such as global warming, poverty, homelessness, equality, and health and wellness. Horst Rittel (1973) identifies ten characteristics of wicked problems:

1. Wicked problems have no definitive formulation. For example, poverty in North America is different from poverty global south.
2. It's hard, maybe impossible, to measure or claim success with wicked problems because they bleed into one another, unlike the boundaries of traditional design problems that can be articulated or defined.
3. Solutions to wicked problems can be only good or bad, not true or false. There is no idealized end state to arrive at, and so approaches to wicked problems should be tractable ways to improve a situation rather than solve it.
4. There is no template to follow when tackling a wicked problem, although history may provide a guide. Teams that approach wicked problems must literally make things up as they go along.
5. There is always more than one explanation for a wicked problem, with the appropriateness of the explanation depending greatly on the individual perspective of the designer.
6. Every wicked problem is a symptom of another problem. The interconnected quality of socio-economic political systems illustrates how, for example, a change in education will cause new behavior in nutrition.

7. No mitigation strategy for a wicked problem has a definitive scientific test because humans invented wicked problems and science exists to understand natural phenomena.

8. Offering a "solution" to a wicked problem frequently is a "one shot" design effort because a significant intervention changes the design space enough to minimize the ability for trial and error.

9. Every wicked problem is unique.

10. Designers attempting to address a wicked problem must be fully responsible for their actions.

Written at grade/content appropriate levels, wicked problems make an important starting place for design challenges because, by definition, the problems are ill structured, complex, situational, and authentic. Complex and wicked problems require extended periods of time and effort to address them well, so both types of problems support a sustained investigation or inquiry.

How You Might...

...Introduce a School Wide Initiative

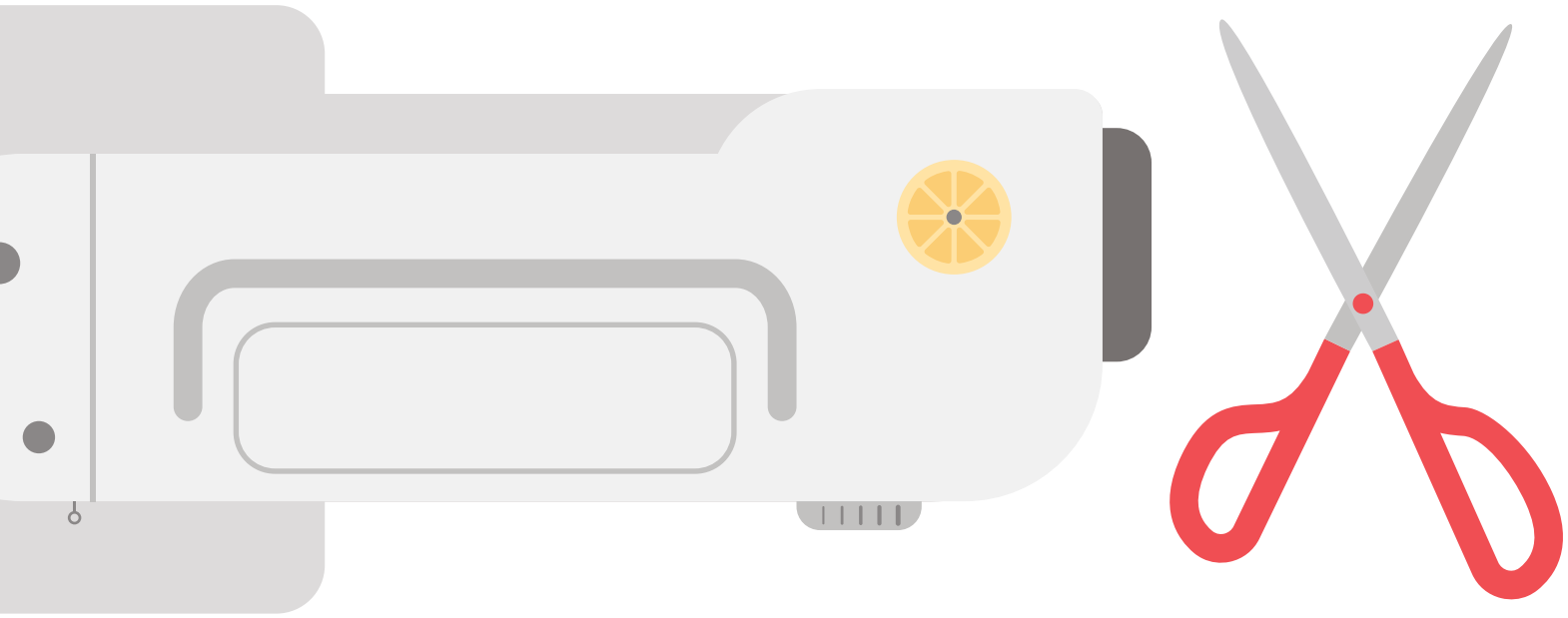
Consider ways in which you could create a complex or wicked problem that would be the focus for your school for an entire semester or school year. How might it focus fund raising, social justice initiatives, guest speakers, and community engagement activities for that time period?

...Develop an Inquiry Based Unit of Study

Consider ways in which a complex or wicked problem could be the focus on inquiry within a classroom for a sustained period of time. Could a complex or wicked problem be the way to introduce a unit of study? Can you determine a curricular link to a big idea and develop a Design Challenge to help students uncover the deep, personal learning within the learning outcomes while gaining the required competencies?

...Explore Resources

Please explore **http://www.learnalberta.ca/content/kes/pdf/or_ws_tea_inst_02_inqbased.pdf** and **https://open.alberta.ca/publications/0778526666**.



Crafting a Design Challenge

Crafting a design challenge is the same whether you start with a complex or wicked problem, a curricular objective, or a learning outcome. After years of using the structure in Table 3-1, we have found that each component included in the design challenge is essential and interrelated. You do not need to start writing the components in the order in which they will ultimately appear in the design challenge. Our experience tells us that as you write each component, the other components will need to be modified and edited to reflect your intent. The design challenges consist of the following components:

- **Overview Statement** provides the background for the challenge.
- **Design Rationale** provides the authentic context for why the challenge is important. It connects the actual challenge to the students' learning by situating it within class discussions or experiences.
- **Problem Scenario** invites students into the challenge and explains the groups' roles and reasons for involvement in addressing the challenge.
- **Success Determinants** provide the criteria for how the design solutions will be assessed or peer evaluated during the design charrette. Examples of assessment strategies are offered in Section 4.
- **Parameters** set the rules and limitations to which groups have to adhere. Parameters explain the opportunities, constraints, rules, requirements to use the materials, resources, tools available during the challenge.

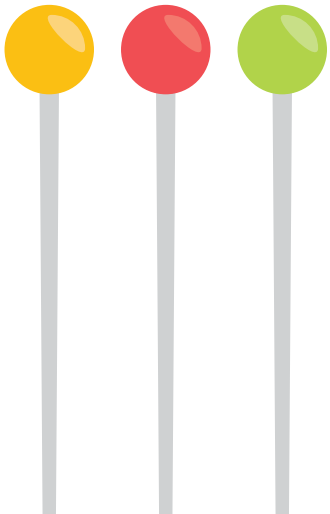
Tips on crafting each component follow.

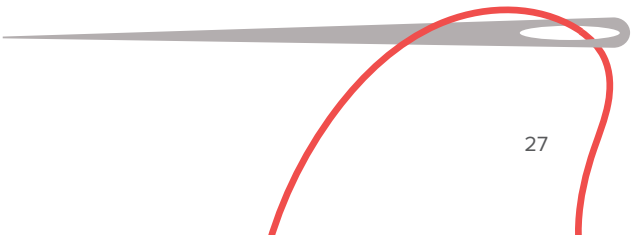
Overview

- Typically, the overview is very short and subtly positions the challenge within what the students already know (previous curriculum or field trips or shared experiences).
- The introduction makes the challenge real by situating it within current events, history, your community, etc.
- Depending on the literacy levels of the students, web links can be provided that link the challenge to existing content/resources. You might want to consider linking to or creating an accompanying WebQuest (**http://webquest.org/**) to focus the students inquiries and web searches.

Design Rationale

- In this section, new learning/content can be introduced.
- Again, a WebQuest, web links, or other resources can be added.
- If there are local experts you can invite into class or bring in via video/audio links, this is where you could list/name them. Local experts could be extremely valuable when you get into the design thinking process, as the students can interview them to gain further empathy and understanding of the challenge.
- Linking to Ted Ed (**https://ed.ted.com**) and other sources of expertise on timely topics can enhance students' understand of the significance of the challenge in which they are engaging. For example, if your design challenge is focusing on Global Warming, you might incorporate Erin Eastwood's Ted Ed on wildlife adaption to climate change (**https://ed.ted.com/lessons/can-wildlife-adapt-to-climate-change-erin-eastwood**). The Ted Ed link provides content expertise and the "Discuss" link provides an interesting guided discussion question that could be shaped into a great inquiry question for the next component—Problem Scenario.





Problem Scenario

Everyone loves a good story. Scenarios provide a narrative that helps students move from merely thinking about concepts in an abstract sense (theoretical knowledge) to feeling about the concepts and applying them in real or concrete applications. It helps students to shift from passively reading about/thinking about information to doing something with the information. When passively learning, students typically respond to teacher questions by finding correct answers. When actively creating their own knowledge about complex things, students begin to form their own questions, and to recognize that learning is not merely about answers, it is about great questions. Einstein said it best: "Education is not the learning of facts, but the training of the mind to think."

Success Determinants

- Design thinking and making engage students in a process that tends to lead to a product.
- Assessment of the process is as important as evaluation of the product.
- Consider informal, formative and summative forms of assessment, including self and peer assessments. See Section 4 for suggestions.

While the best design challenges will be the ones you write for your own students in your own classroom contexts, Section 12 offers a variety of design challenges that you might want to use with your students or to inform your design challenge development.

Parameters

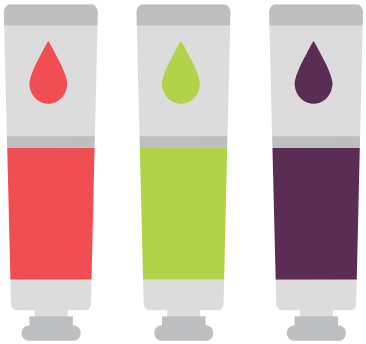
- Parameters set the ground rules for working within the challenge. For example, this section might tell students what they have to use or do to create common experience—i.e. students to have to use something of everything in a group kit provided for them, whereas they have the option to use things in a shared pantry of consumable items.
- Students should be directed to a Safety Station where they can be shown the proper way to use the tools and materials available during the challenge. Please see Section 8—Safety Issues.

How You Might...

...Modify Sample Design Challenges

Modify one of the Design Challenges from Section 12 to fit into your context (curricular area, student skills and abilities).

Modify one of the design ideas from Section 8 to fit into your context (curricular area, student skills and abilities).



SECTION 4

ASSESSMENT: REIMAGINING WAYS TO VALUE PROCESS, PRODUCT, CREATIVITY, AND LEARNING

Introduction

Most of us have read Einstein's quote: "Imagination is more important than knowledge." Fewer of us have seen the rest of the quote: "For knowledge is limited to all we know and understand, while imagination embraces the entire world, and all there ever will be to know and understand." Einstein was not suggesting that imagination become separate or opposite from knowledge; rather, he believed the two supported one another in important ways that lead to innovation, creativity, and action.

"When ideas fuel inspiration, the in-between state that leads to action is imagination. We crossed the oceans to discover new lands, invented the means to travel the world, reached for the stars and landed on the moon. All that started as an idea first held in the minds of imagination. Imagination is the highest freedom of all and the one that no one can deprive us of. The greatness of creative imagination is praised not only by the romantics and artists of this world, but the brightest of scientific brains," (Haralabidou, 2015, https://www.virgin.com/entrepreneur/great-ideas-is-imagination-more-important-than-knowledge).

Einstein's famous statement on imagination was part of an essay explaining why, at times, he would know something was correct but did not have the facts or proof to know why. He stated, "at times I feel certain I am right while not knowing the reason. When the [solar] eclipse of 1919 confirmed my intuition, I was not in the least surprised. In fact, I would have been astonished had it turned out otherwise. Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution. It is, strictly speaking, a real factor in scientific research," (From A. Einstein, Cosmic Religion: With Other Opinions and Aphorisms, p. 97, 1931).

When we invite students into Inquiry Based Learning and Problem Finding, we are asking them to use both their knowledge and their imagination to envision alternative solutions to complex or wicked problems (see Section 3). We are inviting them to take risks, design alternatives, and engage in risk-taking and critical/creative thinking. Each of the things we ask students to do tend to be processes, and each process takes time to learn and master. It is important to remember that rarely do we bother to inquire into things that are factual knowledge; rather, we inquire into conceptual concerns or big ideas. For example, there is no need to ask about the name of a particular provincial capital. It is more meaningful to ask about why one city rather than another is the provincial capital—what were the economic, political or geographic reasons, etc.

A current issue for many teachers is that traditional, school based assessment tends to be product oriented. However, British Columbia, as well as other jurisdictions, are changing their views on assessment, aligning more closely to Carol Dweck's work on growth that was shared in Section 2. How we value / assess students' learning appears to directly influence their mindset and attitude toward learning. In a study of hundreds of primarily adolescent students, Dweck and her team discovered three significant findings. They gave "each [student] ten fairly challenging problems from a nonverbal IQ test, then praised the student for his or her performance—most had done pretty well. But they offered two types of praise: Some students were told "Wow, you got [X many] right. That's a really good score. You must be smart at this," while others, "Wow, you got [X many] right. That's a really good score. You must have worked really hard." In other words, some were praised for ability and others for effort. The findings, at this point, are unsurprising yet jarring:

The ability praise pushed students right into the fixed mindset, and they showed all the signs of it, too: When we gave them a choice, they rejected a challenging new task that they could learn from. They didn't want to do anything that could expose their flaws and call into question their talent. In contrast, when students were praised for effort, 90 percent of them wanted the challenging new task that they could learn from.

The most interesting part, however, is what happened next: When Dweck and her colleagues gave the students a subsequent set of harder problems, on which the students didn't do so well. Suddenly, the ability-praised kids thought they weren't so smart or gifted after all. Dweck puts it poignantly: If success had meant they were intelligent, then less-than-success meant they were deficient," (Popova, 2014, par. 11–12 **https://www.brainpickings.org/2014/01/29/carol-dweck-mindset/**).

We have worked closely with teachers who want to take making into their classrooms. They recognize that substantial educational change is necessary. Wiggins and McTighe's classic book, *Understanding by Design* (2005), is helpful in identifying ways to change practice. They suggest teachers should begin with the learning outcomes in mind and:

1. focus on teaching and assessing for understanding and learning transfer; then
2. design curriculum "backward" from those ends (McTighe & Wiggins, 2012, p. 1).

Backward design is a helpful way to consider the development and use of design challenges because it encourages us to think about students' demonstrations of learning (the product) as well as the process we want to encourage as they learn. McTighe and Wiggins argue that students truly understand when they:

- can explain concepts, principles, and processes by putting them in their own words, teaching them to others, justifying their answers, and showing their reasoning.
- can interpret by making sense of data, text, and experience through images, analogies, stories, and models.
- can effectively use and adapt what they know in new and complex contexts.
- demonstrate perspective by seeing the big picture and recognizing different points of view.
- display empathy by perceiving with sensitivity and trying to walk in someone else's shoes.
- have self-knowledge by showing meta-cognitive awareness, using productive habits of mind, and reflecting on the meaning of the learning and experience (p. 5).

Wiggins (2005) offers an overview of the backward design approach as well as a template, which can easily be used with the design challenge structure shared in Section 3. As you write your own design challenges or modify those provided in Section 12, you need to consider what the success determinants are for a specific challenge and share them with your students.

Types of Assessment

We use the term "Success Determinants" because it is more consistent with the iterative nature of the process of design. However, we recognize that teachers need ways in which to assess student learning when making and design are situated within formal, intentional learning settings such as schools. Typically, we think of assessment in three distinct ways:

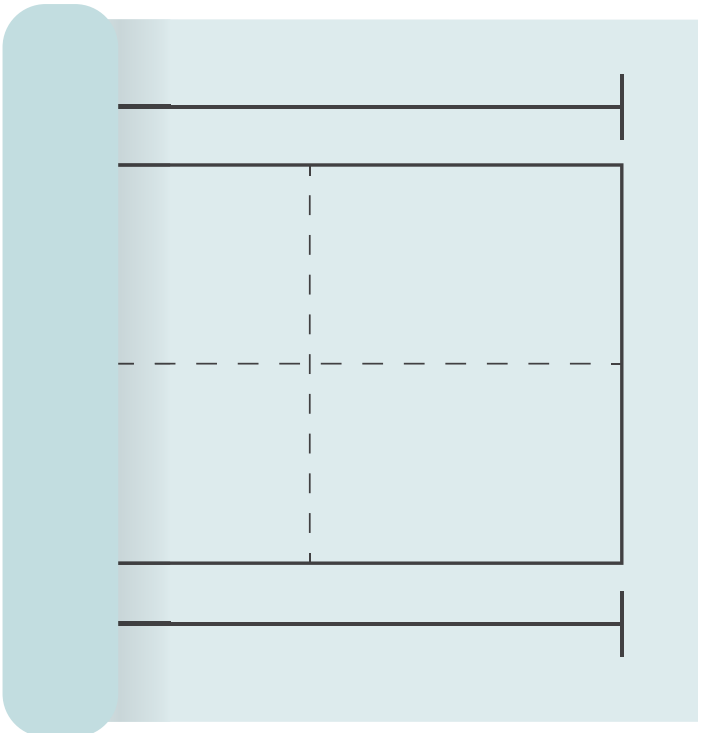
- **Assessment for Learning**—formative assessment or ongoing assessment that helps teachers modify their teaching and activities to support student learning.
- **Assessment of Learning**—summative assessment typically done at the end of a unit or project. While it does little to improve student learning, it does provide a snapshot of a student's skills and abilities at a specific moment on a specific task.
- **Assessment as Learning**—informal assessment that allows a student to learn more, make modifications, etc. It is aimed specifically at helping the student improve. It might be useful to think of assessment as learning as an ongoing form of coaching.

The Board of Studies Teaching and Educational Standards, New South Wales, Australia, clarifies the distinction amongst the three types of assessment, stating, "Assessment for learning and assessment as learning approaches, in particular, help teachers and students to know if current understanding is a suitable basis for future learning. Teachers, using their professional judgment in a standards-referenced framework, are able to extend the process of assessment for learning into the assessment of learning," (2012, par. 3).

Further, they describe Assessment **for** Learning as involving "teachers using evidence about students' knowledge, understanding and skills to inform their teaching. Sometimes referred to as 'formative assessment', it usually occurs throughout the teaching and learning process to clarify student learning and understanding," (par. 5).

They describe Assessment **as** Learning occurring "when students are their own assessors. Students monitor their own learning, ask questions and use a range of strategies to decide what they know and can do, and how to use assessment for new learning," (par. 6).

They describe Assessment **of** Learning as assisting "teachers in using evidence of student learning to assess achievement against outcomes and standards. Sometimes referred to as 'summative assessment,' it usually occurs at defined key points during a unit of work or at the end of a unit, term or semester, and may be used to rank or grade students. The effectiveness of assessment of learning for grading or ranking depends on the validity and reliability of activities. Its effectiveness as an opportunity for learning depends on the nature and quality of the feedback," (par. 7).



Success Determinants within the Design Challenge Format

When you use a design challenge you will need to determine the type(s) of assessment you want to accomplish and what factors you will accept as evidence of student learning. By adopting a constructionist pedagogy and using an inquiry or problem based learning instructional approach, you will be creating a more open, student centred learning environment. Therefore, identifying the success determinants in the design challenge is essential for fairness and transparency in assessment. For example, it would seem unfair to introduce students to the design thinking process, ask them to collect information, conduct research, create design notes and sketches and then only assess them on the final product of the process. Consider which if the following you might want to include as part of your assessment:

- Students' participation in the group design thinking process
- Students' understanding of key concepts positioned in the Overview and Design Rationale
- Students' understanding of specific content areas or curricular big ideas or competencies
- Students' understanding and abilities with developing skills and using appropriate technologies (tools)
- Students' ability to ask good questions and reflect on the process as well as their shared products
- Students' understanding of the challenge and the quality of the finished product
- Students' creativity and imagination
- Other aspects identified in lesson outcomes or curricular modules

Assessment Tools

Success determinants for a design challenge can be spelled out in general terms for the students. As the teacher, you will probably want to develop an assessment tool that allows you to make a fair and equitable assessment of student learning that might be demonstrated in a variety of ways. Fair and equal are challenging concepts, and open ended, project based

learning pushes teachers to think creatively about how to be fair and accountable to student learning.

There are a variety of assessment tools you might use. We suggest the following:

- **Design Portfolio** – see the How You Might… tip in Section 2. A design portfolio allows you to support your students' growth through reflective, formative dialogue.
- **Rubrics** – used to assess performance along a continuum. Please see Section 12 for the *Simple Machines* Sample Design Challenge. We created a rubric using Rubistar (**http://rubistar.4teachers.org/index.php**).
- **Checklists** – used to record Yes/No observations of students' abilities against specific criteria. Criteria need to be written clearly and linked to specific learning outcomes, skills and abilities.
- **Rating Scales** – observations of students' abilities against specific criteria for assessment along a range—always, sometimes and never; or fair, good, excellent. Criteria need to be written clearly and linked to specific learning outcomes, skills, and abilities.
- **Anecdotal Notes** – teacher recorded observations that are typically informal, short, and describe a student's developing understanding and participation throughout a design challenge or inquiry unit. They focus on behaviours as well as skills and abilities.
- **Observation Checklists** – allow teachers to make quick yes/no observations of what students can do, how they interact with others, and how they are progressing through the process of a design challenge.
- **Portfolios** – a purposeful compilation of design notes, sketches, digital documentation, and other evidence that students are asked to collect throughout the design challenge. Each element of the design challenge (see Section 5) can generate items for inclusion on a portfolio.
- **Peer Assessment** – student peers can use checklists or rubrics to assess classmates' work on a design challenge.
- **Self-Appraisal** – students can use a framework to consider their own learning and achievement within or across specific or open learning outcomes.

Teachers know that assessment practices are the tail that wags the pedagogical dog. If assessment stays the same (i.e. only summative or standardized examinations, etc.) then innovative ways of teaching and learning become lost in the battle over what counts as learning. Changes in assessment in British Columbia are going a long way to address this concern and the introduction of the Applied Design, Skills and Technologies framework and curriculum can help us to take making into the classroom in an intentional way.

As David Gooblar writes in his blog, "real learning comes from practice and from awareness of past missteps. When we don't let students redo their graded work for credit, are we telling those students who did poorly that there's no point in trying to learn from their mistakes?

I see two main arguments here:

- The first is that we unfairly reward students who get it right the first time, while penalizing those students who need more time to learn what's being tested.
- The second is that we discourage students from working to learn from their mistakes," (2016, para. 6).

Wiggins and McTighe's work on assessment within *Understanding by Design* offers support to teachers as they make substantial change to assessment.

How You Might...

1. Review the assessment suggestions made in the How You Might... tip in Section 2.
2. Consider ways in which you might integrate success determinants into existing assessment practices.
3. Reflect on the ways in which you currently use the assessment tools and ideas presented in Section 3.

Photo: **Skills Canada Alberta**

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

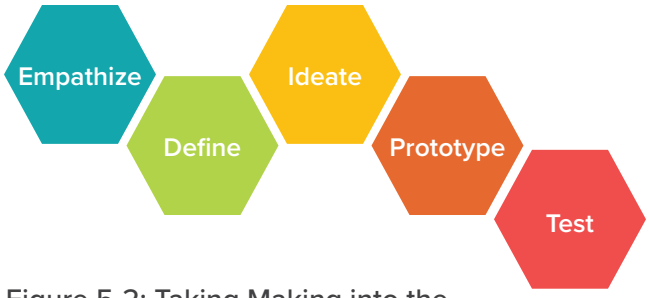
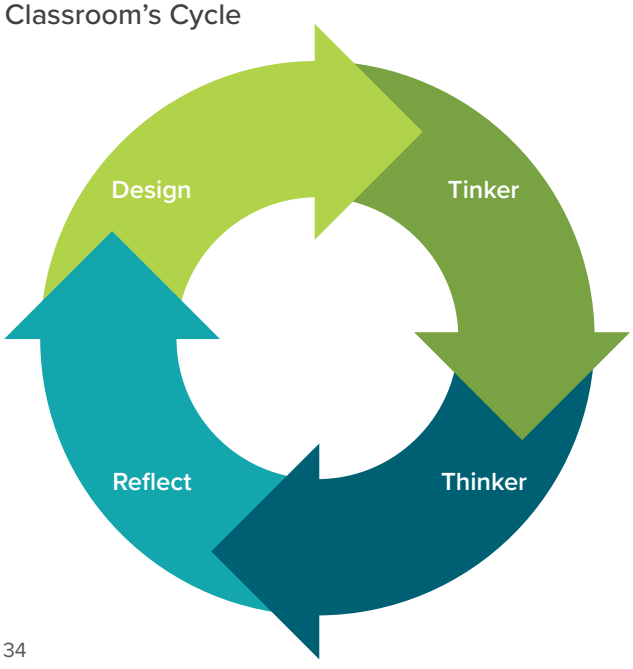


Figure 5-2: Taking Making into the Classroom's Cycle



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://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf**). 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

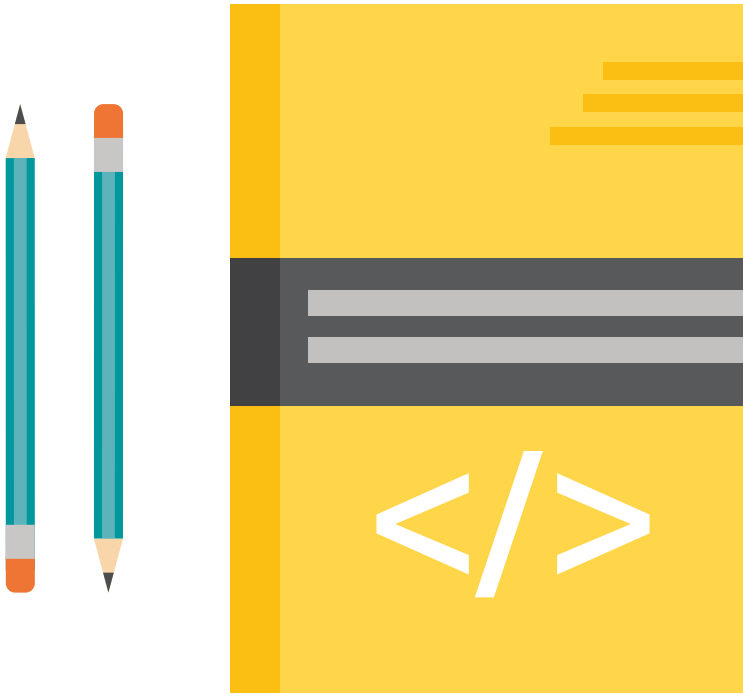
- What are your next steps?
- What are you willing to do to refine this?
- What strengths do you see with this?
- What would be helpful in assisting you?

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

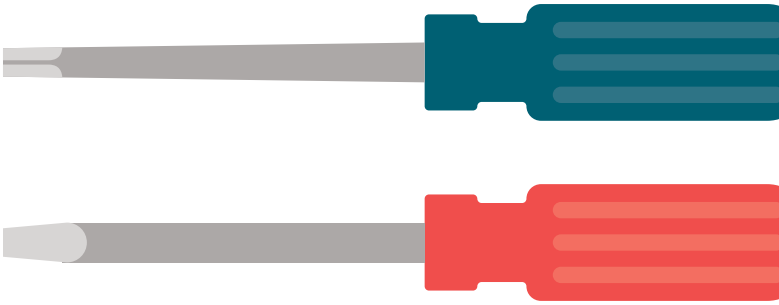


Table 5-2 aligns the *Taking Making into Classrooms* phases and activities with other design processes. Please note, each of these phases can contribute significantly to the assessment process as each contains evidence of student learning.

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 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.

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/resources**) 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**

SECTION 7

INTENT AND CHOOSING A MAKER EXPERIENCE FOR YOUR CLASSROOM

Introduction

Taking Making into Classrooms is both a pedagogical choice and a domain to be studied.

The new Applied Design, Skills and Technologies (ADST) curriculum in British Columbia requires educators K–12 to introduce design and making K–5 in an integrated, cross curricular way, while Grades 6–12 have specific content areas for study.

Many teachers will tell you that the curriculum is already too overcrowded to add anything more. Even with the ADST curriculum, teachers feel pressure both to cover the curriculum and to address new learning opportunities. We suggest that a maker approach allows teachers and their students to uncover the richness embedded in the curriculum and work together to make meaning. Rather than attempting to cover content in a linear, scope and sequence approach, which is often termed "just-in-case learning," our experience tells us uncovering what is needed to know in time to address a learning challenge supports personalized learning and is more authentic and real! This is typically termed "just-in-time learning." It provides learning as it is needed or required rather than teaching concepts or ideas "just in case" students might need them at some point in the future (e.g. on an exam, etc.).

The introduction of makerspaces into some schools has already added pressure for many teachers. School districts have raced to create makerspaces, retrofit libraries into learning commons, and add events like Maker Faires to the already busy school year. By taking making into classrooms in an intentional way, we suggest that rather than adding another thing to the curriculum, making could become the way to uncover your curriculum in a proactive, engaged, and personal way. Making as both pedagogy and a domain of study (ADST) helps teachers to foster an intentional mindset with their students and integrate making into learning. When we take the time to unpack the name–Applied Design, Skills and Technologies we come to understand that design is the provocation for the development skills needs to complete the design and use the technologies. Making is not amateur shop class, and

Deepen Your Understanding

The Maker Movement—A Global Perspective

We all have a need to make. It stems from our curiosity with the world and our basic desire to make things and then make those things better. Our earliest ancestors led the way in making when they crafted the first hand tools in East Africa and experimented with fire. They continued to make things and make those things better as they adapted to new locations and migrated around the world.

There is a growing interest in learning how to make things rather than buying them—it is called the Do-It-Yourself (DIY) movement. People are growing tired of cheaply made, disposable goods that cannot be repaired or modified. Increasingly, people are turning to traditional ways of doing things. Many are turning away from prepackaged food items with little nutritional value or poorly made items that are expensive, complicated, and have proprietary parts that are not interchangeable and cannot be reused.

Globally, we are reclaiming our need to make and we are formalizing it into a movement. We are creating shareable workshops (makerspaces), providing hours of online instructional videos (e.g. **YouTube** and **Instructables**), and offering workshops. (From the *Toolkit for Challenging Contexts*, p. 6.)

it is an intentional way for students to create meaning using actual tools, materials and resources, informed by design thinking.

Four Learning Intentions

All classrooms in any school can support making, but teachers must consider the intent of the learning and the purpose of the making. With the recent announcement from the BC Premier's office concerning the need to introduce coding in schools, educators are additionally stressed to find ways to integrate programming, robotics, and ICT in their work. We suggest positioning coding and simple circuits with appropriate technologies within making in order to use them to add functionality to student designs. Please see Section 10 for suggestions.

We suggest four learning intentions you might consider prior to taking making into classrooms. You will probably want to modify our intentions and add nuances that are supportive of your context (e.g. physical resources, student readiness, your readiness, etc.). Table 7-1 states the learning intentions and suggests purpose, tools and materials needed, along with ease of use and cost implications.

Table 7-1: Learning Intentions

	Learning Intention	Description	Basic Tools (See Section 9 for details)	Basic Materials
Introductory, Inexpensive, Simple ↓ Advanced, Expensive, Complex	**Design and Basic Making**	Introduction of design thinking and the making of simple, tangible items to illustrate design ideas in 3D	Hand tools, including glue guns, rulers, knives, scissors, etc.)	Cardboard, recycling, simple dollar store items
	Design and Simple Prototyping	Introduction and continued use of design thinking and more elaborate prototyping of ideas to scale	Hand tools and simple power tools such as Dremel tools, electric drills, etc.	Cardboard, recycling, simple dollar store items with additional of Styrofoam, plastic pipe and fittings and other materials that can easily cut and fastened
	Design and Fabrication	Use of design thinking and introduction of fabrication to create working prototypes at scale	Hand and power tools with option for 3D printers, CNC machines, etc.	Use of authentic materials
	Design, Prototyping, Circuitry and Coding	Use of design thinking with the addition of coding and circuitry to add functionality to prototypes	Hand and power tools, soldering irons, circuits, breadboards, etc.	Use of authentic materials, including Arduino, circuits, etc.

Regardless of intention, *Taking Making into Classrooms* requires teachers to value their students' process over their final products. This is not to suggest that making cannot be assessed, as there will be plenty of evidence of student learning throughout the process of making: design thinking sheets, design sketches, negotiated group collaborative design sketches, models and prototypes, and reflections (see Section 4).

The challenge for teachers is to figure out ways to value the:

- learning and experience of each element of the design thinking and making process;
- time needed to gain the skills to use the technologies available;
- time spent and evidence gained through the design thinking process;
- effort needed to participate well in a group; and
- actual work, frustration, joy, and struggle of design thinking and making.

Regardless of the learning intention, *Taking Making into Classrooms* allows students with any level of experience or skill to engage in design and making. Because of the openness of the design challenge structure, students can move away from projects that have been created using a step-by-step recipe approach (just-in-case learning) and explore things that are timely and of interest (just-in-time learning).

With an appropriately equipped makerspace or mobile maker kit, teachers can keep the learning affordable and flexible so there is little need for expensive kits or prescribed lessons. Please see Section 9 for ideas.

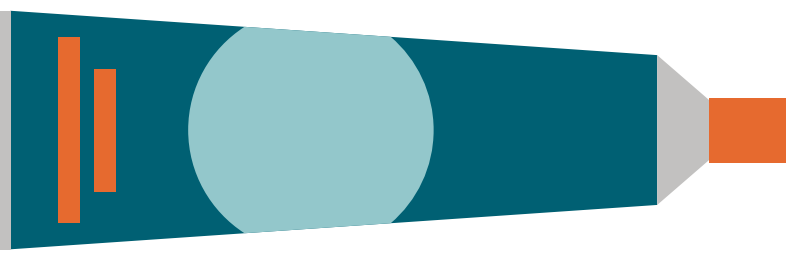
How You Might...

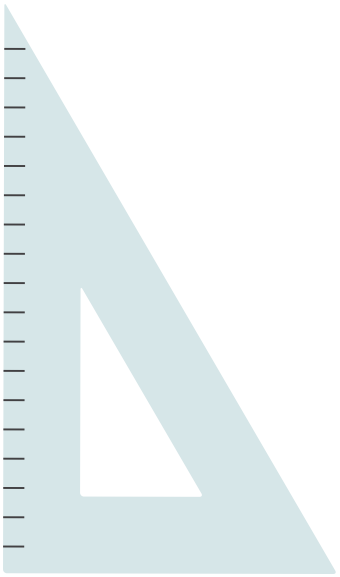
...Adapt Existing Spaces

There are numerous resources suggesting ways to create makerspaces or workspaces in existing classroom settings and school learning environments. Once you have thought through your pedagogical intent for *Taking Making into Your Classroom*, you might want to explore sites like **https://www.edutopia.org/discussion/2-quick-inexpensive-ways-add-collaborative-space-your-classroom**.

...Explore a Shareable Mobile Maker Configuration

It is not necessary to retrofit an entire classroom or library into a makerspace. You might want to consider creating a shareable, mobile maker configuration of tools, supplies, and resources. In Section 14, we suggest a list of tools to support a mobile maker configuration for classrooms.





SECTION 8

SAFETY ISSUES

Introduction

Taking Making into Classrooms is different from opening a school shop and periodically using the equipment without paying any mind to the potential hazards. Rather, teachers who incorporate making and design thinking into their classrooms must be aware of everything from safety equipment (i.e. eye and ear protection) to tool training changes and the most appropriate materials that are available for student use.

Linking Safety, Intent to Tools and Spaces

We take a just-in-time approach to safety issues, in order to introduce the need to be safe and maintain safe work spaces in a timely and situational manner. We know that students and teachers need to work safely, and safety issues are not something that should be taught to students in order to instill a fear of working with tools. Instead, safety should be taught to students to promote a sense of empowerment and confidence in their skills. We embrace the mantra from our colleagues and friends in Women in Trades Training (WITT), “Empowerment through power tools!”

When we can use powerful tools safely, we are empowered to do more and to try more. Empowerment is a strength-based approach to learning. Empowering both teaches and students allows them to overcome the mindset that tells them they won’t succeed due to factors like age, gender, or a lack of experience.

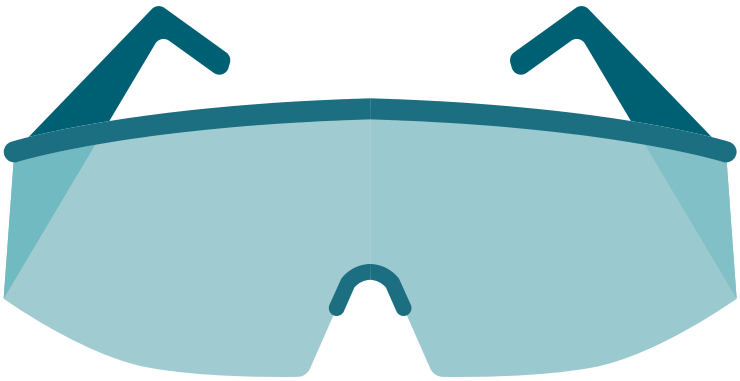


Table 8-1: Mapping Learning Intentions, Tools, and Safety

	Learning Intention	Basic Tools (See Section 9 for details)	Initial Safety Concerns
Introductory, Inexpensive, Simple	**Design and Basic Making**	Hand tools, including glue guns, rulers, knives, scissors, etc.)	Emphasis is on accurate measuring, safe cutting, and careful assembly. • Use of ruler both for measuring and as a straight edge to cut against • Safe ways to walk holding sharp objects • Safe ways to use hot elements like glue guns and hot glue • Ways to help your group members—where to stand, how to hold things, use of tools with and among other people
	Design and Simple Prototyping	Hand tools and simple power tools such as Dremel tools, electric drills, etc.	Focus is on accurate measuring, safe cutting, and careful assembly; emphasis is on the selection of the appropriate tool for the task. • See above • Use of v-blocks and clamps to hold materials prior to drilling, cutting or shaping • Use of eye and ear protection for user and those immediately around them • Use of gloves where appropriate • Use of drill bits and Dremel attachments • Use of extension cords, cables, power bars, etc.
	Design and Fabrication	Hand and power tools with option for 3D printers, CNC machines, etc.	Focus is on accurate measuring, safe cutting, and careful assembly; emphasis is on the selection of the appropriate tool for the task. • See above • See safety concerns specified by specific tool to be used • Address issues of ventilation and air quality
Advanced, Expensive, Complex	**Design, Prototyping, Circuitry and Coding**	Hand and power tools, soldering irons, circuits, breadboards, etc.	Focus is on accurate measuring, safe cutting, and careful assembly, and the selection of the appropriate tool for the task; emphasis is on the addition of functionality to the design through the inclusion of circuits and coding. • See above • Address issues of ventilation and air quality, especially when soldering

How You Might...

...Create a Safety Station

Consider ways in which you might create a safety station where students can be shown the proper way to use the available tools and materials available.

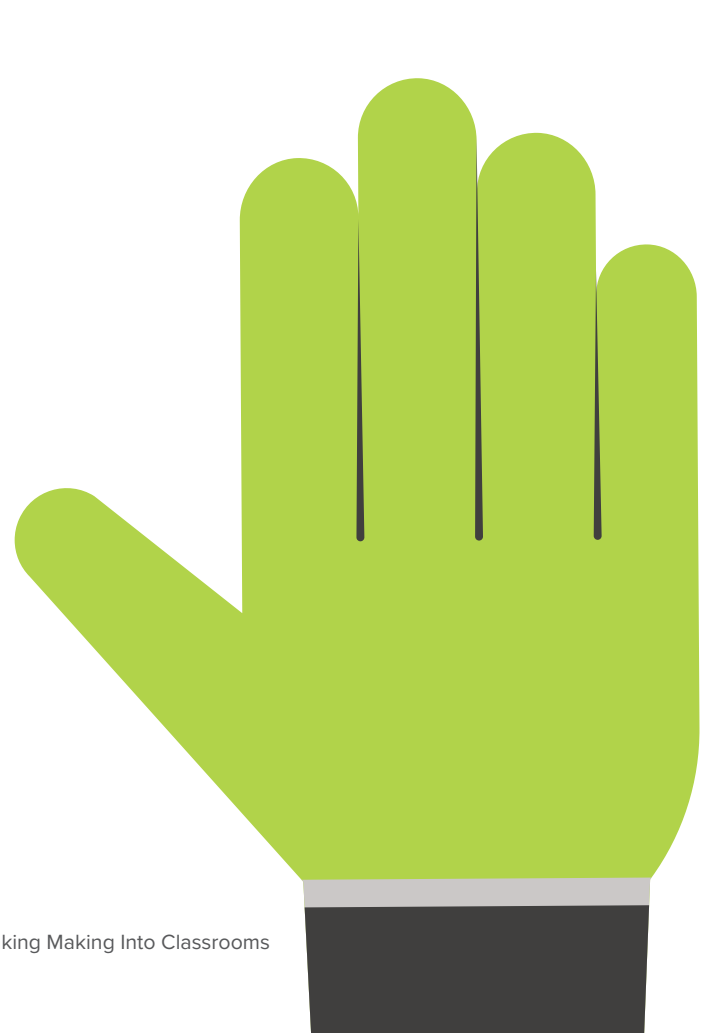
Is there expertise you can draw on—colleagues who have Red Seal certification, knowledgeable colleagues who are makers, parents, or community members who can help you to hone your skills? Do you know someone who could help with the set up and introduction of your Safety Station, etc.?

...Explore Safety Resources

Explore the safety resources that are available and ensure you have the necessary safety equipment and expertise.

- Heads Up for Safety (**http://www.bctea.org/heads-up-for-safety/**)
- Young Workers (**https://www.worksafebc.com/en/health-safety/education-training-certification/young-new-worker/student-worksafe**)
- Heads Up—Work Smart (**http://headsupab.com**)

Explore the resources shared by colleagues at the **Surrey, BC MakerSpace**.



SECTION 9

CHOOSING A MAKER CONFIGURATION FOR YOUR SETTING: IMAGINING TOOLS, RESOURCES, MOBILITY, ACCESSIBILITY ALONG A CONTINUUM OF POSSIBILITIES

Introduction

You will have noticed we used the term "maker configuration" rather than "makerspace" in the title of this section. This signals our intent (see Section 7) that making can take place in any setting—from a classroom equipped with scissors and glue (Design and Basic Making) to a classroom with circuitry, soldering irons, and 3D printers (Design, Prototyping, Circuitry and Coding and Fabrication). Even Ben Franklin, an early American inventor and maker, used the Philadelphia Library for some of his initial electrical experiments (Fallows, 2016).

We believe:

- Design is personal and driven by curiosity and challenges.
- Skill development is situational, age and stage dependent, and driven by the need to use specific tools.
- Technology use is situational, grade, age and stage dependent, and driven by the need to complete personal tasks.

Our view is consistent with the BC Applied Design, Skills and Technologies' framework that suggests "Design involves the ability to combine an empathetic understanding of the context of a problem, creativity in the generation of insights and solutions, and critical thinking to analyze and fit solutions to the context. To move design to final product or service requires skills and technology. Skills are the abilities gained through competence to do something and to do it increasingly well, and the technologies are tools that enable human capabilities" (**https://curriculum.gov.bc.ca/curriculum/adst/introduction**).

Resources and Options

The starting point for *Taking Making into Classrooms* is the consideration of your intention—why are you doing it? As we stated in Section 3, it is the design challenge that takes making into classrooms in a meaningful way, not simply access to a space or a collection of tools. Once you have determined how you will integrate design challenges into your teaching, you can consider the appropriate access to the technologies/tools that you need.

Section 14 offers suggestions for materials, resources, and tools, as well as an initial mobile maker kit that supports design, basic making, and simply prototyping. While prices and brand names may vary, the items included in the mobile maker kit costs approximately $250 in spring 2016.

How You Might...

...Design Your Maker Configuation

Explore the resources below as they provide makerspace options you might consider.

Educational Makerspaces and Resources

https://sites.google.com/gafeecsd.com/roffeyresources/home
This is an amazing resource developed by Trisha Roffey, an Edmonton educator with a passion for making and making a difference in education. This site was developed as part of her Master of Education Technology at UBC.

Inclusive Makerspaces—Consideration of UDL and Accessibility

http://www.washington.edu/doit/making-makerspace-guidelines-accessibility-and-universal-design
Making a Makerspace Guidelines for Accessibility and Universal Design

Making for All: How to Build an Inclusive Makerspace

https://www.edsurge.com/news/2015-05-10-making-for-all-how-to-build-an-inclusive-makerspace

Innovations in Education

https://flipboard.com/@davehetheri51jh/innovative-education-8g0te485y

Libraries as Makerspaces

http://www.theatlantic.com/technology/archive/2016/03/everyone-is-a-maker/473286/

Makerspaces

https://spencerauthor.com/category/makerspaces/

The Smithsonian Learning Lab

https://learninglab.si.edu/
The Smithsonian Learning Lab provides access to ideas, materials, resources, learning resources drawn from their vast collection.

Figure 9-1: Example of a Makerspace in a Converted Classroom

Image retrieved from Makerspace for Education (**http://www.makerspaceforeducation.com/**).

SECTION 10

MAKING CONNECTIONS BY CONSIDERING TECHNOLOGIES IN THE MOST GENEROUS WAYS

Introduction

Taking Making into Classrooms is an K–12 approach to multidisciplinary learning. Making supports a constructionist approach to inquiry and STEM (Science, Technology, Engineering and Mathematics) learning by including the arts in design.

As suggested in Section 7, teachers need to consider making along a continuum of intentions—from simple design and making through to fabrication and the addition of coding and circuitry. A recent study from the National Science Foundation in the US notes STEM and computer science is not just "training a limited number of students to be good in computer science…[it] is being seen as a new form of literacy," (Shammas, 2016, para 7). Further, the study found "if kids don't get exposed to [STEM and coding] before fourth grade, they've already made career choices, they've already made decisions about what they can and can't do," (para 4).

We are lead to believe that the students in our classes are digital natives (Prensky, 2001), individuals born with an innate ability to do all things digital. However, evidence suggests the majority of youth are simply avid consumers of social media and digital technologies rather than producers of code, media or digital content made with anything more sophisticated than smart phone applications.

Despite whether or not one agrees with the overused construct of digital immigrant/digital native, researchers are noticing we are "starting to hunger for life beyond the screen," and feel the need to do something more tangible with our time (Morozov, 2014, para 17). Morozov documents this need in his *New Yorker* article (**https://www.newyorker.com/magazine/2014/01/13/making-it-2**) chronicling the history of making from the Arts and Crafts movement in the early 1900s to garage-based innovators who changed Silicon Valley. It is a must read.

Kong Kong Wie, a Beijing artist, is an interesting example of moving from a career in 3D graphics into a career in hands-on fashion design.

"Her dedication to drawing brought her to study 3D computer graphics and illustration at college, but she soon began to miss working with her hands. 'During my days at the university dorm I was often discussing with my friends about what our future would have been, about the purpose of life… For me it was perfectly clear that my mission was to keep drawing, no matter what my canvas was.'

Indeed, in 2006 her ever-evolving interests brought her to the fashion world. She registered her own brand KongKongWei and she began using shoes as a canvas. Vans and high heels are her favorite shapes to transform from regular shoes into works of art. Bright colors, whimsical plants, pixies and tiny clay and resin sculptures evolve from her wild imagination and into daily life, with her creations oftentimes spicing up catwalks and media events," (de Toni, 2014, para. 1, Retrieved from **http://www.coolhunting.com/design/kong-kong-wei-beijing**).

By adding interesting and appropriate bits and bytes of technology to our making, we can address all manner of concerns, from joyful entertainment to promoting healthy life styles and the public good. Truly, these intentional and exploratory additions help us maximize the potential and promise of the Internet of Things, which is mentioned in Section 1.

A fascinating example of adding functionality to fun objects is the work of Josue Maldonaldo, who applies his skills from the automotive industry to whimsical robots. Check out his creations at **http://www.coolhunting.com/design/chv-27-robots**.

Also, check out Alex Reben's discussion about robotics and human interaction at **http://www.coolhunting.com/design/chv-alex-reben**.

While many schools feel pressured to purchase 3D printers and CNC machines, out of the hope that this equipment will inspire digital natives to become creative makers, in actual practice this is not necessarily the case. Schools can have powerful maker

configurations with a variety of simple tools, materials, and options (see Section 7), including open source or access software (i.e. Scratch, Python, Linux, etc.) and simple circuits (i.e. Arduino, etc.). The key to successful learning is helping students to understand they can be both consumers and inventors of fascinating, valuable and significant items that address human concerns. Central to this learning is an exploration of "perspective and how we perceive the similarities and differences between 2D and 3D objects." For a fascinating example of re-thinking design, please explore Jongha Choi's work (**http://www.wired.com/2016/05/flat-furniture-folds-place-like-pop-book/**).

ISTE Standards for Students (Revised June 2016)

Recently, the International Society for Technology in Education (ISTE) revised their skill and knowledge standards for students (June 2016). The standards include seven skill and knowledge areas. The ISTE competencies can easily be achieved through offline approaches such as CS Unplugged—an open source resource to support computational thinking (**http://csunplugged.org/**) and access to ideas from **code.org**.

For more on the skills that students need to master to achieve the ISTE standards and examples of activity progressions to practice those skills, visit their site (**https://www.iste.org/iste-standards**).

Table 10-1 suggestions ways in which a *Taking Making into the Classroom* approach addresses the new ISTE standards.

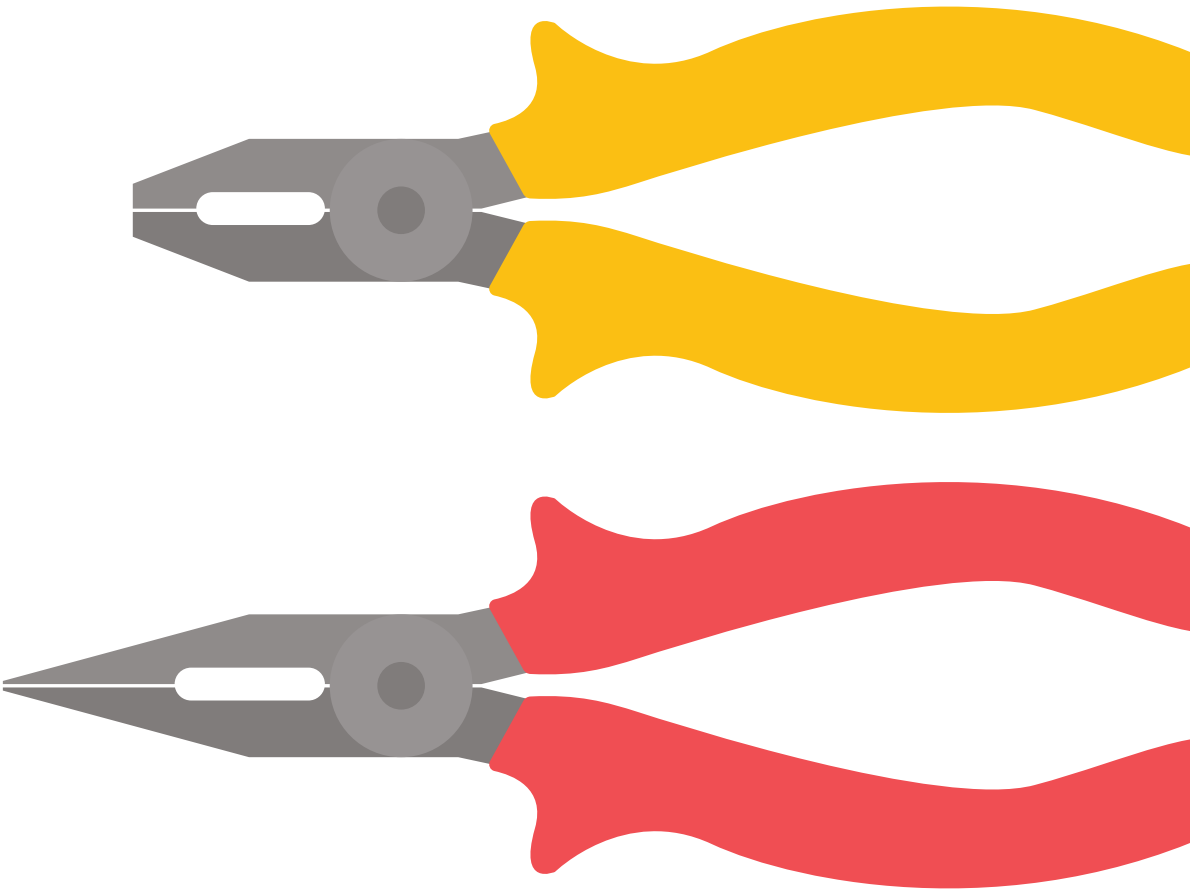


Table 10-1: Definitions of 2016 ISTE Standards for Students

ISTE Student Standard 2016	ISTE General Definition	*Taking Making* Phase
Empowered Learner	Students leverage technology to take an active role in choosing, achieving, and demonstrating competency in their learning goals, which are informed by the learning sciences.	**Design**
Digital Citizen	Students recognize the rights, responsibilities, and opportunities of living, learning, and working in an interconnected digital world, and they act and model in ways that are safe, legal, and ethical.	**Design** (emphasis on fostering empathy)
Knowledge Constructor	Students critically curate a variety of resources using digital tools to construct knowledge, produce artifacts, and make meaningful learning experiences for themselves and others.	**Tinker**, **Thinker**
Innovative Designer	Students use a variety of technologies within a design process to solve problems by creating new, useful, or imaginative solutions.	**Design**, **Tinker**, **Thinker**, **Reflect**
Computational Thinker	Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.	**Tinker**, **Thinker**
Creative Communicator	Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats, and digital media appropriate to their goals.	**Thinker** (emphasis on preparing for and hosting Gallery Tour), **Reflection**
Global Collaborator	Students use digital tools to broaden their perspectives and enrich their learning by collaborating with others and working effectively in teams both locally and globally.	**Design**, **Reflect**

Increasingly, there are both kits and proprietary, closed software/hardware options available on the market to support students in gaining STEM related competencies. These include littleBITs (**https://sphero.com/collections/design-build-systems**), Lego Mindstorms (**http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com**), and SPHERO 2.0 (**http://www.sphero.com/sphero**).

Design Challenge Examples

We are quite intrigued with the use of open source/open access options where possible. Not only do they let students see what is "inside the box," they tend to be less expensive, interchangeable with other components, and more interesting in the long term. Open options include software like Scratch, Linux, Raspbian, Java, Mindcraft, etc. We also encourage the use of hardware options including Raspberry Pi. Consider exploring Kano (**http://us.kano.me/**), Piper (**http://playpiper.com/shop/**) and pi-top (**https://www.pi-top.com/**), which are complete solutions for the initial Raspberry Pi board. Sensors and external elements can be added to the Raspberry Pi option by using Arduino components (**https://www.arduino.cc/**).

For more resources, please explore Arduino (**https://www.arduino.cc/**), Raspberry Pi (**https://www.raspberrypi.org/**) and Code (**code.org**).

How You Might...

...Introduce Technologies

Explore Design Challenge #6, *Animal Care*. This challenge was created by Joan Britton and her team from Chilliwack and was piloted with teachers. It is an example of the intentional use of design, prototyping, and circuitry. Participants were challenged to develop a prototype part of a system or a tool that would allow animal caregivers/owners the ability to leave for a period of time with peace of mind. In that challenge, one element of the success determinants was the use of LittleBits (**https://sphero.com/collections/design-build-systems**) to add functionality to the prototype. LittleBits is a proprietary, snap together platform of electronic building blocks that introduce circuits, sounds, sensors in a magnetic assembly format—no soldering needed. The basic kit provides power (either plug in via UBC or battery) and input/output devices.

In the LittleBits STEM Student Set, students can explore buttons, simple circuits, sensors (temperature, light, pulse, sound), inverters, LED, motion, etc. The STEM Student Set includes guided challenges (recipes for completion) and open challenges that support student exploration and project personalization.

For resources, consider exploring Code (**code.org**), Raspberry Pi (**https://www.raspberrypi.org/**) and Arduino (**https://www.arduino.cc/**).

As a way of introducing the power of 3D printers, introduce students to software like Gravity Sketch (**http://www.wired.com/2016/03/gravitysketch-3-d-software/?mbid=nl_32516**) for 3D modeling. Software like this helps students to understand the relationship between two dimensional and three dimensional design.

Explore the Waterloo Offline Computing Challenge that focuses on building an understanding of Computational Thinking skills. Here are examples of the 2015 challenges:

Grade 7/8 Challenge **http://www.cemc.uwaterloo.ca/contests/past_contests/2015/2015BCCContest7_8.pdf**

Grade 9/10 Challenge: **http://www.cemc.uwaterloo.ca/contests/past_contests/2015/2015BCCContest9_10.pdf**

More info from prior years is found here (scroll down page): **http://www.cemc.uwaterloo.ca/contests/past_contests.html**

Download a copy of the CS Unplugged materials from Tim Bell, an academic in New Zealand whose open source resources supports offline (unplugged) development of computational thinking and spatial reasoning (**www.csfieldguide.org.nz**).

Become engaged with electronic textiles. Research (Peppler and others, **http://kpeppler.com/**) suggests that eTextiles (i.e. sewing circuits and LEDs into clothing) transcends gender and introduces students to how technology works, the logic of off/on switches, aesthetics and design, coding, and electricity. A good starting point for eTextiles is LilyPad Arduino (**https://www.youtube.com/watch?v=L4a89n4ZJ5w**) and the terrific ideas in *The Art of Tinkering* (**http://tinkering.exploratorium.edu/art-tinkering**).

SECTION 11

SUGGESTED RESOURCES: AN ANNOTATED BIBLIOGRAPHY OF ESSENTIAL READINGS AND REFERENCES THAT INFORMED THIS TOOLKIT

Things to Explore

Maker Ed

http://makered.org/about-us/who-we-are/

Edutopia

http://www.edutopia.org/blog/maker-tools-and-their-uses-vicki-davis?utm_source=SilverpopMailing&utm_medium=email&utm_campaign=072314%20enews%20maker%20ngm%20B&utm_content=&utm_term=feature3hed&spMailingID=9072925&spUserID=MjcyODg5NjI0MjMS1&spJobID=341826896&spReportId=MzQxODI2ODk2S0

Instructables

http://www.instructables.com/

Make:

http://makezine.com

The Tinkering Studio

http://tinkering.exploratorium.edu/

Stanford's d.School

http://dschool.stanford.edu/

Maker Day Toolkit, Version 2

https://media.royalroads.ca/owl/media/takingmakingwordpress/makerday-2-toolkit.pdf

Educational Makerspaces and Resources

https://sites.google.com/gafeecsd.com/roffeyresources/home
This is an amazing resource developed by Trisha Roffey, an Edmonton educator with a passion for making and making a difference in education. This site was developed as part of her Master of Education Technology at UBC.

Mindset Kit

https://www.mindsetkit.org/
Comprehensive collection of lessons, ideas, prompts and research supporting the importance of fostering a growth mindset.

Inclusive Makerspaces—Consideration of UDL and Accessibility

Making a Makerspace? Guidelines for Accessibility and Universal Design

http://www.washington.edu/doit/making-makerspace-guidelines-accessibility-and-universal-design

Making for All: How to Build an Inclusive Makerspace

https://www.edsurge.com/news/2015-05-10-making-for-all-how-to-build-an-inclusive-makerspace

Innovations in Education

https://flipboard.com/@davehetheri51jh/innovative-education-8g0te485y

Libraries as Makerspaces

http://www.theatlantic.com/technology/archive/2016/03/everyone-is-a-maker/473286/

Makerspaces

https://spencerauthor.com/category/makerspaces/

Resources to Support Design/Ideation

The Smithsonian Learning Lab

https://learninglab.si.edu/
The Smithsonian Learning Lab provides access to ideas, materials, resources, learning resources drawn from their vast collection.

Innovations in Education

https://flipboard.com/@davehetheri51jh/innovative-education-8g0te485y

Things to Read

Alberta Education (2015). CTF Draft Program of Studies. Retrieved from **https://education.alberta.ca/media/1224736/ctf-program-of-studies.pdf**.

Alberta Education (2016). CTF Classroom Assessment Tool. Retrieved from **https://education.alberta.ca/media/3114928/ctf-classroom-assessment-tool-2016.pdf**.

Alberta Education (2005-2006). Assessment in Mathematics. Retrieved from **http://www.learnalberta.ca/content/mewa/html/assessment/index.html**.

Design Kit

http://www.designkit.org/
Design Kit breaks down the methodology and the mindsets of human-centered design.

IDEO Design Thinking for Educators

http://www.designthinkingforeducators.com/
From the website: This toolkit contains the process and methods of design along with the Designer's Workbook, adapted specifically for the context of K–12 education.

Rubber Band Engineer

https://www.amazon.com/Rubber-Band-Engineer-Slingshot-Unconventional/dp/1631591045
A book by Lance Akiyama. Brilliant resource with clear directions and examples for building hand-held shooters, mini siege engines, hydraulic and pneumatic power devices, rockets and helicopters, and propeller-powered cars. An example of his designs can be found at **http://makezine.com/projects/construct-fun-powerful-rubber-band-crossbow/**. The challenge for school settings is the first 36 pages includes guns, rifles, and other hand-held devices that could be problematic in school settings. The introduction to hydraulic and pneumatic power is excellent!

BC's Redesigned Curriculum

https://curriculum.gov.bc.ca/

ADST Introduction

https://curriculum.gov.bc.ca/curriculum/adst/introduction

ADST framework

https://curriculum.gov.bc.ca/curriculum/adst

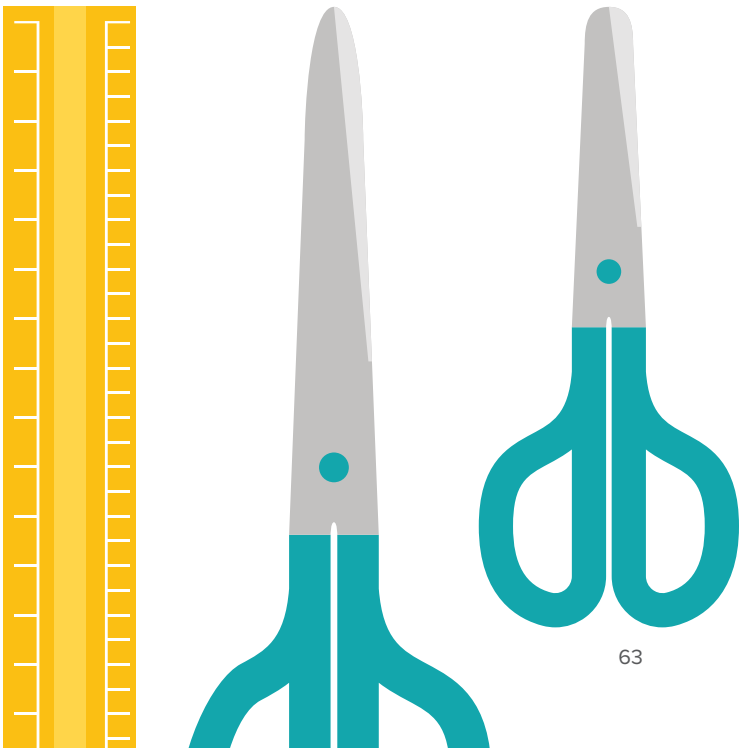
Safety Resources

Heads Up for Safety

http://www.bctea.org/heads-up-for-safety

Student Work Safe–WorkSafe BC

https://www.worksafebc.com/en/health-safety/education-training-certification/young-new-worker/student-worksafe



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https://curriculum.gov.bc.ca/curriculum/adst/introduction

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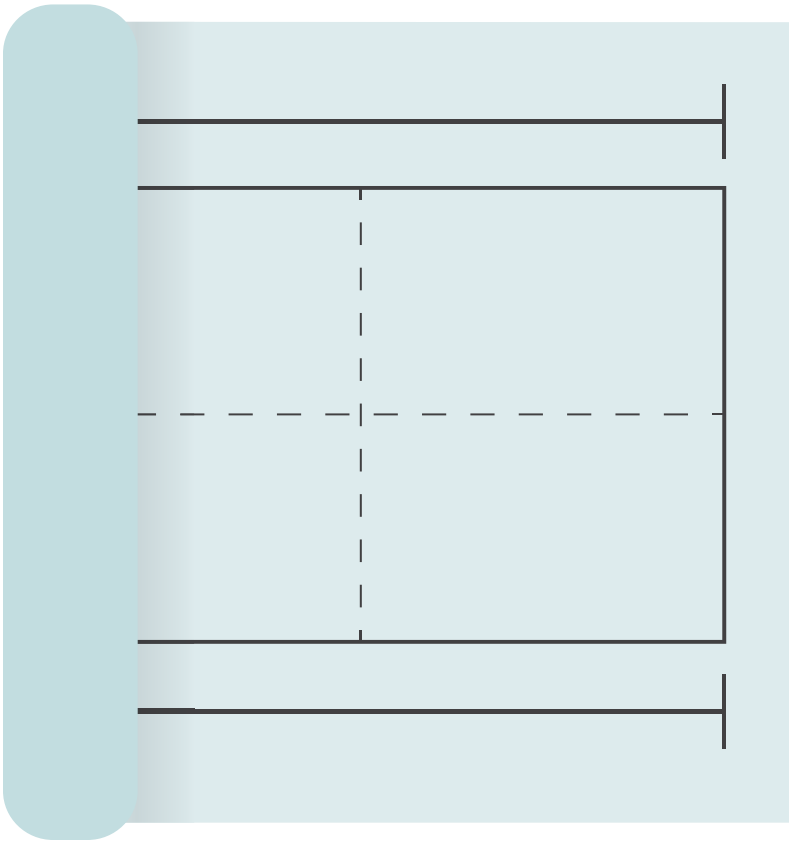


SECTION 12

SAMPLE DESIGN CHALLENGES

Assessment is not addressed as a separate or discrete item in our Design Challenge structure. Rather, it is embedded within Design Challenge as an element of the Success Determinants. Examples of assessment options are included in Design Challenge 2 (rubric) and Design Challenge 32 (self-appraisal). Please refer to Section 4 for assessment suggestions.

Table 12-1: Overview of Sample Design Challenges

Design Challenge	Topic	Curriculum Area
1. **Designing a Healthy Lunch Experience**	• Affordable lunch options • Nutrition • Food integrity • Product design	• ADST • Arts Education • Culinary Arts • Home Economics • Physical and Health Education • Social Studies
2. **Using Simple Machines to Make Overly Complex Compound Machines**	• Simple and compound machines • Mechanical advantage • Aesthetics and quality	• ADST • Science
3. **Considering Maslow's Hierarchy Through a Refugee Lens**	• Current events • Refugees • Psychology • Social Justice	• ADST • Social Studies
4. **Inclusive Communities**	• Current events • Refugees • Citizenship	• ADST • Social Studies

Design Challenge	Topic	Curriculum Area
5. Froebel's Gifts: Building Blocks to Learning in Early Childhood and Primary Education *A Resource for Teachers and Parents*	• Imagination and creativity • Self-confidence and a feeling of accomplishment • Sense of responsibility for block care and clean-up	• ADST • Physical and Health Education • General early learning and readiness skills and abilities, including • Pre-number skills such as size, shape, matching and classification • Critical thinking and problem solving
6. Animal Care	• Animal care • Simple circuits • Environment	• ADST • Science • Social Studies
7. Frugal Innovation for a Sustainable, Happy Future	• Sustainability • Innovation • Globalization	• ADST • Science • Social Studies
8. *Chindogu*: Designing Purely for the Joy of Design	• Creativity • Design • Sociology • Imagination	• ADST • Arts Education

Design Challenge	Topic	Curriculum Area
9. Hand Shadows: Seeing is Believing	• Creativity • Design • Theatre • Imagination	• ADST • Arts Education • English Language Arts • Drama • Citizenship
10. Geometrigraph and Polygraph Templates: Designing with Geometry	• Drawing geometric shapes • Creating ornamental shapes	• ADST • Arts Education • Mathematics • Geometry
11. Automata	• Mechanical structures • Machines using cams, levels, linkages, connections, etc.	• ADST • Arts Education • English Language Arts • Mathematics • Social studies
12. It's Never Black or White or Paper or Plastic	• Complexity inherent in recycling—why simple solutions are sometimes not the best options	• ADST • Business Education • Economics • Science • Social studies
13. Between a Number and a Person: Considerations of Identity and Respect	• Development of federal identification systems	• ADST • Arts Education • Social studies

Design Challenge	Topic	Curriculum Area
14. Agricultural Automation	• Agricultural tool or process innovations • Economic diversification	• ADST • Science • Social Studies
15. Classroom Furniture	• 21st century learning • Ergonomic design • Aesthetics and functionality	• ADST • Arts Education • Physical and Health Education
16. Integrative Learning/ Integrative Living *A Resource for Teachers*	• Diversified economy • Diversified living • Ecology and ecosystems	• ADST • Science • Social Studies
17. Waste Management	• Recycling • Trash reduction	• ADST • Business Education • Science
18. Defining the Components of Society Using Artist Trading Cards	• Belonging • Society and youth empowerment	• ADST • Arts Education • English Language Arts • Physical and Health Education
19. Apathy to Empathy	• Society and youth empowerment • Social issues	• ADST • English Language Arts • Physical and Health Education
20. Displaced Students	• Belonging • Society and youth empowerment • Social issues	• ADST • English Language Arts • Physical and Health Education

Design Challenge	Topic	Curriculum Area
21. Growth Mindset: Electricity *A Resource for Teachers*	• Electricity—scientific principles • Electricity—safety	• ADST • Science
22. Developing Historical Empathy	• Social issues • Belonging • Social Injustice • Aboriginal issues	• ADST • English Language Arts • Physical and Health Education • Social Studies
23. Eco-smart Recreation Facility	• Diversified economy • Diversified living • Ecology and ecosystems • Recreation	• ADST • Business Education • English Language Arts • Physical and Health Education • Science
24. Water Conservation	• Water • Ecology • Conservation • Sanitation	• ADST • Science
25. Alternative Dwellings	• Housing • Architectural design • Interior design	• ADST • Arts Education • English Language Arts • Physical and Health Education • Social Studies
26. Mars Shelter and Transportation	• Housing • Transportation • Space—interplanetary living	• ADST • English Language Arts • Science

Design Challenge	Topic	Curriculum Area
27. Stimulating Our Senses	• Sensory processing challenges • Sensory smarts	• ADST • Arts Education • English Language Arts • Physical and Health Education
28. Inclusive Playgrounds	• Inclusive • Play • Recreation	• ADST • Arts Education • English Language Arts • Physical and Health Education
29. Outdoor Classroom	• 21st century learning • Ergonomic design • Aesthetics and functionality	• ADST • Arts Education • English Language Arts • Physical and Health Education
30. Outdoor Learning Spaces	• 21st century learning • Ergonomic design • Aesthetics and functionality	• ADST • Arts Education • English Language Arts • Physical and Health Education
31. Up-cycling Fashion	• Clothing • Social justice • Fabric design	• ADST • Arts Education • Business Education • Home Economics • Physical and Health Education

Design Challenge	Topic	Curriculum Area
32. Using Smart Technology Smartly to Improve Life in Rural and Remote Communities	• Internet of Things • Sustainability	• ADST • Arts Education • English Language Arts • Physical and Health Education

1 Designing a Healthy Lunch Experience

Overview

Everyone knows that packing our own lunch on a regular basis saves money and gets us to eat healthier. But like other healthy things (e.g. exercise, personal wellness, time management, etc.), we often lose our way and forget to make the time it takes to do what is best for us.

Design Rationale

The busy world of work/life balance, combined with the ever increasing cost of good food, we need to pause and consider what might be a healthy and sustainable lunch experience.

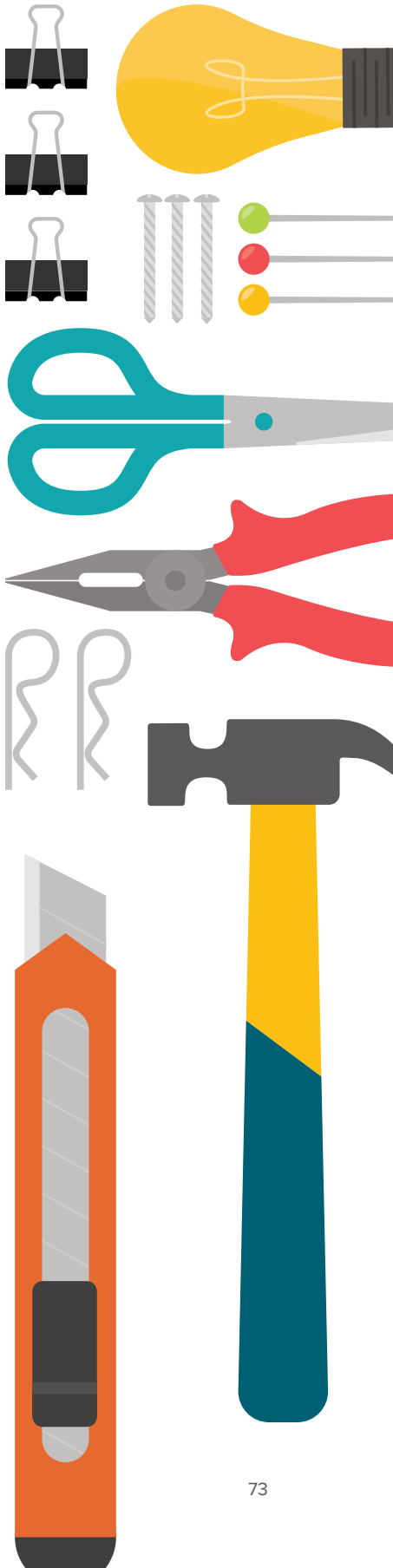
The website Lifehacker offers an interesting formula to help us to have a balanced, delicious box lunch experience (**http://lifehacker.com/pack-healthy-hearty-lunches-with-this-six-layer-formul-1752826181**).

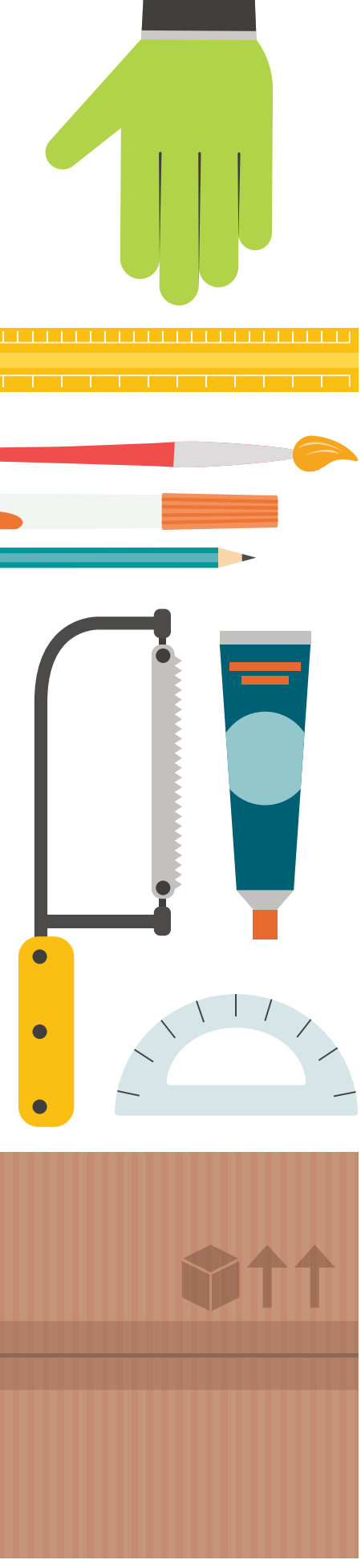
Central to the formula is the notion of the six-layer lunch experience which consists of the following elements:

- **Grains:** Anything from rice to quinoa, this will act as the foundation of your meal and be integral to staying full the whole afternoon. Obviously optional if you're watching your carbs.
- **Seasonal vegetable:** You can throw in more than one veggie, whichever ones you happen to have on hand. This is a great layer to use up roasted veggies from last night's dinner.
- **Leafy greens:** Raw or cooked, greens will bulk up your lunch, and if you're cutting out grains or watching your carbs, switch these out as the base of your lunch for a fibrous, healthy alternative.
- **Protein:** Tons of ways you can go here, from sliced chicken, cured meats, tofu cubes, beans, or a hard boiled egg.
- **Sour/acidic flavor:** Lighten things up and pull your dish together with an acidic dressing, sauce, or even just a squeeze of lemon.
- **Healthy fats:** This is your chance to really customize each day's lunch, from olive oil to avocado to nuts.

Of concern is how to "pack" and "transport" our healthy lunches in a way that looks good, trendy, and keeps all the food elements in an appetizing way that maintains the integrity and goodness of each of the food elements. Globally, there are many great solutions to this concern. Examples include:

- Tiffin boxes (**https://en.wikipedia.org/wiki/Tiffin_carrier**)
- Bento boxes (**https://en.wikipedia.org/wiki/Bento**)





The foodie site, Bon Appétit offers some excellent food examples packed away in a Bento box (**http://www.bonappetit.com/trends/article/bento-box-lunch-recipe**).

Problem Scenario

Your team has been selected to develop the perfect lunch box that addresses the problems we face in packing and transporting a healthy lunch. Currently, we see the use of brown bags, throw away containers, and generally unappetizing lunch solutions. Your task is to make a solution to this problem that is different from those already available on the market.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the design challenge
- ❒ Addresses an identifiable need for the end-user
- ❒ Uses the provided materials, resources, and tools
- ❒ Is a helpful and unique option for those of us considering packing and transporting our increasingly healthy lunches

Parameters

- ❒ Plan how to use something of every consumable item in the participant group kit provided.
- ❒ You can use items from the pantry
- ❒ You can use any of the tools that have been provided.
- ❒ Your prototype could be a scale version rather than actual size.

Suggestions for Use

- The Healthy Lunch Experience design challenge has been used successfully with students Grades 7–12 and with teachers. Obvious curricular connections can be in the British Columbia Applied Design, Skills, and Technologies K-12 curriculum (**https://curriculum.gov.bc.ca/curriculum/adst**). The Framework for Kindergarten to Grade 12 Wellness Education attends to Physical Wellness, focusing on healthy growth, development, nutrition and care of the body.
- The importance of eating healthier lunches has prompted an Indiegogo campaign—Prepd Pack: The Lunchbox Reimagined—which includes containers as well as a smart app to help you purchase food and organize menus (Indiegogo campaign: **https://www.indiegogo.com/projects/prepd-pack-the-lunchbox-reimagined#/** and Prepd website: **https://www.getprepd.com/**).

2 Using Simple Machines to Make Overly Complex Compound Machines

Overview

Einstein is quoted as saying, “Everything should be made as simple as possible, but not simpler.” Simple machines are classic examples of what Einstein claims. They are classified in six types, and they can be found everywhere—often in some very surprising places and things. Simple machines offer mechanical advantages, which makes it easier to do work. The six simple machines are levers, inclined planes, wedges, screws, wheels and axles, and pullies.

Design Rationale

It is important to understand the principles, functions and application of simple machines. The workings of simple machines are central to most of our significant accomplishments in buildings, tools, and technologies.

When simple machines are combined into another machine, they are called compound machines. For example, a bicycle is made up of levers (shifters, derailleurs, handlebars, freewheel assembly, brakes); wheels and axles (the wheels, pedals, crankset); pulleys (parts of the shifting mechanisms, braking mechanisms, and the chain on gears); screws that hold parts together; and wedges (the teeth on the gears). When all the simple machines on a compound machine like a bicycle work well together, riders gain a mechanical advantage of traveling faster then they could if they were walking.

Compound machines can be highly technical like airplanes or relatively simple such as a hand powered can opener. The master of making compound machines profoundly complicated, highly whimsical, quirky, and fun was Rube Goldberg (1883–1970), an engineer and cartoonist who invented contraptions that made every day, simple tasks more complicated. His contraptions are the absolute opposite of Einstein’s idea!.

To this day, Rube Goldberg Contraptions delight us (**https://www.rubegoldberg.org/**). However, at the heart of every contraption is a collection of interdependent simple machines.

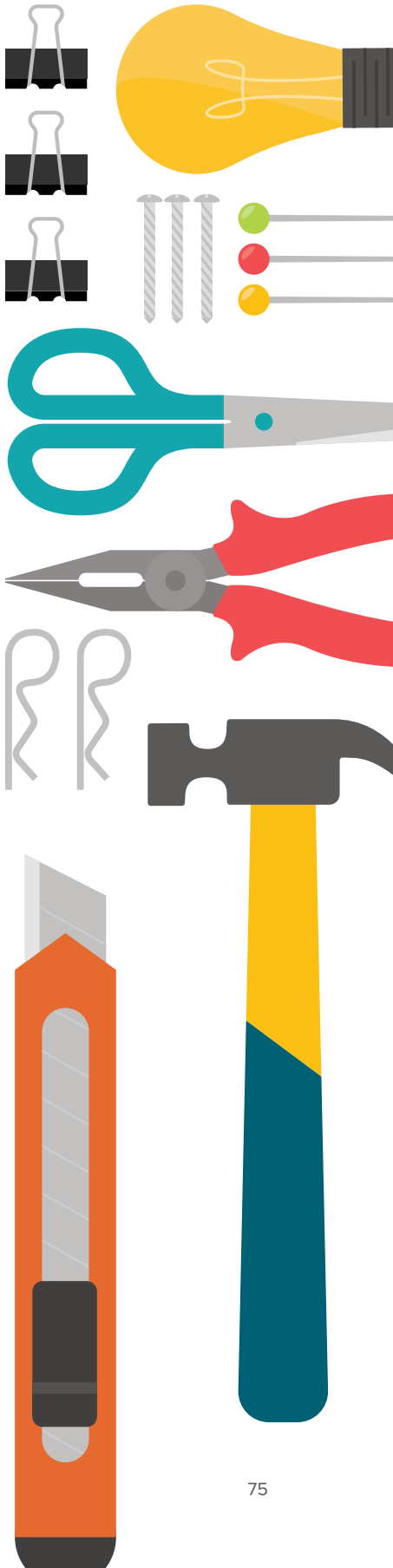
Problem Scenario

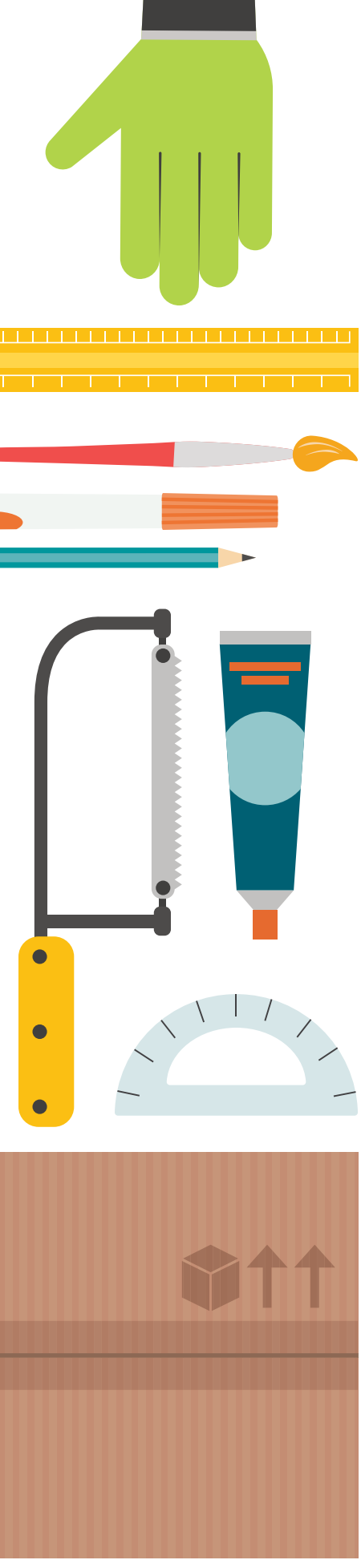
Your team has been selected to develop the ultimate Rube Goldberg contraption capable of moving the marble—found in the participant group kit provided—the furthest distance, over the longest period of time, in the most complex manner.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Is accompanied by a highly elaborate sketch illustrating functionality
- ❒ Addresses the design challenge
- ❒ Uses the provided materials, resources, and tools





- ❒ Shows evidence of your group's understanding of the mechanical advantage provided by the six simple machines
- ❒ Is whimsical and makes us smile
- ❒ Has a clear theme or story (i.e. maybe the marble is a metaphor for a creature that is trying to escape)
- ❒ Has a high degree of absurd complexity (very, very unnecessarily complicated)
- ❒ Is aesthetic and well constructed
- ❒ Is reliable—the marble can be put on its journey multiple times

Parameters

- ❒ Plan how to use something of every consumable item in the participant group kit provided.
- ❒ You can use items from the pantry.
- ❒ You can use any of the tools that have been provided.
- ❒ Your contraption can be no larger than 2 feet x 2 feet x 2 feet square.
- ❒ You must use all six simple machines at least once within your contraption.

Suggestions for Use

- *The Kids' Book of Simple Machines: Cool Projects & Activities That Make Science Fun* by Kelly Doudna is a terrific resource for this design challenge (**https://www.amazon.ca/The-Kids-Book-Simple-Machines/dp/1938063597?ie=UTF8&*Version*=1&*entries*=0**).
- Rather than a Rube Goldberg machine, think about designing a vending machine for a specific purpose. The Japanese are recognized as being the best of vending machines.
  - **http://kotaku.com/the-world-of-japanese-vending-machines-5988536**
  - *40 Things You Don't Expect to Find in Vending Machines*—including live crabs and fresh baguettes **http://www.hongkiat.com/blog/bizarre-vending-machines/**
- Obvious curricular connections can be made to British Columbia's Science Learning Standards.
- Please use the rubric on the following pages for summative assessment of the machine. This rubric was generated using Rubistar and is available online as #2614115 (**http://rubistar.4teachers.org/index.php**).

Rube Goldberg Rubric	4	3	2	1
Function	Structure functions extraordinarily well, holding up under atypical stresses.	Structure functions well, holding up under typical stresses.	Structure functions pretty well, but deteriorates under typical stresses.	Fatal flaws in function with complete failure under typical stresses.
Scientific Knowledge	Explanations by all group members indicate a clear and accurate understanding of scientific principles underlying the construction and modifications.	Explanations by all group members indicate a relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations by most group members indicate relatively accurate understanding of scientific principles underlying the construction and modifications.	Explanations by several members of the group do not illustrate much understanding of scientific principles underlying the construction and modifications.
Plan	Plan is neat with clear measurements and labeling for all components.	Plan is neat with clear measurements and labeling for most components.	Plan provides clear measurements and labeling for most components.	Plan does not show measurements clearly or is otherwise inadequately labeled.
Construction, Materials	Appropriate materials were selected and creatively modified in ways that made them even better.	Appropriate materials were selected and there was an attempt at creative modification to make them even better.	Appropriate materials were selected.	Inappropriate materials were selected and contributed to a product that performed poorly.
Construction, Care Taken	Great care taken in construction process so that the structure is neat, attractive and follows plans accurately.	Construction was careful and accurate for the most part, but 1–2 details could have been refined for a more attractive product.	Construction accurately followed the plans, but 3–4 details could have been refined for a more attractive product.	Construction appears careless or haphazard. Many details need refinement for a strong or attractive product.
Evidence of 6 simple machines	Evidence of use of all 6 machines, at least once in the contraption.	Evidence of use of 5 machines, at least once in the contraption.	Evidence of use of 4 machines, at least once in the contraption.	Evidence of limited use of fewer than 4 machines in the contraption.

Rube Goldberg Rubric	4	3	2	1
Participant Group Kit	Evidence of use of something of everything from the participant group kit.	Evidence of use of something of almost everything from the participant group kit.	Limited use of the majority of items from the participant group kit.	Relevance on only a few items from the participant group kit.
Shared Pantry	Evidence of thoughtful use of shared pantry items.	Evidence of use of shared pantry items.	Evidence of over use of shared pantry items.	Excessive or wasteful use of shared pantry items.
Whimsy and Aesthetics	High degree of whimsy and aesthetics.	Good degree of whimsy and aesthetics.	Moderate degree of whimsy and aesthetics.	Little or no whimsical or aesthetic values.
Absurdity and Narrative	Contraption is absolutely absurd in its illustration of a good story.	Contraption is adequately absurd in its illustration of a good story.	Contraption is marginally absurd in its illustration of a good story.	Contraption has little or no absurd qualities told in an unclear story.

3 Considering Maslow's Hierarchy Through a Refugee Lens

Overview

Imagine making the decision with your family to leave your home and walk in the pursuit of a better life. Globally, refugee families are making the decision to leave what they know and walk through dangerous terrain, often taking only the clothes on their backs and a few personal items. In 2015, the United Nations reported that one in every 122 humans is now either a refugee, internally displaced, or seeking asylum.

Design Rationale

In 1943, Maslow created a hierarchy of needs to better understand what motivates people to do what they do. His model is depicted in five stages, suggesting the bottom or basic needs most strongly motivate people to take action. Self-actualization is the top of Maslow's hierarchy, and he felt that only "one in a hundred people become fully self-actualized because our society rewards motivation primarily based on esteem, love and other social needs," (**http://www.simplypsychology.org/maslow.html**).

Maslow also stated, "It is quite true that man lives by bread alone—when there is no bread..." (1943, p. 375). In the case of refugees, one can only assume that they make the decision to leave their homes because the risk or threat to their families' needs is so significant that the pursuit of an uncertain alternative is better than where they are.

While Syrian refugees were top of mind in 2016, refugees are situated globally with the majority originating in Syria, Afghanistan and Somalia (**http://unhcr.org/556725e69.html#_ga=1.225701913.2095888809.1417795315**).

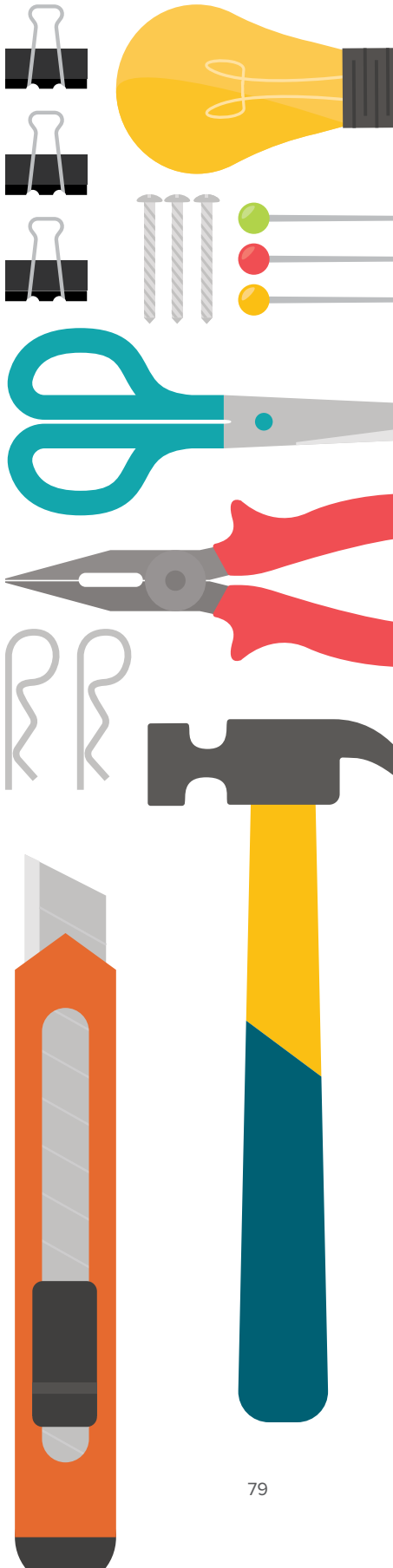
Problem Scenario

Your team has been selected to develop something wearable or portable that would help refugees on their travels. Backpacks are a fairly common solution to this challenge, but typically they are not available, so maybe think more creatively. Currently, we see many refugees walking with a shopping bag or small suitcase. Your team needs to design something that would address some of the basic needs and help families to make their walk to a better future.

Success Determinants

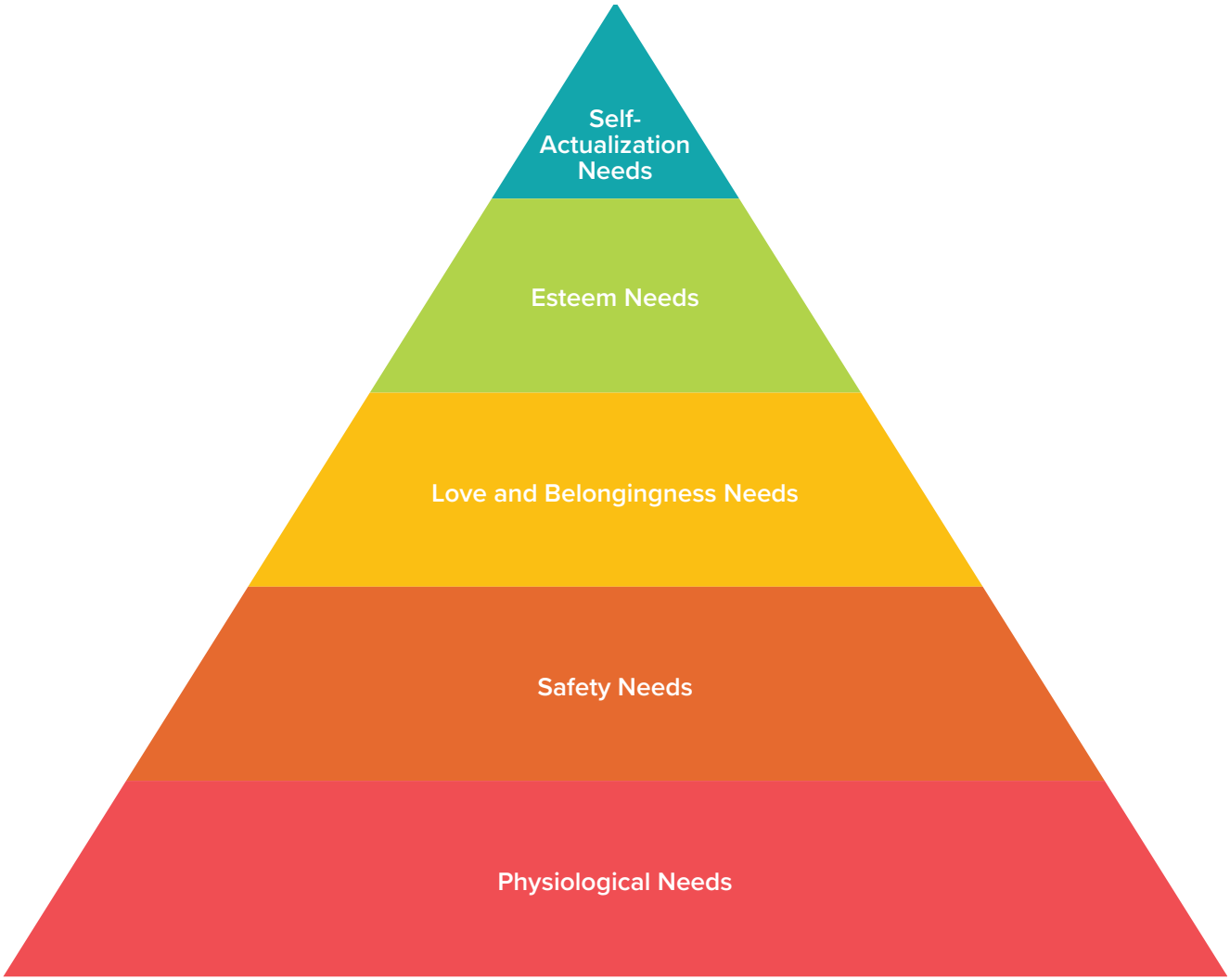
Success will be determined by the degree to which your design solution:

- ❒ Addresses the design challenge
- ❒ Addresses an identifiable need
- ❒ Uses the provided materials, resources, and tools
- ❒ Is helpful and unique for refugees, specifically those currently entering Europe



Parameters

- ❒ You must use something of everything in the bag provided to you.
- ❒ You can use items from the pantry and share the tools.
- ❒ Your prototype can be a scale version rather than actual size.



4 Inclusive Communities

Overview

Canadian Parliament is calling for between 280,000 and 305,000 permanent residents to be allowed into Canada in 2016, including more refugees from war-torn Syria. This will be our country's largest intake of immigrants into Canada since immediately following World War II.

Design Rationale

British Columbia prides itself on being inclusive. With the anticipated influx of Syrian refugees arriving, how can we draw people together and design ways in which we can make the immigrants feel welcome—both here in school and our larger community—and help people to become comfortable getting to know one another and become tolerant, accepting and interested in the diversity?

Problem Scenario

Your team has been selected to develop the prototype of a structural element or component or tool that will help recent immigrants to begin to create a sense of inclusion in their new community. Your prototype should be:

- small scale,
- easy to maintain and use,
- accessible to and for all community members, and
- realistic for a community to be able to recreate and use on their own.

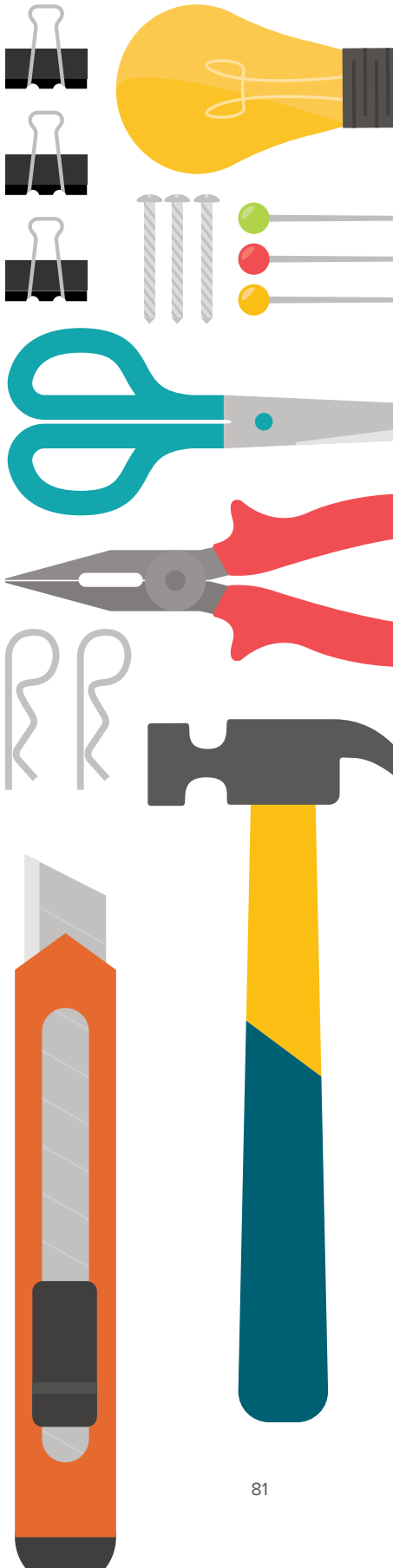
Parameters

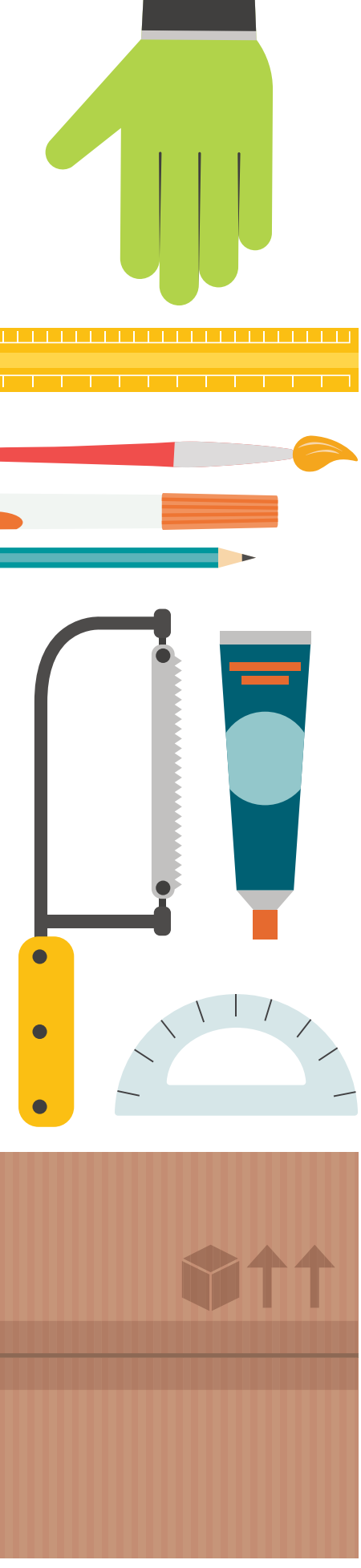
- ❒ You must use some of all of the items in your group kit in some way.
- ❒ You may make a pitch to use materials on the share tables.
- ❒ You should use the tools located in the shared tool area.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Is unique and usable
- ❒ Aligns with your design sketch
- ❒ Interests community members and newcomers
- ❒ Aligns to the design motto: "make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener"





Note

This design challenge was developed by teachers at St. Margaret School in Victoria, BC. The school librarian had experienced a Maker Day that used sample design challenge 3: Considering Maslow's Hierarchy Through a Refugee Lens. To help students stay on task and understand the flow of the day, the teachers provided the following plan.

Maker Day 2016 Day Plan

8:30–8:45

Welcome & Ice Breaker: At your tables (groups of 4), find the pipe cleaners, tin foil and popsicle sticks. Get up and stand in a circle. Have one person grab the pipe cleaner. You have 60 seconds to make something with the pipe cleaner. Hand your object to the person next to you. Now, name the object you see. Use the popsicle stick to add on to the object your partner made. Hand the object to the next person. Name the object you see. Now, use the tin foil to add to the object. Hand the object to the next person. Name the object you see. Now, using the materials in your hands, make a new object. Have your team guess what the object is.

8:45–11:00

#1 Empathy Building with a Settlement Youth Worker for the InterCultural Association of Greater Victoria. Photo essay: Global Oneness Project.

#2 Design Thinking Process

11:00–11:30

Begin Making! Using the materials provided, prototype your designs.

11:30–12:00

Guest Speaker: Importance of Design Thinking when Engaging in Making

12:00–12:30

Lunch

12:30–2:30

Continue prototyping.

2:30–2:45

Clean up materials, finish up.

2:45–3:15

Gallery walk, test, and share your idea with your user group for feedback.

5 Froebel's Gifts: Building Blocks to Learning in Early Childhood and Primary Education

Resource for Teachers and Parents

Overview

What's common among many of the leading architects of the 20th century? They attended Montessori Schools and learned by playing with and exploring Froebel's Gifts.

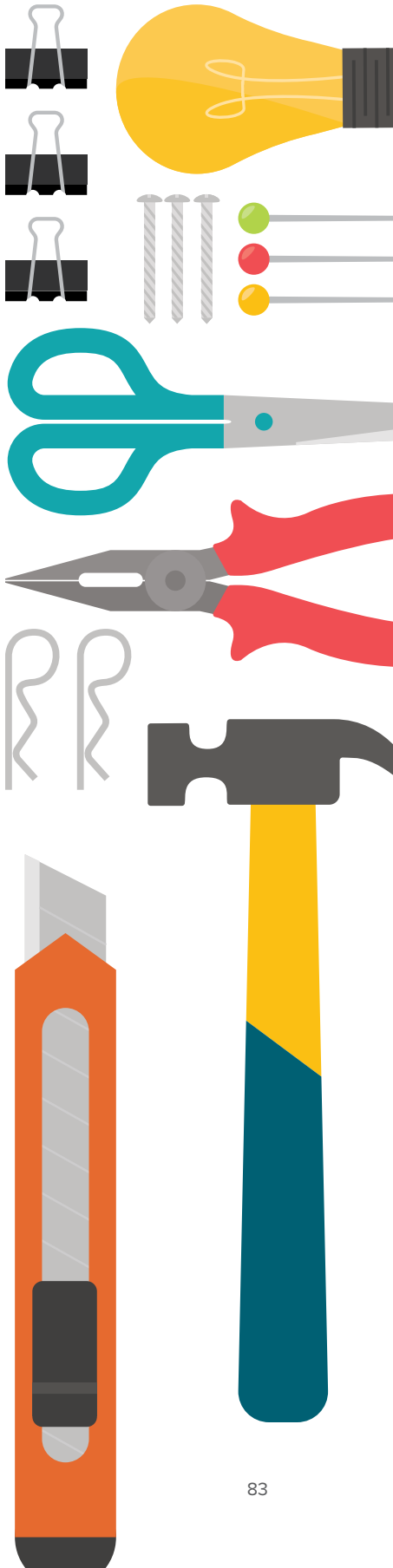
"'The maplewood blocks are all in my fingers to this day,' said Frank Lloyd Wright when he was 88 years old. The architect was referring to the elaborate set of children's building blocks designed in 1830 by the German educator Friedrich Froebel, the originator of the kindergarten system. He was among the first educators to recognize that play is the work of the child." (**http://www.nytimes.com/1985/10/13/style/the-froebel-gift-takes-form-again.html**)

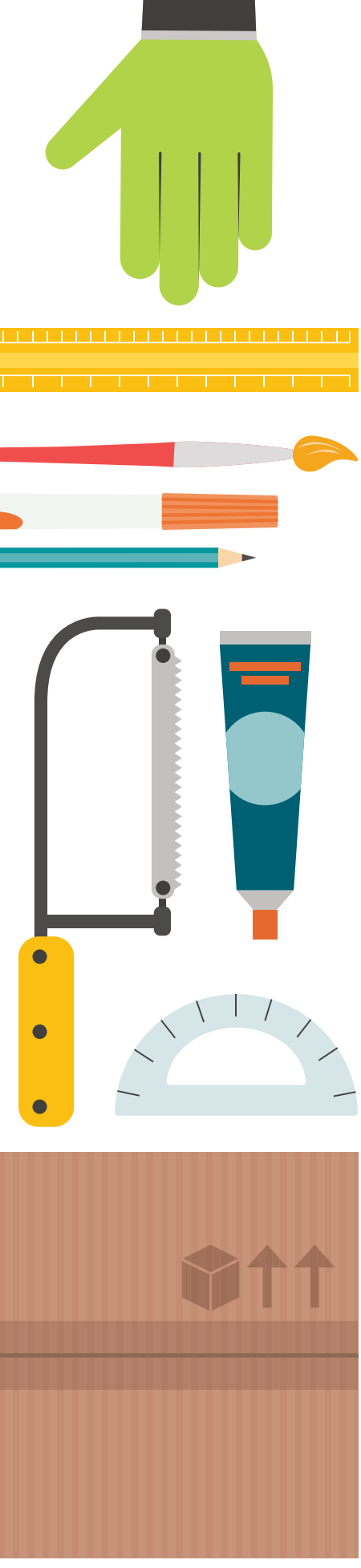
Froebel's Gifts had all but disappeared from schools until 1982 when they were discovered on display at the Frank Lloyd Wright Institute in Oak Park, Illinois. The gifts consist of a set of wooden blocks and a variety of materials such as yarn and Origami that he called vocations. The gifts and vocations were "designed to stimulate all five senses (which are considered the doors to the child's inner world) while aiding understanding and language through discussion and song... The ultimate idea is that all things—art (beauty), science (knowledge) and nature (the physical world)—are fundamentally related and interconnected." (Bultman, 2000, p. 4)

You can download a copy of The Republic of Childhood: Froebel's Gifts from **http://www.gutenberg.org/files/31097/31097-h/31097-h.htm**.

Froebel believed that when children play with blocks, they begin to think and imagine in concrete and tangible ways. It helps them to understand that one's thoughts can be actionable, and a provocation to reactions in others. It helps children to read, see, and negotiate their worlds.

"'The design of the Gifts reflects the way Froebel thought children learned, from the large object to the parts of the object,' said Leslie R. Williams, a professor of early-childhood education at Columbia University's Teachers College. 'They help children look into things instead of at things.'" (**http://www.nytimes.com/1985/10/13/style/the-froebel-gift-takes-form-again.html**)





Design Rationale

Janine Fraser, a primary educator and current President of the British Columbia Primary Teachers Association, sees value in introducing Froebel's Gifts to students from Kindergarten to Grade 12. She explains, the gifts can be used to:

- stimulate imagination and creativity
- contribute to self-confidence and a feeling of accomplishment
- develop a sense of responsibility for block care and clean-up
- explore pre-number skills such as size, shape, matching and classification
- foster critical thinking and problem solving that is inherent in block play
- develop visual discrimination which is a pre-reading skill
- learn concepts of inside/outside, open/closed
- develop language and vocabulary through discussion and description
- develop fine motor skills
- refine eye/hand coordination

The booklet *The Republic of Childhood: Froebel's Gifts* describes Froebel's approach to slowly and thoughtfully introduce each of the multiple gifts to children. Rarely did he create a discovery corner or centre and just let the children play with all gifts at once. Froebel believed there was a rhythm/flow to the introductions and a sequence that supported individual learning. Maria Montessori and Rudolf Steiner integrated Froebel's blocks and concepts into their work with children.

Froebel's Gifts can be purchased or made (**http://www.froebelweb.org/gifts/obtain.html**). The following list is numbered by sequence of introduction to children (Bultman, p. 28).

Gifts (To be used and always returned in their original form)

1. Yarn balls
2. Wood solids
3. Wood cubes
4. Wood rectangles
5. Subdivided 3" cube (cubes & prisms)
6. Subdivided 3" cube (columns, rectangles & caps)
7. Parquetry tiles
8. Sticks & rings
9. Beads
10. Peas & sticks

Occupations (Materials are modified and remain in their new form)

11. Perforating (pricking)
12. Embroidery (sewing)
13. Drawing
14. Cutting paper
15. Weaving paper (braiding)
16. Painting
17. Intertwining paper
18. Origami
19. Box construction
20. Modeling clay

Problem Scenario

Working with pre-school and primary teachers in your community and school, determine ways to integrate Froebel's Gifts into your learning environments. Remember, Froebel is considered to be the inventor of kindergarten. He believed "Children come into the world with their own inner structure, just as an acorn holds the structure of an oak tree. 'It is the destiny and life-work of all things to unfold their essence.' ...Parents and educators act as 'gardeners.' Creating a fertile environment that encourages each child to blossom into his/her full potential," (Bultman, p. 3). Froebel believed as the gardeners, it is our responsibility to introduce each gift and occupation and tend carefully to each child's learning.

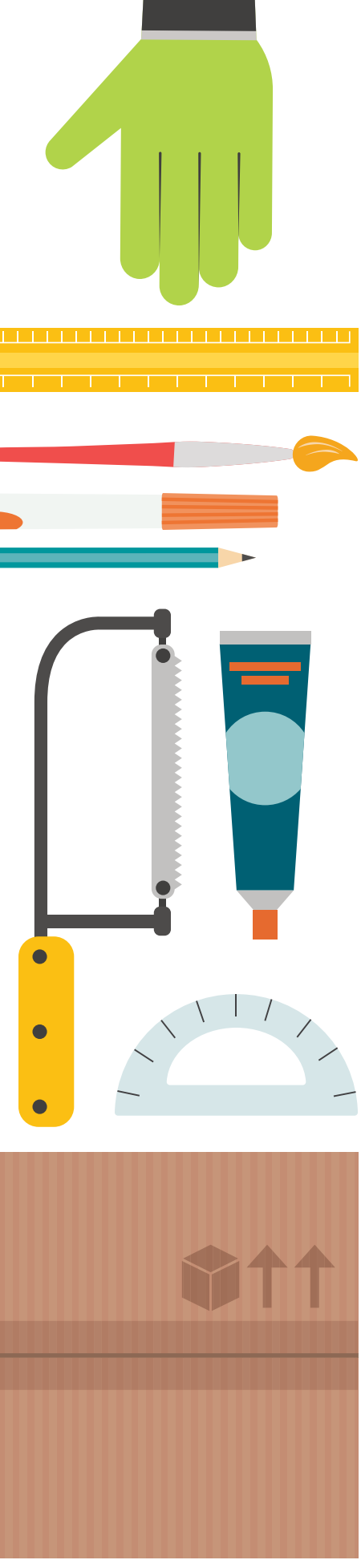
Success Determinants

Success will be determined by:

- ❒ Ways in which you can position Froebel's Gifts within your curricular intent
- ❒ Ways in which you can position Froebel's Gifts within the BC ADST curriculum
- ❒ Consider ways to involve the local makerspace or local makers in the creation of the gifts (**http://www.froebelweb.org/gifts/obtain.html**)

Paramenters

- ❒ Think beyond creating a centre where the gifts are merely available for the children to play with.



Resources

Ballweg, J. (2012). *Inquiry in the Block Area* available from *Math at Play*.

Bultman, S. (2000). *The Froebel Gifts: The building gifts* 2–6. Grand Rapids, MI: Uncle Goose Toys.

Early Childhood Today Editorial Staff (2016). *Pioneers In Our Field: Friedrich Froebel—Founder of the First Kindergarten*. The first installment in Early Childhood Today's series on the Roots of Early Childhood Education, available from **https://www.scholastic.com/teachers/articles/teaching-content/pioneers-our-field-friedrich-froebel-founder-first-kindergarten/**.

Patet, Pradnya (2016). *Empowering mathematical minds through play*, available from **http://www.communityplaythings.co.uk/learning-library/articles/empowering-mathematical-minds**.

Wiggin, K. & Smith, N. (1985). *The Republic of Childhood: Froebel's Gifts* from **http://www.gutenberg.org/files/%2031097/31097-h/31097-h.htm**.

6 Animal Care

Overview

In 2012, many residents of the Fraser Valley experienced, or were threatened by flooding. River levels along the Fraser corridor were at their highest in 40 years. Water eroded berms and caused flooding in many areas along a 600 km stretch from northern BC to the Fraser Valley. Natural disaster is just one reason a family may have to unexpectedly vacate or abandon their home on short notice.

Design Rationale

People in our community rely on pets for love, companionship, security, entertainment and more, and they give them the same in return, each enhancing the other's existence. At times though, life does not allow us to provide the daily care they require. In these instances, we take on the responsibility of ensuring their needs are met even when we are not there to provide for them.

Problem Scenario

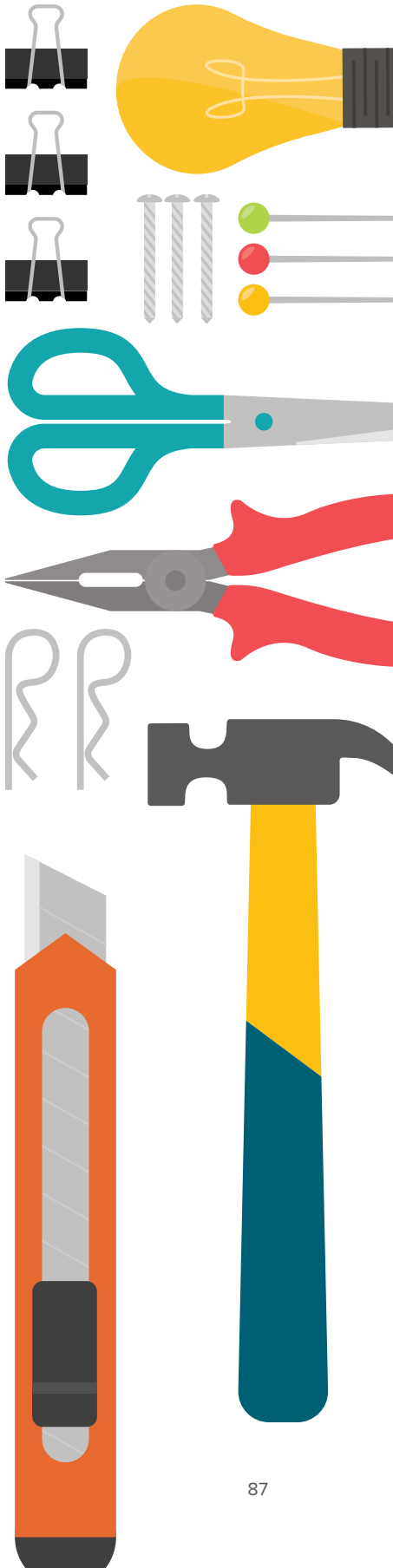
Your team has been selected to develop the prototype of a system or a tool, that will allow animal caregivers/owners the ability to leave for a period of time with peace of mind. Your prototype will address one or more of the following needs:

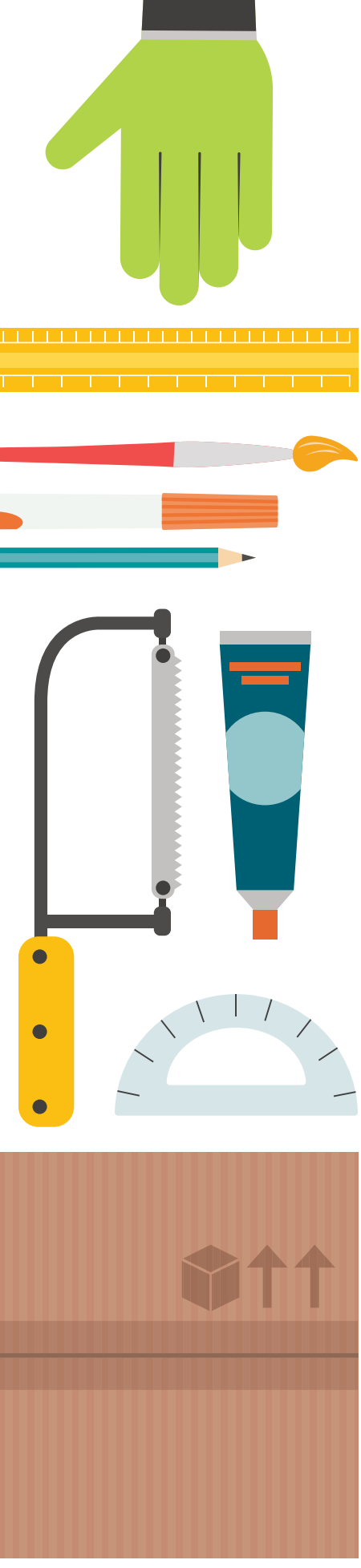
- Access to food
- Access to water
- A waste solution
- Comfort (temperature/light)
- Exercise
- Companionship

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Uniqueness and usability of the tool
- ❒ At least one piece of functionality using technology
- ❒ Alignment of the prototype with the design
- ❒ Ability of your tool to be adaptable to animals of different species and size, indoor/outdoor use
- ❒ Uses the consumable items in the participant group kit provided
- ❒ Alignment to the design motto: "Make it smaller, stronger, do more, be easier to use, be cheaper, be cleaner, be greener."





Parameters

- ❒ Must incorporate at least one functional element enabled by the technology (Little Bits) found in your participant group kit.
- ❒ Plan how to use something of every consumable item in the participant group kit provided.
- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use the tools that have been provided at the shared tool station.

Note

This Design Challenge comes from Joanne Britton and her colleagues at Chilliwack School District, British Columbia. It was first designed for use at a Maker Day for educators held at the University of the Fraser Valley. It is a modification of Design Challenge #7.

7 Frugal Innovation for a Sustainable, Happy Future

Overview

We live in an interconnected world; our actions and activities impact living conditions for others both locally and globally. In 2000 the United Nations drafted initial Millennium Goals (**http://www.un.org/millenniumgoals/**) to improve quality of life. Recently, these goals were revised, focusing on issues of environmental sustainability, happiness, and well being.

Frugal innovation refers to removing nonessential features from a solution in order to make it as widely applicable as possible. Of primary concern is achieving the highest quality at the lowest cost. Experts suggest frugal innovation may provide the best approach to reducing the complexity and cost of finding solutions to global challenges impacting our global community. It is suggested that frugal innovation may be one of the best ways to achieve the new Millennium Goals (**https://www.unicef.org/innovation/frugal**).

Design Rationale

As Canadians, we enjoy an enviable quality of life—clean water, expectation of safety, strong government, etc. We expect that these qualities will be sustained, maintained, and even improved. However, concerns related to environmental sustainability increasingly impact our life. It is important that we find solutions to our problems that respect environmental sustainability at local and global levels and continue to provide the quality of life that is important to us. A challenge in the future will be how we can sustain our values and lifestyle, maintain a sense of happiness and well being, and address the concerns that face us, in ways that are respectful of larger contexts.

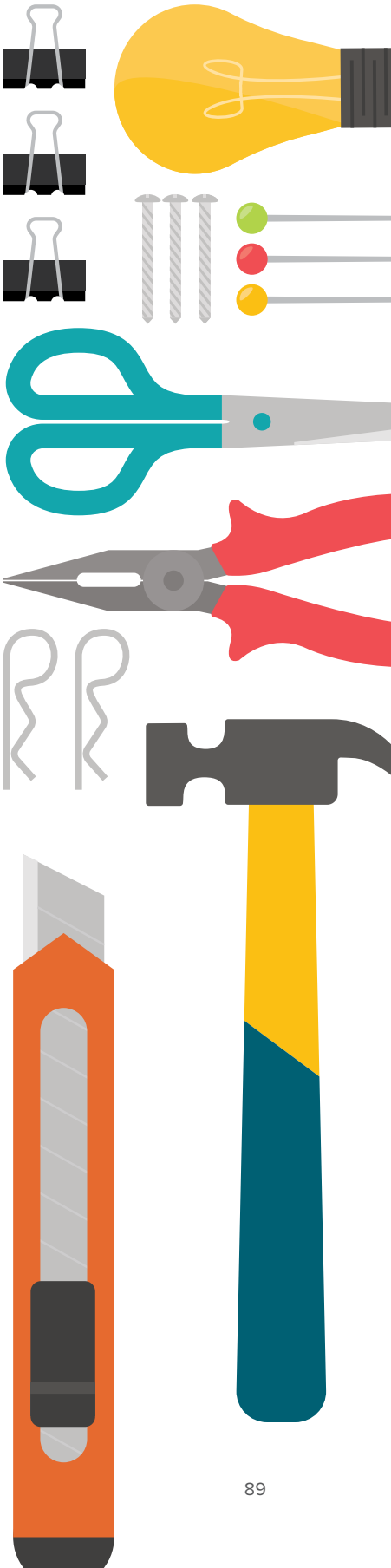
Problem Scenario

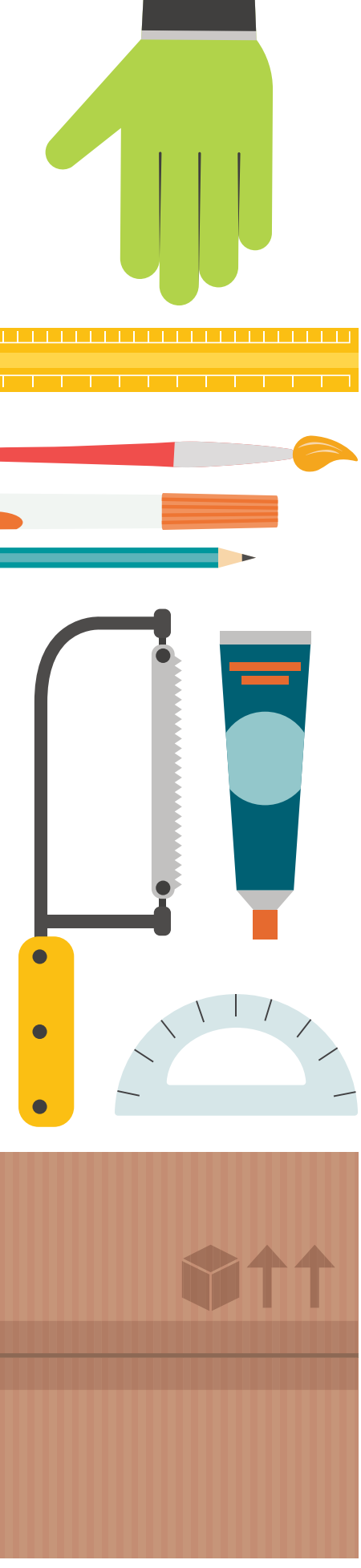
Your team has been selected to look at sustainability issues in your region. Your team must choose an issue that resonates with you and develop a prototype to address the concerns raised by that issue. The issue that you choose should have an impact on the day-to-day quality of life for an identified group in your region. The solution should also increase their happiness, be frugal in design, and have little impact on the environment.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Uses some of all the consumable items found in the participant group kit provided
- ❒ Introduces the functional elements from the appropriate technologies bar and enhances your prototype
- ❒ Demonstrates accurate measures and cuts with careful fabrication
- ❒ Aligns with your design sketch





Parameters

- ❒ Plan how to use something of every consumable item in the participant group kit provided.
- ❒ Use materials found in the Appropriate Technologies Bar section described in **https://issuu.com/ubcedo/docs/diy_guidebook** and the shared pantry to aid your group in the development your solution.
- ❒ Use the tools that have been provided at the shared tool station.
- ❒ Incorporate at least three (3) functional elements enabled by components from the appropriate technologies bar, and your team must be prepared to explain how these components support your prototype.

8 *Chindogu*: Designing for the Pleasure of Design

Overview

We often think of design as the creation of plan or object for a specific function. We use a design process to move our thinking from initial ideas to conceptual sketches. From the sketches, we can then create working prototypes that we can test and evaluate. When we use design thinking, we engage in human centred design, focusing our design on how the end user might use our prototype to address a real problem.

Chindogu is a fun twist on the typical design process. Chindogu is a Japanese word that means unusual tool. The inventor of the term, Kenji Kawakami actually thinks "weird tool" is a better translation! There are three basic rules for chindogu objects. They must be "make-able," although they actually do not serve any real or needed purpose; be open access and cannot be patented; and be humorous, but that is not their entire purpose or function. In other words, they are an actual tool and not a joke or a trick.

Design Rationale

People are encouraged to make chindogu for the sheer pleasure of designing a tangible item. Kenji Kawakami suggests that making chindogu helps us to

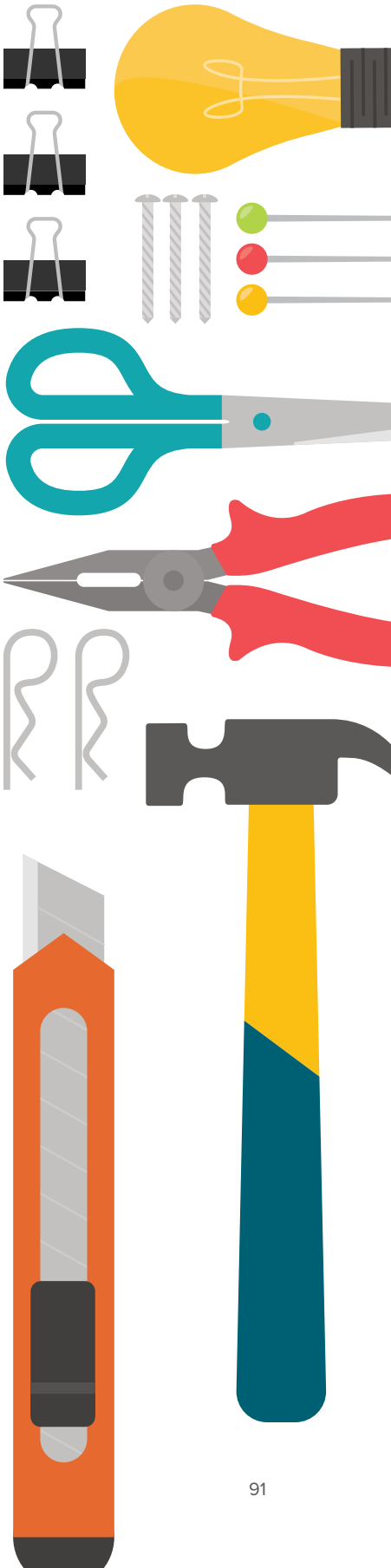
- improve our divergent thinking and creativity
- improve our craft abilities and artist skills
- revel in creativity without the pressure of making something functional or commercial

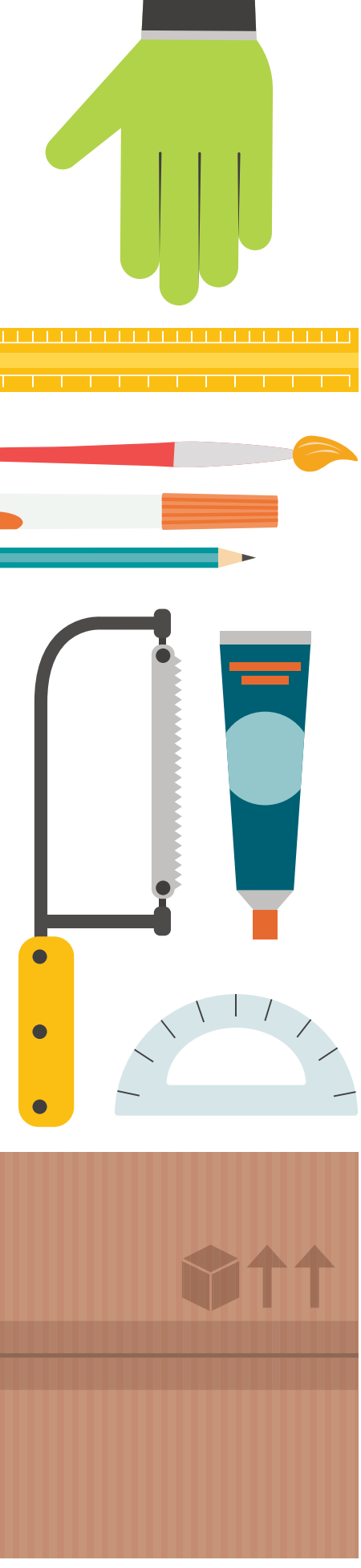
Examples of chindogu include

- duster slippers for cats, so they can help out with the housework
- the baby mop, an outfit worn by babies, so that as they crawl around, the floor is cleaned
- the all-day tissue dispenser, which is basically a toilet roll fixed on top of a hat, for hay fever sufferers

You can find more examples on the official chindogu site **http://www.chindogu.com/?page_id=181** or search chindogu and images on the Internet for pictures of existing designs.

One of the best ways to think about chindogu is to consider two items that have seemingly absolutely no connection. For example, think about shoes and an umbrella. Anything pop into your mind?





Problem Scenario

Your team has been selected to design a prototype of a chindogu that is functional (in a chindogu kind of way), well crafted, and will provoke a smile on the face of someone seeing it! Please remember, a prototype is a model that illustrates the functionality of an idea or design. It may be life sized or scaled to a model that fits in your hand. However, a prototype needs to be as real looking as possible, using the materials available.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Uses some of all the consumable items found in the participant group kit provided
- ❒ Aligns with your design sketch
- ❒ Meets the definition of a chindogu

Parameters

- ❒ Plan how to use something of every consumable item in the participant group kit provided.
- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use the tools that have been provided at the shared tool station.

9 Hand Shadows: Seeing Is Believing

Overview

Some people believe that the art of hand shadowing has existed since about 850 AD. Hand shadows have provided entertainment and education since there was a controllable light source and blank wall onto which to project the shadow.

The first known book about this topic was published in 1859 by Henry Bursill, *Hand Shadows to be Thrown Upon the Wall*. It is available from Project Gutenberg as a free download (**http://www.gutenberg.org/ebooks/12962?msg=welcome_stranger**). Bursill hand drew all the illustrations in his book. Of course, there are now apps for hand shadows. A great resource for hand shadows *The Classic Art of Hand Shadows* is available from Lee Valley (**https://www.leevalley.com/en-ca/shop/home/books-magazines-and-dvds/58216-classic-art-of-hand-shadows?item=49L8610**).

Design Rationale

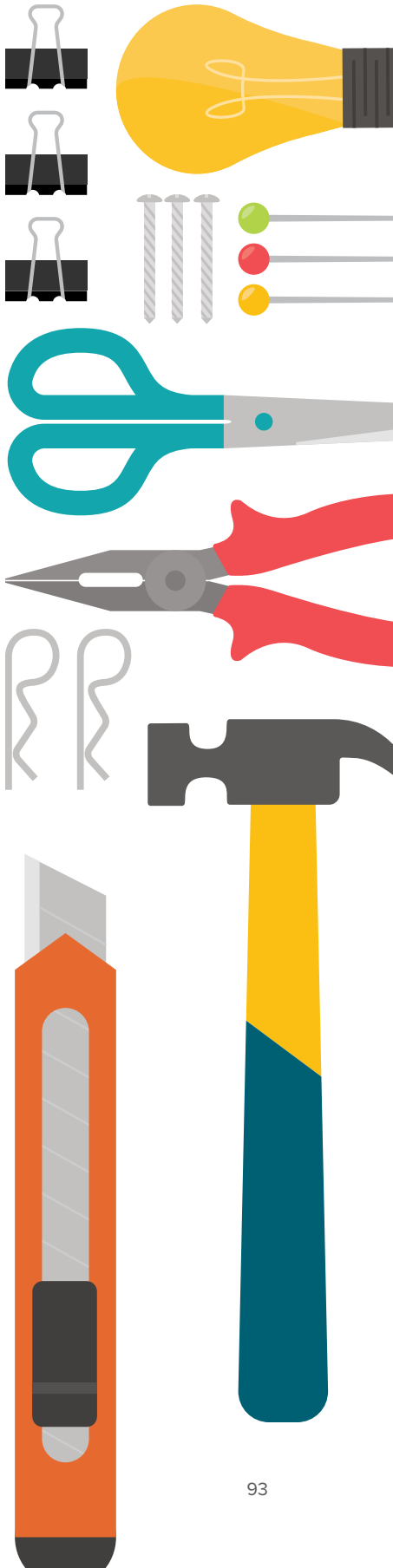
To see what is being depicted in a hand shadow, we have to look beyond the actual hands and see only the shadow image. For the best viewing of a hand shadow, people often create a frame or a stage so only the shadow image can be seen. By figuring out a set of movements, you can animate your hand shadows. It is also possible to add small props (i.e. paper cuts outs, etc.) to make your shadows more realistic.

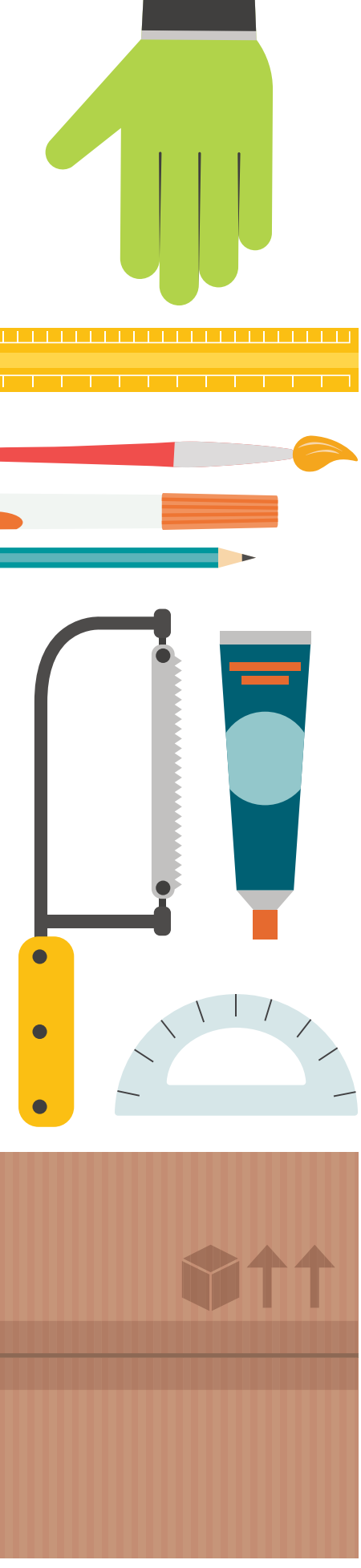
The educational value of hand shadowing is in learning to:

- decode or make sense of shapes and images
- produce a short show using hand shadows as characters
- think in multiple dimensions or formats
- think about light and shadow
- image shapes and movement

Problem Scenario

Your team has been selected to produce a 1-minute hand shadow production that encourages positive citizenship or general good behavior. Your production should have multiple characters and each member of your group must play a role in the production. We will use a design thinking process to help your group identify an issue related to citizenship or behavior that is of concern in our school.





Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Aligns with your design sketch
- ❒ Meets the production and uses of hand shadows well
- ❒ Develops an entire production—shadows, story, props and light source

Parameters

- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's frame or stage.
- ❒ Use the tools that have been provided at the shared tool station.

10 Geometrigraph and Polygraph Templates: Designing with Geometry

Overview

The geometrigraph and polygraph were manufactured in the late 1800s. Using just these two devices, you can create curved, parallel or perpendicular lines as well as circles, angles and a range of polygons from 3-sided to 20-sided.

Design Rationale

These shapes have been used by wood workers, quilters, sign makers, graphic artists, and many others to create geometric shapes in tangible forms or in three dimensions.

The geometrigraph and polygraph can be found in the Victoria and Albert Museum in London. The geometrigraph and polygraph also inspired the creation of the Spirograph in 1965 where it was introduced at the prestigious Nuremberg International Toy Fair.

Interest in the geometrigraph and polygraph template has increased with the introduction of Zentangles as a relaxing, meditative art form (**https://www.zentangle.com/**).

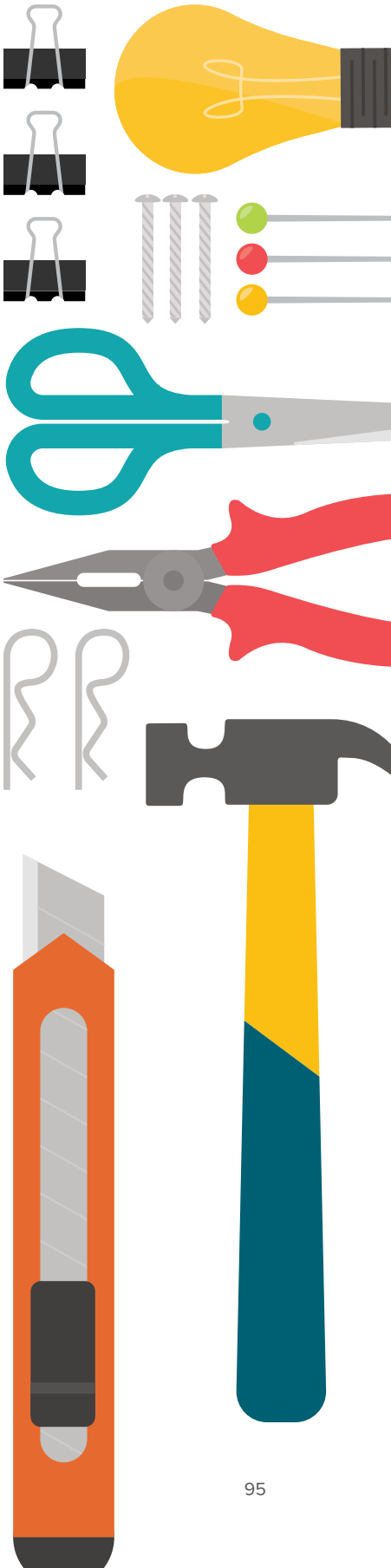
Problem Scenario

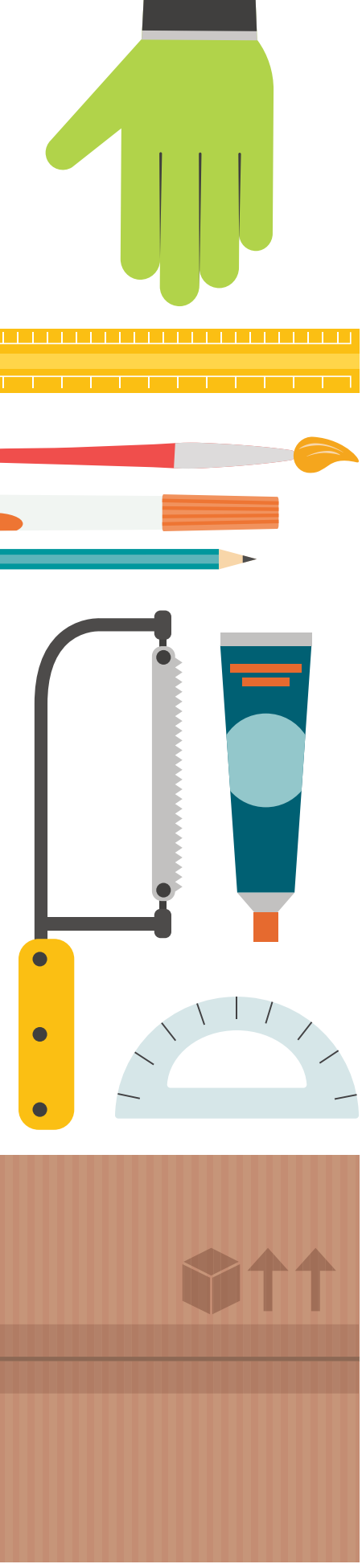
Your team has been selected to produce an interesting, complex, aesthetic geometric image that requires the use of both the geometrigraph and polygraph. You should be able identify the shapes in your image. You also need to design a structure that allows you to secure your paper and the templates and allow for complex drawing by multiple users.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Uses the templates well
- ❒ Includes multiple geometric shapes
- ❒ Is aesthetic and complex
- ❒ Provides easy identification of the geomotric shapes to your audience





Parameters

- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use the tools that have been provided at the shared tool station.

11 Automata

Overview

Automata are whimsical and wonderful machines that combine art, play, humour, science and engineering. They have a long history that appears to transcend geography and culture.

Cuckoo clocks with movable figures and mechanical bell ringers, often found in medieval European churches, are examples of automata, as are complex toys with multiple movable parts from Japan and China. Some of the earliest mention of automata can be found in Greek mythology where Prometheus was tortured by an artificial eagle for giving fire to humans. If you are unfamiliar with automata, please watch **https://www.youtube.com/watch?v=9OqEze9JTu0**.

Design Rationale

In Design Challenge 2, *Using Machines to Make Overly Complex Compound Machines*, we introduced the concept of mechanical advantage. Automata are complete units that typically tell a short story—someone chopping wood, a horse running, etc. They utilize a combination of levers, cranks, linkages, cams, shafts, ratchets, gearing, and drives.

For specific tips on how to make an automata out of simple materials, please refer to **https://www.exploratorium.edu/sites/default/files/tinkering/files/Instructions/cardboard_automata_guide_final_screen.pdf**.

Problem Scenario

Your team has been selected to produce an interesting, complex, narrative automata that uses as many mechanical combinations as possible (i.e. levers, cranks, linkages, cams, shafts, ratchets, gearing, and drives).

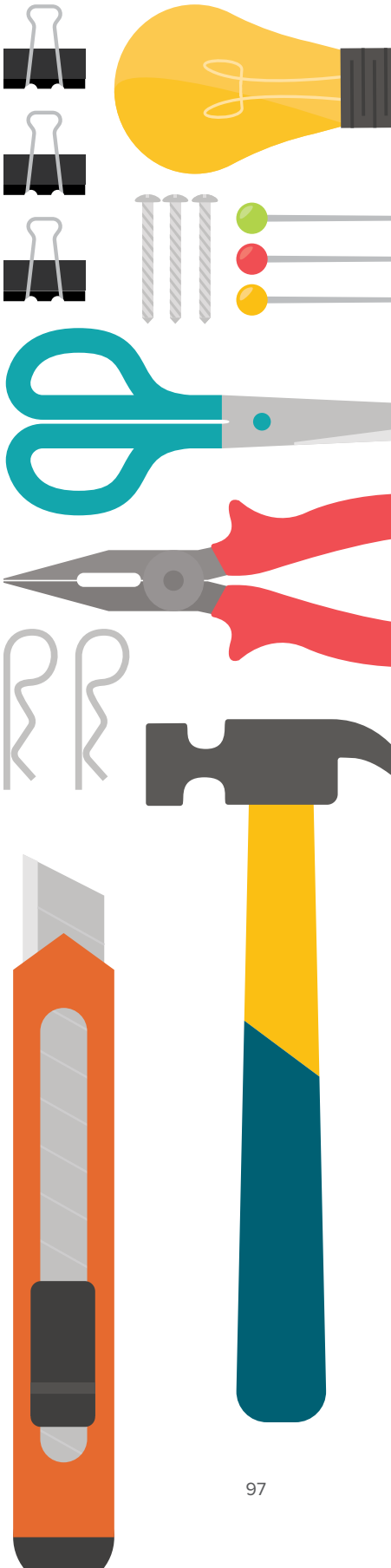
Success Determinants

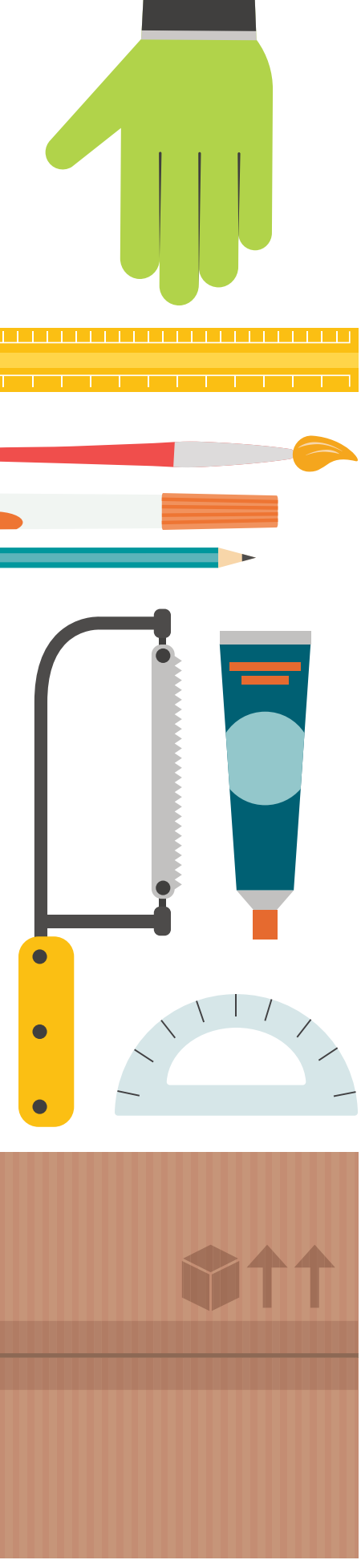
Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Is aesthetic and complex
- ❒ Identifies the various mechanical functions of an automata

Parameters

- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use the tools that have been provided at the shared tool station.
- ❒ Use at least two mechanical combinations (i.e. levers, cranks, linkages, cams, shafts, ratchets, gearing, and drives).





Note

If you this position this challenge in Social Studies or English, the students' automata might be a specific character doing contextually relevant task. For example, if students were reading the novel *The Old Man and the Sea*, the automata might be an older man fishing from a boat. If students were studying the exploration of the Northwest Passage, the automata might be people paddling a canoe. Also, please note automata differ from Rube Goldberg machines as automata are narrative while Rube Goldberg machine are excessive in their complexity!

12 It's Never Black or White or Paper or Plastic

Overview

We have all heard the phase, "Reduce, Reuse and Recycle." The majority of Canadians have recycling options right on their doorsteps, provided by their municipalities. The recycling symbol is a common marking on the items we use. On a personal level, what to use and how to reduce our consumption can be challenging.

Design Rationale

The evolution of packaging and the use of containers to carry purchases from shopping is interesting. In many parts of the world, customers are expected to bring their own shopping bags, and these often take the form of baskets, reusable cloth or heavy-duty plastic bags, boxes, etc. Not so long ago, a very familiar question at our store's check out counter was whether you wanted a paper or plastic bag to transport your purchase. Currently, many stores will either charge you for a disposable bag or will credit you a few cents if you use your own bag.

Many of us feel that we are doing our part to reduce waste by bringing our own fabric bags or recyclable containers. However, the issue of what is the best solution for waste reduction may not be so black and white/paper or plastic. Please read this article from *WIRED Magazine* **http://www.wired.com/2016/06/banning-plastic-bags-great-world-right-not-fast/**. This article reminds us that using anything is complicated and has unintended consequences and impacts. While plastic bags litter the landscape and take years to decompose, paper bags consume trees, and many cloth bags are made using cotton, a very environmentally costly plant to grow.

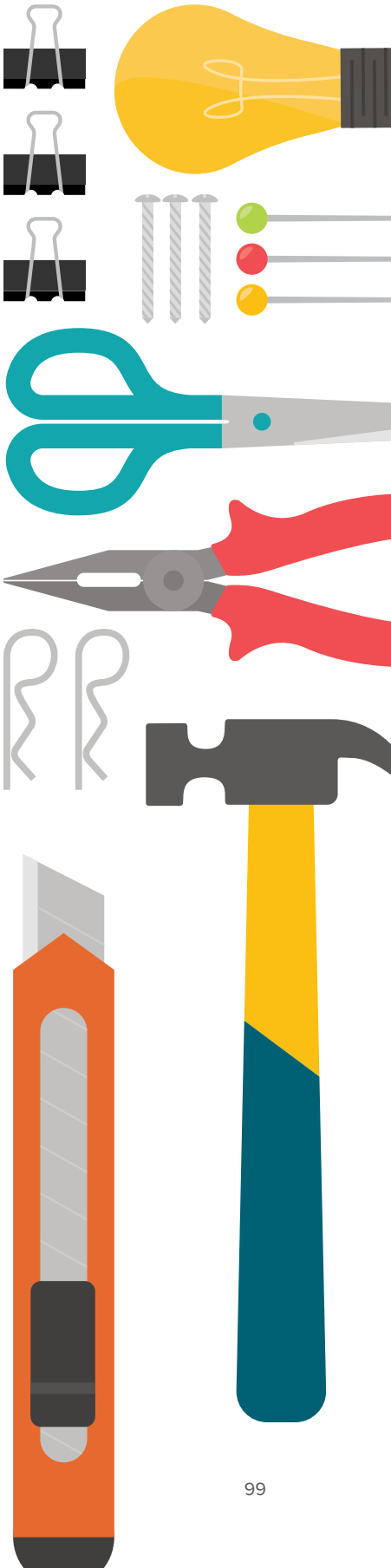
Problem Scenario

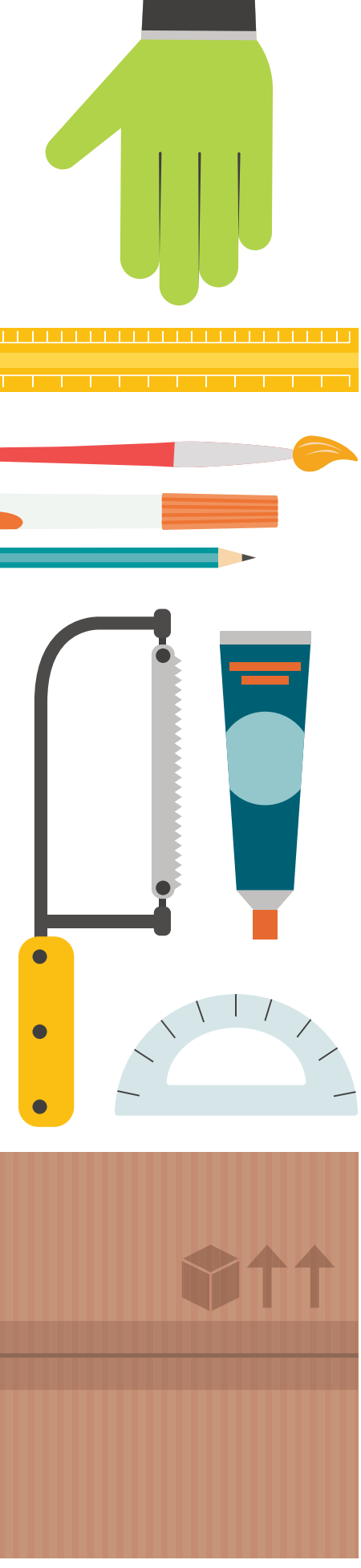
Your team has been selected to produce an option for consumers to transport their purchases. Your option needs to tend to the challenges and issues surfaced in the article, *Banning Plastic Bags Is Great for the World, Right? Not So Fast* (**http://www.wired.com/2016/06/banning-plastic-bags-great-world-right-not-fast/**). Your option also needs to be flexible, portable, reasonable, and useable by a large sector of the population.

Success Determinants

Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Uses some of all the consumable items found in the participant group kit provided
- ❒ Aligns with your design sketch
- ❒ Is useful, aesthetic and environmentally responsible
- ❒ Is easy to show how the merits of your option in relationship to the points shared in the article, *Banning Plastic Bags Is Great for the World, Right? Not So Fast* (**http://www.wired.com/2016/06/banning-plastic-bags-great-world-right-not-fast/**)





Parameters

- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use the tools that have been provided at the shared tool station.

13 Between a Number and a Person: Considerations of Identity and Respect

Overview

Between 1944 and 1969, the Canadian government implemented the Eskimo Identification Tag system. These tags were given to "...every Inuk living in the Western and Eastern Arctic. Each disc was about 2.5 centimetres in diameter, made of hard cardboard or leather and sienna-like in colour. The expectation was that each Inuk would keep the disc, which had a hole punched in its top, on his or her person at all times.

One side of the disc was embossed in its centre with a black image of the seal of the Crown, with the words "Eskimo Identification Canada" circling the perimeter. The other side had a line of code beginning with either the letter "E" (for Eastern Arctic) or "W" (for Western Arctic), followed by a number representing the community or region where the individual was living. (A "6," for example, indicated the Pangnirtung/ Broughton Island region.) Completing the code was a set of identification numbers specific to the Inuk carrying the disc. (If you didn't have the disc on you, it was considered wise to have memorized the line of code.)," (Adams, 2016, Para 3-4, Retrieved from **http://www.theglobeandmail.com/arts/art-and-architecture/barry-pottles-photography-explores-inuit-objectification-by-id-tags/article30060124/**).

Design Rationale

The rationale for the Eskimo Identification Tag system was, "Federal agents deemed Inuit names to be too long, difficult to spell and frustrating to pronounce. In addition, Inuit naming traditions were complex. There was no gender specificity, no surnames. Women didn't take the family name of their husbands upon marriage. Children would carry several names for a time, then discard or change them as their personalities became more fixed," (para. 5-6).

Identity and identification are important in a civil society. Globally, obtaining legal identity is a struggle in some places. Organizations such as United Nations work with independent groups and companies to design ethical and respectful ways of providing identity to refugees and others disposed by global challenges. Biometrics is one way (see *Biometric Identity Management System*, **https://www.unhcr.org/550c304c9.pdf**).

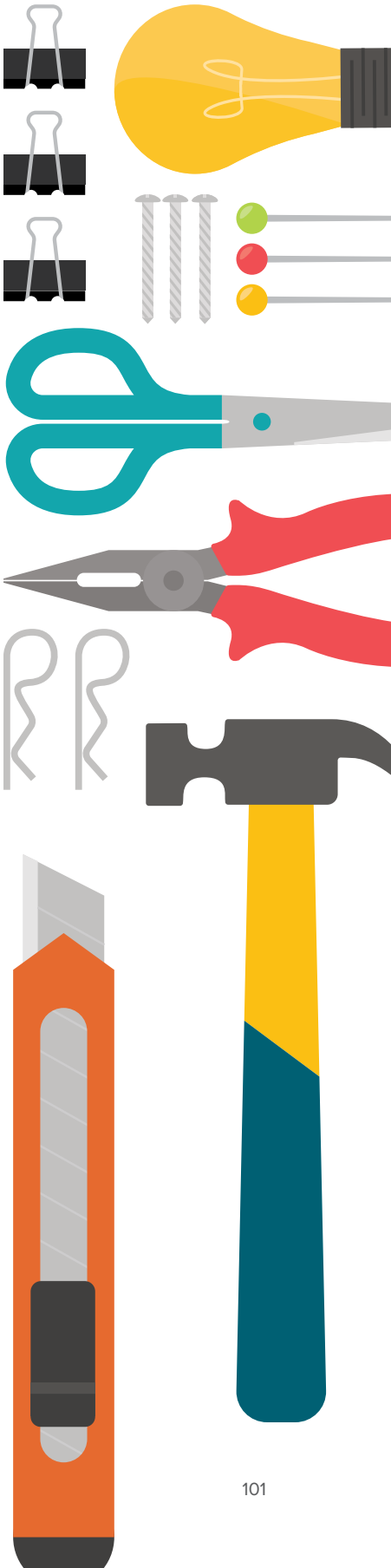
In Canada, identity and proper identification are essential for access to social services such as medical assistance, financial aid, and even job certification.

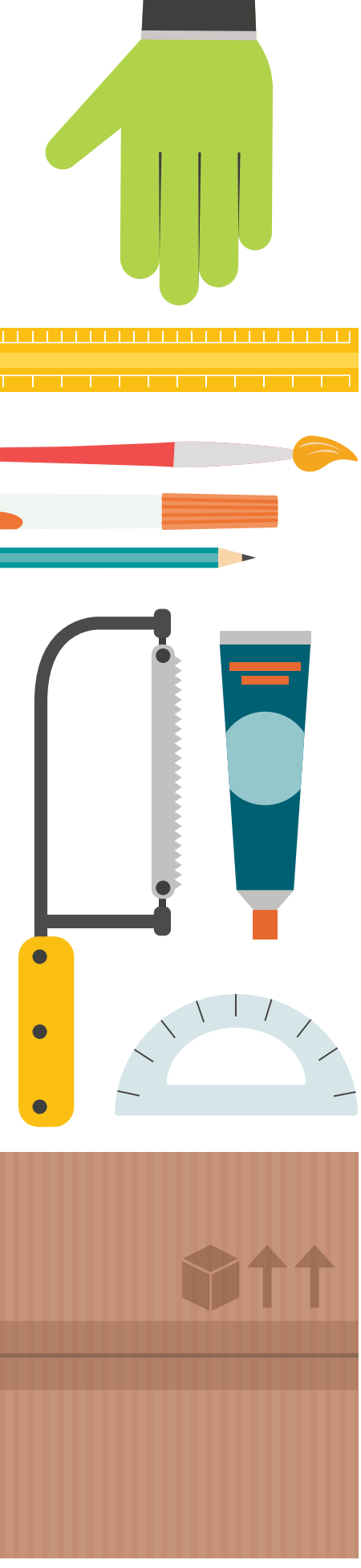
Problem Scenario

Your team has been selected to design a respectful yet secure way of providing identification for new immigrants, refugees and/or elderly or very young Canadians who might not have ready access to existing forms of complex identification records.

Your option also needs to be secure, flexible, portable, reasonable, and respectful to a large sector of the population.

Success Determinants





Success will be determined by the degree to which your design solution:

- ❒ Addresses the issues suggested in the design challenge
- ❒ Is useful and respectful

Parameters

- ❒ Choose consumable items and materials found in the shared pantry to aid in the enhanced development of your group's prototype.
- ❒ Use social media options or other digital technology as a portion of your solution.
- ❒ Use the tools that have been provided at the shared tool station.

14 Agricultural Automation

Overview

Agriculture is the cultivation of animals, plants, fungi, and other life forms for food, fiber, biofuel, medicinal and other products used to sustain and enhance human life. In Canada, agriculture is often a business that operates on a large or small scale. Increasingly, agricultural operations have some aspect of their work that is automated in some way, regardless of the size of the operation.

Design Rationale

Each time there is a downturn in oil prices, Canadians are reminded how important it is to have a diversified economy.[6] For example, British Columbia exports lumber and farmed fish as well as promotes tourism. Canada competes in a global marketplace, so it is important that we remain as competitive as possible. Around the world, automation and mechanization have dramatically increased productivity in many areas of agriculture. The spin-off industries that refine raw products require technological innovation to strengthen the economy and increase jobs and services.

Problem Scenario

Your team has been selected to develop a prototype[7] of a tool or piece of equipment that will improve an aspect of an agricultural operation and improve its functionality. Your prototype must improve on existing economic viability, safety, effectiveness, or provide something absolutely new. Because this is a prototype, it may be full size or a scale model.[8] However, your prototype needs to represent / illustrate the components of its functionality, and it needs to look real as possible.

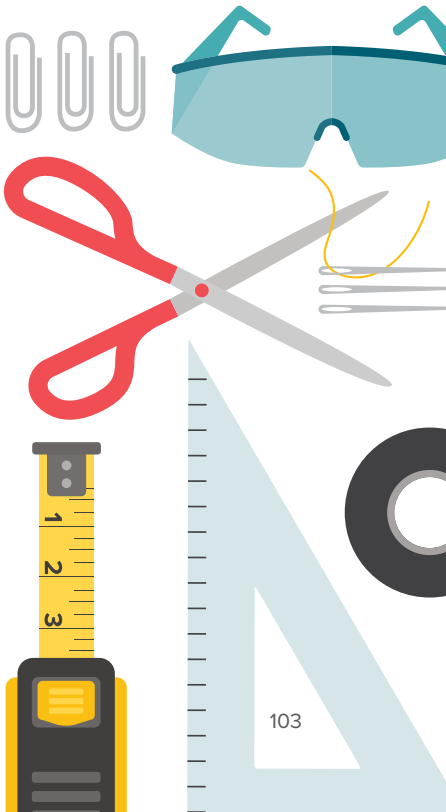
SkillsCanada Alberta

Suggested Grade Level

- Upper elementary through to secondary school

Suggested Subject Area

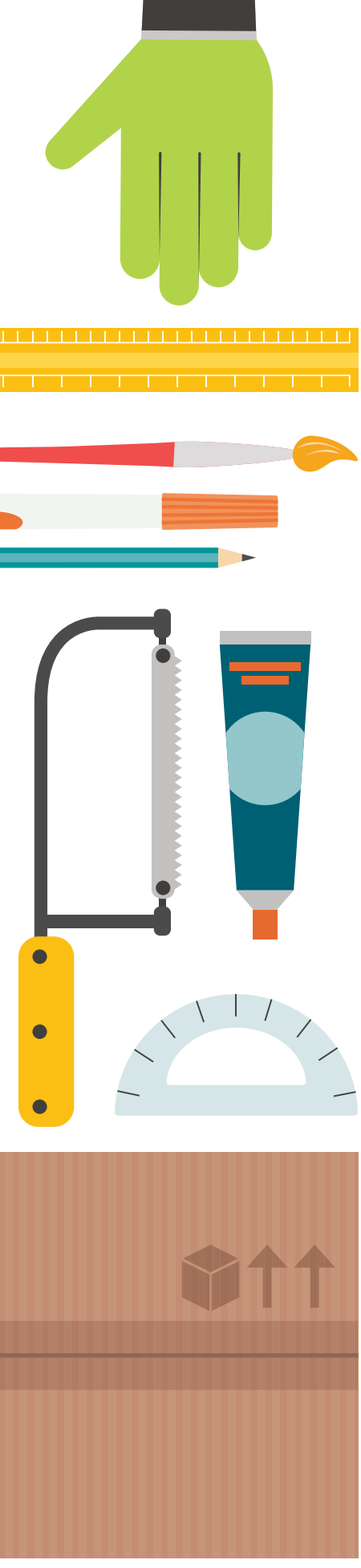
- ADST
- Economics
- Science
- Social Studies



6 A diversified economy means that a region is not solely reliant on single source of revenue.

7 A prototype is a model that illustrates the functionality of an idea or design. It may be life sized or scaled to a model that fits in your hand. However, a prototype needs to be as real looking as possible, using the materials available.

8 A scale model means that your model may be much smaller or larger than the actual, final product.



Success Determinants

Success will be determined by:

- ❒ Ability of your prototype of a tool or piece of equipment to save an agriculturist time, money, or some other needed functionality
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Functionality of your automation or mechanization
- ❒ Uniqueness and usability of your prototype and the degree to which it solves an actual problem
- ❒ Your ability to fully explain the physical and software aspects of your project to someone unfamiliar with agricultural operations and the problem for which your prototype is a possible solution

Parameters

- ❒ Your prototype must have a technological component to it that is controlled by code that your team has written. That code must have at least one for loop (or while loop) or an if-else statement.
- ❒ Your project must include some use of code that you haven’t learned in class.
- ❒ Your project must include at least one sensor (physical input) and two actuators (physical output).

Sensors (physical inputs)

- button
- photo resistor
- piezo (as a microphone)
- potentiometer
- soil moisture sensor
- temperature sensor
- ultrasonic sensor

Actuators (physical outputs)

- dc motor
- lcd display
- led
- piezo (as a speaker)
- rgb led
- servo motor

- ❒ The only resources or materials you can use that are not provided in your participant group kit include:
  - Cardboard / corrugated cardboard
  - Duct tape
  - Hot glue
  - Pipe cleaners

15 Classroom Furniture

Overview

The classroom furniture may help or hinder collaborative learning. The ability to move furniture easily, quickly, and safety is important in classrooms wanting to create and support collaborative learning. When students are using digital technologies such as tablets or laptops, they need to be able to move around, connect to electricity, work in ever-changing groups, and use a variety of materials and resources. Also, recent studies suggest that sitting is the new smoking. From Smith Systems website: "movement can contribute to ... concentration and is considered beneficial to physical health," (Retrieved January 2016, **https://smithsystem.com/school-setting/classrooms/**).

Design Rationale

In some Canadian schools, classrooms look and feel very traditional. Students sit in individual desks and those desks are often arranged in rows. Increasingly, some schools are changing the arrangement of furniture in their classrooms. Typical individual desks and chairs are being replaced with more welcoming, colourful, and different looking furnishing. Educators are increasingly suggesting that we need to think about how the furniture students use can become a physical point of contact between the student, the teacher, the learning, and the school.

Problem Scenario

Your team has been selected to develop a prototype for a structure component of classroom furniture that supports learning innovations and collaboration. It needs to be welcoming, comfortable, functional, colourful, and mobile. Your furniture must be a scale prototype of a classroom furniture model that could be found in a class setting. For this design challenge, your prototype must satisfy two of the following identified concerns:

1. Be adaptable for use by children with disabilities
2. Be affordable
3. Be easy to move
4. Be enjoyable for users of all ages
5. Be innovative and not an exact copy of something that currently exist
6. Be useful and beneficial for students of varying heights and sizes
7. Foster a positive, collaborative and enjoyable learning environment by addressing a specific concern or function

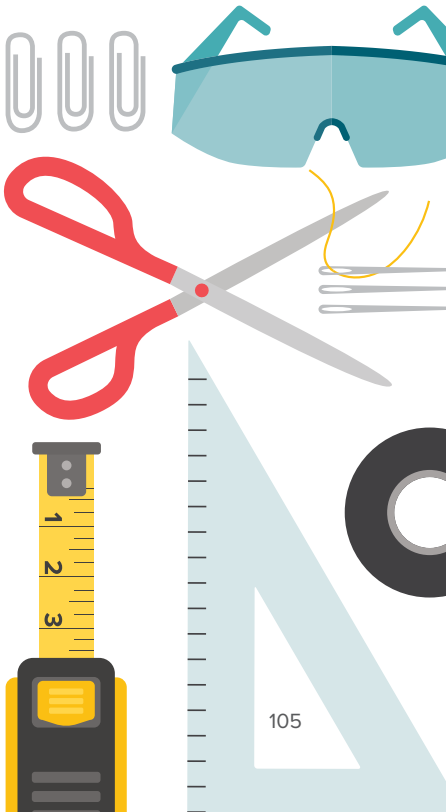
SkillsCanada Alberta

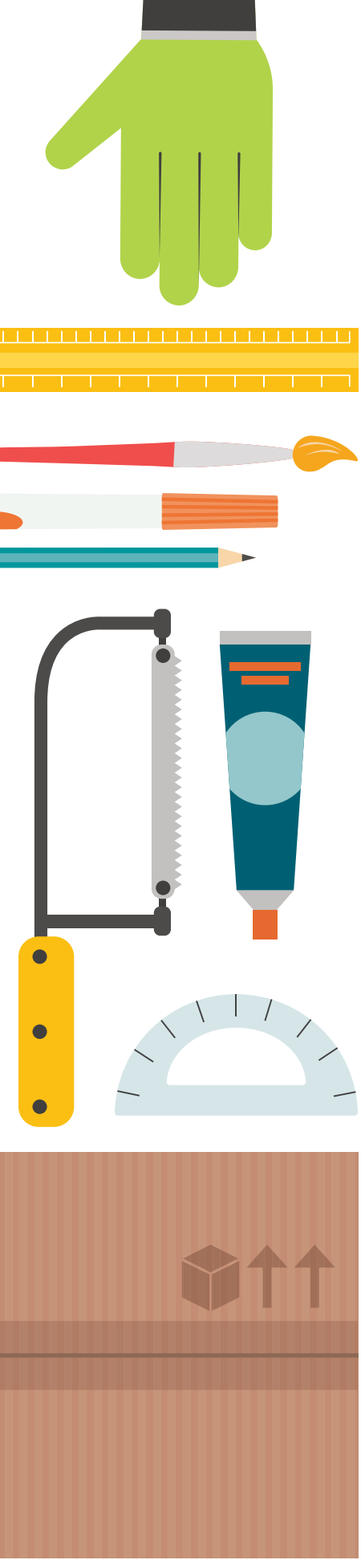
Suggested Grade Level

- Elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—wherever school culture or community is addressed
- ADST
- Health Sciences
- Mathematics
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Ability of your prototype for a structure component of classroom furniture to help the user enjoy learning
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which your prototype is adaptable to all users
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Ease of long term maintenance and durability
- ❒ Ergonomic design
- ❒ Functionality
- ❒ Promotes active learning
- ❒ Uniqueness and usability of your prototype and the degree to which it solves an actual problem

Parameters

- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing and ergonomic.
- ❒ You must use some of all the consumable items in the participant group kit in some way.

16 Integrative Learning / Integrative Living

A Resource for Teachers

Overview

When educators create rich learning experiences for their students, they engage in the complex act of curricular interpretation and planning. The act of moving from curriculum as written to curriculum as embodied through learning requires thoughtful consideration and continuous design, iteration and revision. Research informed by the learning sciences (Bell, Lewenstein, Shouse, & Feder, 2009), growth mindset (Dweck, 2012), and PISA results (Programme for International Student Assessment, 2012) has shown that what we know about learning and how students learn has changed. As well, the needs of Canadian society, especially in terms of what constitutes a skilled workforce, have changed over the last few decades. These changes require educators to reconsider how students might engage differently with mandated curricular intentions, suggesting a multi-disciplinary and multi-faceted approach to instructional delivery focused on active learning and problem finding and problem solving situated in real world contexts is appropriate.

Design Rationale

Over the past two decades, large Canadian cities such as Calgary have rapidly expanded and diversified their economic bases. Calgary is a city with an ever-growing boundary and a footprint that exceeds New York City—a city with eight times the population of Calgary (Retrieved January 2016, **http://forum.skyscraperpage.com/showthread.php?t=136479**). Calgary's growth has slowly encroached on the natural habitats in the area. As a result, animal habitats in the region are in danger. There is a desperate need to consider the impact of urbanization on the natural environment.

In 2005, the City of Calgary produced a document, *Green Infrastructure In Calgary's Mobility Corridors* (Retrieved January 2016, **https://www.scribd.com/document/215236286/Calgary-Green-Infrastructure-Mobility-Corridors-Sec**). This document is one of many that frame the problem of urban impact on the natural environment. Documents like this help educators to situate general curricular outcomes into relevant local or regional contexts. To make this link, educators need to hone their knowledge, understanding, and consideration of various disciplines and create rich learning opportunities for their students.

SkillsCanada Alberta

Suggested Grade Level

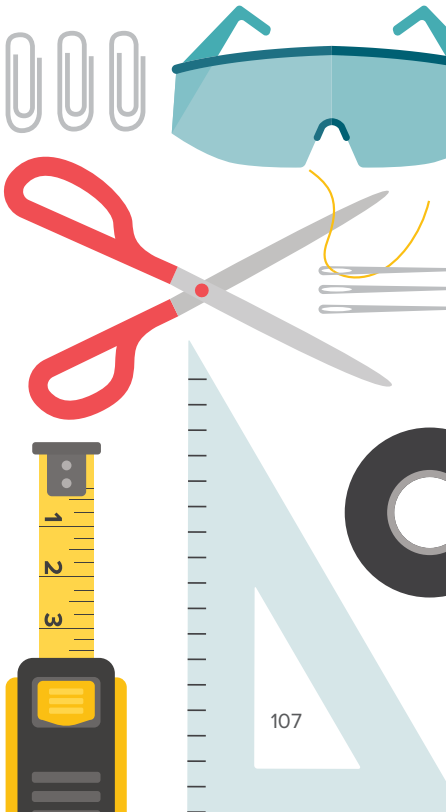
Adults working in elementary through to secondary school

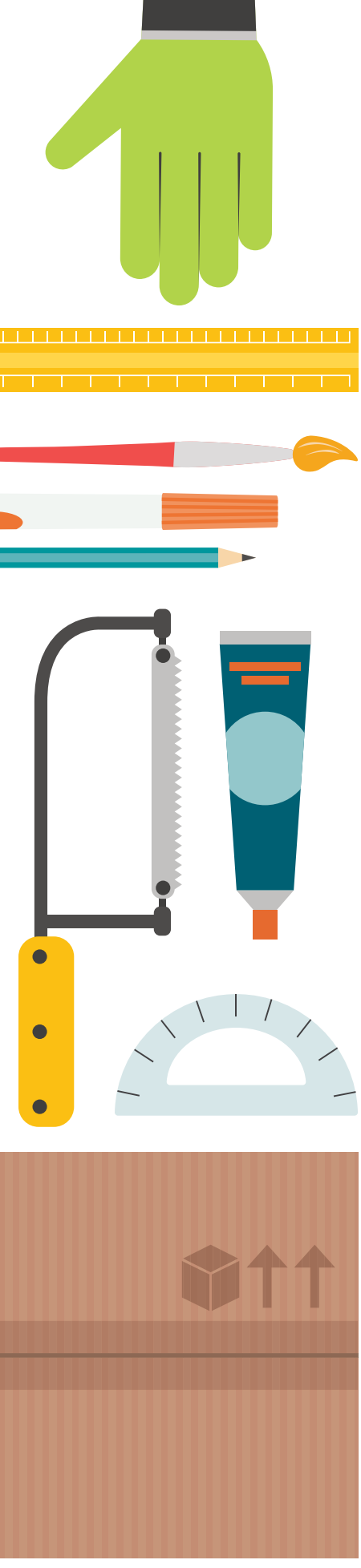
Suggested Audiences

- Directors of Instruction
- Principals
- School-based learning leaders

Suggested Subject Area

- Citizenship—wherever school culture or community is addressed
- Science
- Social Studies





Problem Scenario

The City of Calgary and surrounding areas are in need of your help. Local government offices are seeking innovative solutions to protect the ecosystem that sustains its local animal population. These potential solutions require the integration and synergy of multiple discipline areas, including ecology, biology, animal and human behaviours, natural resources, impact of urbanization and industrialization on rural areas, and economic implications. Proposals should include graphic representation of data analysis and predictions of population changes and patterns.

Your team has two tasks:

1. Create a metaphor[9] of student learning.
2. Develop a learning experience based on the problem scenario.

Task One: Your team will create a metaphor that illustrates your concept of how students learn. This will be a facilitated process using a human-centred design thinking process, collaborative prototyping, a design charrette[10] and reflection.

Task Two: Your team will design a learning experience for your students that requires them to:

- conduct a needs analysis of the current state of local habitats,
- research and develop strategies for remediation of an affected ecosystem, and
- create an opportunity to present their recommended action plans—possibly to members of the city planners or their local aldermen.

In creating your learning experiences, you need to consider a number of factors that students will need to understand:

- Action plan considers research on all areas that have contributed to the ecological impacts of urban sprawl
- Careful consideration of human factors that have led to the decline of the animal population
- Close consideration of the financial implication of your proposed action plan
- Description of the current state of affairs and potential future scenarios for animal growth based on analysis of data collected
- Identification of a specific animal populations for the students to target in their proposals
- What constitutes a sustainable and viable plan
- What constitutes a viable remediation strategy

9 A metaphor is a representation of ideas or concepts in a tangible and often creative or imaginative way. For example, we might use hearts as a metaphor for love, and then tear the heart or pierce it in some way to show angst or heartbreak.

10 A design charrette invites all participants to stop creating and become critical friends to other groups by asking good, open-ended questions while participating in a gallery tour of all the groups' metaphors.

Success Determinants

Success will be determined by:

- ❒ Clear linkages between curriculum outcomes and local issues
- ❒ Creation of assessment approaches that honour summative and formative learning (Retrieved January 2016 **http://www.learnalberta.ca/content/mewa/html/assessment/types.html**)
- ❒ Creation of engaging hands-on learning that fosters a growth mindset (Dweck, 2012) in students and supports learning innovations suggested by the learning sciences—possibly a 2 or 3 page lesson plan with supporting references and student resources

Parameters

- ❒ You must create a tangible metaphor, using some of all the consumable items in your participant group kit.
- ❒ You must incorporate multiple discipline areas into your lesson plan and resources.
- ❒ You must present formative and summative assessment strategies.

References

Bell, P., Lewenstein, B., Shouse, A., & Feder, M. (2009). *Learning science in informal environments: People, places, and pursuits*. Retrieved January 2016, **http://www.nap.edu/catalog/12190/learning-science-in-informal-environments-people-places-and-pursuits**.

Dweck, C. (April 20, 2012). *Exploring a growth mindset*. Retrieved January 2016, **https://www.youtube.com/watch?v=9hC1DwZS8tI**.

Girling, C., Galdon, M., Davis, L. & R. Kellett. (2005). *Green infrastructure in Calgary's mobility corridors*. Retrieved January 2016, http://www.dcs.sala.ubc.ca/docs/calgary_green_infrastructure_mobility_corridors_sec.pdf.

Programme for International Student Assessment (PISA). (2012). *PISA 2012 results*. Retrieved January 2016, **https://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm**.

17 Waste Management

Overview

Consider the impact landfills have on society and what alternatives might be. Globally, the world's cities are struggling with what to do with their daily trash. In 2014, it was reported that 3 billion of the world's 7 billion population live in cities, producing more than 1.3 billion metric tons of sold waste per year (Retrieved January 2016, **https://weather.com/science/environment/news/worst-cities-trash-garbage-problems-20130926#/1**). As you look through the pictures on the website Trash Cities: The World's Worst Garbage Problems, try to identify the types of trash and how it might have found its way into those settings. The trash illustrated in the pictures does not just make the environment look unattractive, it is potentially dangerous to us all!

Design Rationale

We love to think about Canada as being clean—drinkable water, clear air, and environmentally responsible. At the same time, Canadians produce more garbage per person than any other country on earth (Retrieved January 2016, **http://www.cbc.ca/news/business/canadians-piling-up-more-garbage-than-ever-before-as-disposables-rule-1.3248949**). In 2015, Canada sent one of the largest delegations to the Global Environmental Summit (Retrieved January 2016, **http://www.carbonbrief.org/analysis-which-countries-have-sent-the-most-delegates-to-cop21**). On a global scale Canada should take steps towards leading the field on environmental awareness and has a responsibility to model good practice and assist others address their trash issues. Trash is a problem both of use (over packaging, disposable rather than reusable items, etc.), reuse, recycling, and disposal.

Problem Scenario

Your team has been selected to develop a more effective way to deal with trash. Sites like **https://www.conserve-energy-future.com/15-easy-ways-to-reduce-landfill-waste.php** suggest ways to reduce landfill waste. However, your task is to develop a prototype of a product that:

- Fosters recycling or re-using of previously wasted materials,
- Provides a needed purpose or service,
- Reduces trash going into landfills, and
- Satisfies the following factors:
  - Does not currently exist
  - Does not negatively impact the environment
  - Has a legitimate purpose
  - Has long term benefits
  - Is small scale and inexpensive

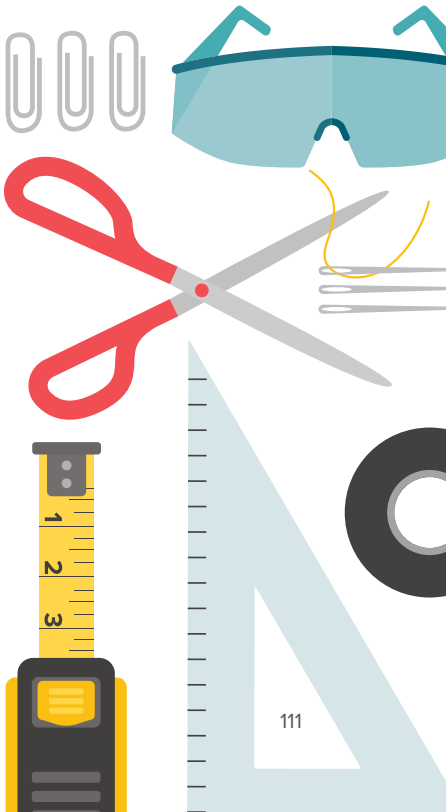
SkillsCanada Alberta

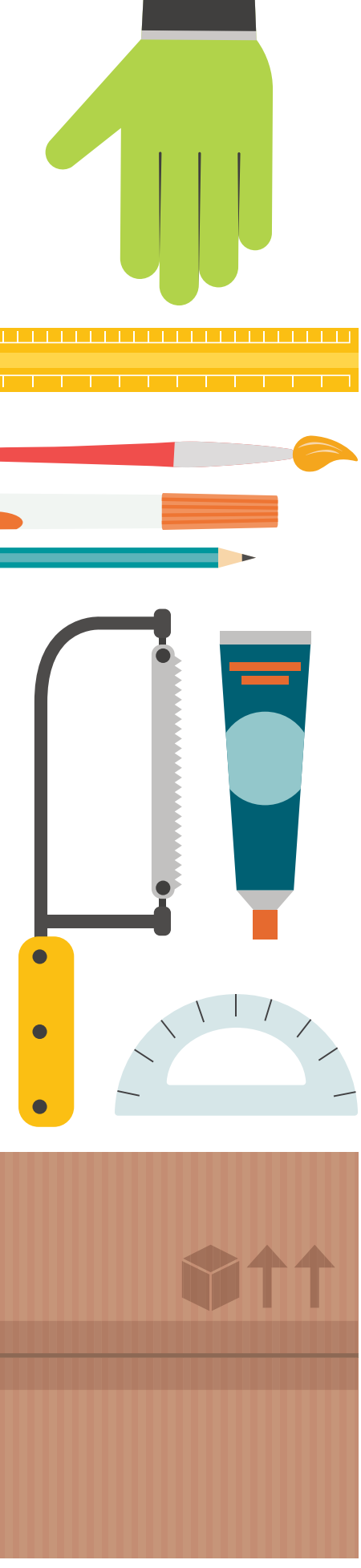
Suggested Grade Level

Elementary through to secondary school

Suggested Subject Area

- Citizenship—wherever school culture and community is discussed
- ADST
- Mathematics
- Science
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which your prototype addresses the problem posed in the design challenge
- ❒ Degree to which your prototype aligns with your group’s design sketch
- ❒ Ease of long term maintenance suggested with your prototype
- ❒ Functionality illustrated within your prototype
- ❒ Uniqueness

Parameters

- ❒ You may use the tools provided to you in the classroom/pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing and ergonomic.
- ❒ You must use some of all the consumable items in the participant group kit.

18 Defining the Components of Society Using Artist Trading Cards

Overview

Society is typically defined as a group of people living together in the same geographical and social territory. Historically, the word society comes from the Latin word *societas*, which means friend or ally. This connection suggests many societies were formed for protection and strength (Retrieved January 2016, https://en.wikipedia.org/wiki/Society). In Canada, we pride ourselves in creating a multicultural society built through immigration (Retrieved January 2016, https://en.wikipedia.org/wiki/Category:Canadian_society).

In our globalized world, society is becoming an increasingly complex system. We often refer to complexity within a society as being a social fabric that is woven together by different social structures (i.e. clubs, groups, etc.) and social components including points of view, age, gender, race, culture, religion, activities, dress, etc. Given the complexity within our society, many times symbols (**https://en.wikipedia.org/wiki/Symbol**) become representations of our society. These symbols can appear on many items including artist trading cards (**https://en.wikipedia.org/wiki/Artist_trading_cards**).

Design Rationale

Often students may feel like our Canadian society is run primarily by adults. One example: *2020 vision: What will downtown Edmonton look like at the end of the decade?* (Retrieved February 2016, http://www.edmontonjournal.com/business/commercial-real-estate/2020+vision+What+will+downtown+Edmonton+look+like+decade/10198815/story.html).

"Students may struggle to find their place. Within our schools, there are clubs, groups, and other social structures that may be organized by educators or students. As students gain understanding of which social structures and social components constitute a society within their schools, they may more easily find their places, and begin to work towards becoming productive members of society. Alternatively, older students might mentor younger students and build relationships across multiple schools," (one example of mentorship programs—Retrieved January 2016, **http://albertamentors.ca/**).

Problem Scenario

As part of the older student population in our school, your group has been selected to develop a set of 12 artist trading cards (3 artist trading cards per group member). Your artist trading cards will be used as models for the rest of the school as everyone participates in *Artist Trading Cards Trading Week*. During the week, all the students in our school will be invited to make their own set of cards to trade. Your group's set of 12 cards needs to illustrate a social structure or social component within the school that represents Canadian Society in 2020. If you have friends who are reluctant to draw their own card, you might introduce them to Zentangles—an inclusive start to making personal marks on small paper.

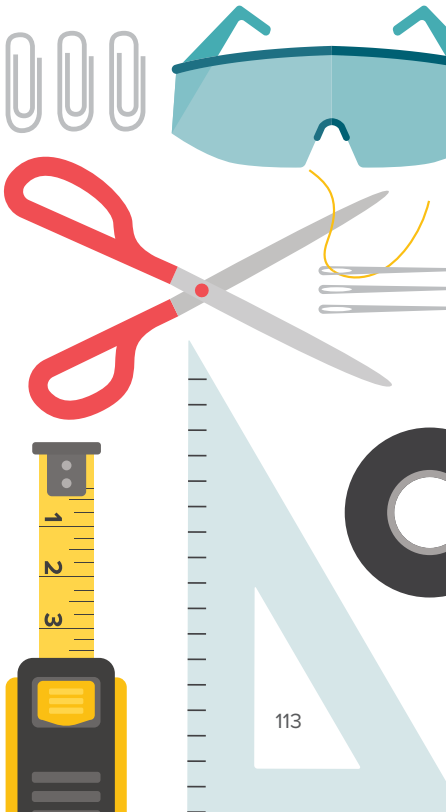
SkillsCanada Alberta

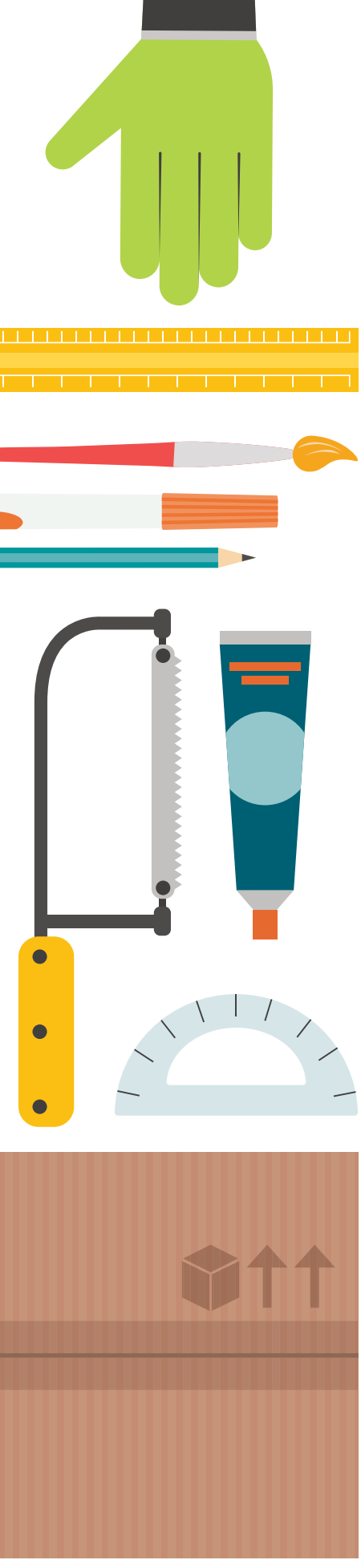
Suggested Grade Level

- Elementary through to secondary school
- Used as school community building activity

Suggested Subject Area

- Citizenship—wherever school culture and social community are discussed





The set of cards must satisfy the following:

- Illustrate one social structure or social component within the school
- Be reflective of one social structure or social component presented in Canadian Society in 2020
- One side of the card is your representation; the other side of the card clearly labels what you are representing

Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Artist trading cards can be created in any medium available from the shared pantry of resources
- ❒ Artist trading cards should be colourful and carefully created
- ❒ At least one of the group’s artist trading cards reflects a unique aspect of Canadian society in 2020 and that aspect is clearly labeled
- ❒ Each artist card is 2 ½" x 3 ½" card and can be in either portrait or landscape orientation
- ❒ Each member of the group makes 3 unique cards

Parameters

- ❒ You must complete a display panel including your design thinking sketches, sample artist trading cards, your design notes, and your reflections on the activity which will illustrate the artist trading cards you are illustrating.
- ❒ You must use some of all the consumable items in participant group kit in some way in the production of your cards.

Resources

Artist Trading Cards **https://en.wikipedia.org/wiki/Artist_trading_cards**

Zentangle **https://www.zentangle.com/**

ReadWriteThink **http://www.readwritethink.org/classroom-resources/student-interactives/trading-card-creator-30056.html**

19 Apathy to Empathy

Overview

Thanks to social media and an almost continuous news cycle (e.g. television, radio, newspapers, etc.), we are provided many glimpses into global events, both happy and tragic, on a daily basis.

Some suggest social media has made our society apathetic to the world around us. Others propose that we are merely sympathetic to tragedies in a superficial, short-term way because another tragedy is always being reported. Initiatives like *Fight Apathy* (Retrieved January 2016, **http://states.jsa.org/fightapathy/**) and *Me to We* (Retrieved January 2016, **http://www.metowe.com/**) attempt to mobilize youth to make a difference and move from apathy to sympathy to empathy.

Apathy typically refers to lacking passion or emotion or care for things that others might find engaging or important. When we talk about social or world issues, apathy is demonstrated by a lack of awareness of the issues or in statements like, "That problem is too big or taking place too far away," and "Why should I care?" or "What could I do?"

Sympathy typically refers to the ability to feel an emotion about an issue, whether it be sadness, joy, compassion, etc. When we talk about social or world issues, sympathy may be demonstrated in statements like, "Those poor people, I wonder what I can attend to help?" Sympathetic activities include crowd funding efforts, charity events, and awareness raising.

Empathy typically refers to the ability to deeply understand and almost enter into another's feelings. When we empathize, we move beyond sympathy and begin to engage with both the feelings and the cause of those feelings. When we talk about social or world issues, empathy can be demonstrated in statements like, "I wonder what is causing this situation or lack of emotion... how might we alleviate this person's concerns and engage others through our actions?"

Examples of apathy, sympathy and empathy, positioned within the situation of homelessness might include:

- Apathy: Homelessness is terrible but it isn't my problem. I don't know anyone who is homeless.
- Sympathy: Homelessness must be terrible. Let's organize a bottle drive and give the proceeds to our local homeless shelter.
- Empathy: Homelessness must be terrible. I'm going to volunteer to serve meals at our local homeless shelter and begin to learn more about the causes and issues of homelessness in our community.

It takes effort to create empathic newspaper headlines and social media tweets of human stories. That effort helps others to start caring for people and to comprehend empathetically. Classroom activities like Stanford's d.School Empathy Mapping may help to understand this process (Retrieved May 2016, **http://dschool-old.stanford.edu/wp-content/themes/dschool/method-cards/empathy-map.pdf**).

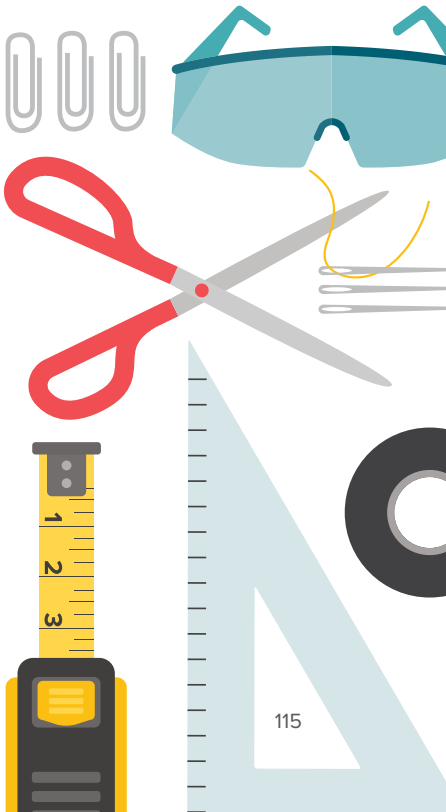
SkillsCanada Alberta

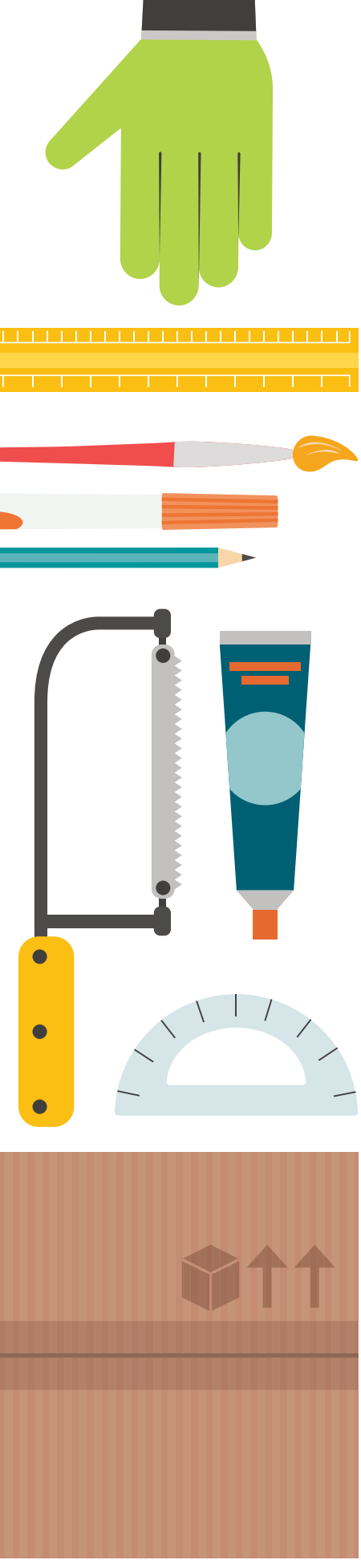
Suggested Grade Level

Middle school to secondary school

Suggested Subject Area

- ADST
- Economics
- Science
- Social Studies





Design Rationale

We live in a global community connected through various forms of media. The youth of today have many opportunities to become empathetic and to be aware of global issues. They bring their passion and energy to personally engage in global change. A key for developing responsible global awareness begins with moving from apathy or sympathy to empathy and action. Agencies and organizations may help us find ways to start being responsible for the well-being of others. A few examples include the United Nations (Retrieved May 2016, **http://www.un.org/millenniumgoals/**), Red Cross and Red Crescent (Retrieved January 2016, **https://www.icrc.org/en/who-we-are/movement**), Medecins sans Frontieres (Retrieved January 2016, **http://www.msf.org/**), Citizen Journalism (Retrieved January 2016, **https://en.wikipedia.org/wiki/Citizen_journalism**).

Problem Scenario

Your team has been selected to identify a global problem and create either a metaphor that helps others understand the origin/cause of the problem and represents a potential solution that is innovative and creative OR a prototype of an object that would help alleviate the problem. There is no shortage of global problems that your group of extremely energetic, committed, and aware young people could identify, discuss, and engage. The key is to find a global problem that ignites your team's passion. In order to affect change, everyone on your team needs to be personally invested and engaged in the outcome. In other words, you must begin to replace your apathy or sympathy with empathy.

Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: "Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener."
- ❒ Degree to which your metaphor or object looks like your design sketch
- ❒ Development of a metaphor or object that will affect change
- ❒ Uniqueness of your metaphor or object and the degree to which it describes or solves an actual global problem
- ❒ Your team's ability to articulate the connections between your chosen global problem and your metaphor/object.
- ❒ Your team's ability to develop a meaningful connection between a global problem and your personal passion

Parameters

- ❒ Global issue must come from the ideas generated during class discussions.
- ❒ You may use items and tools in your classroom's pantry.
- ❒ You must prepare an appropriate social media or news presentation, which demonstrates your global issue, your passion, and how your solution/object will affect change.
- ❒ You must use something of everything in your participant group kit.

20 Displaced Students

Overview

The population boom, immigration, and rural families continuing to move into urban centres have taxed the capacity of schools to accommodate students in their immediate area. Not so many years ago, children walked or rode their bikes to their neighbourhood schools. However, increasingly urban centres are building large community schools to accommodate students being bussed or driven from multiple neighbourhoods. As a result, more and more students feel alienated and isolated, like strangers in their schools. A challenge becomes how to create initial and ongoing experiences for new students so they can increasingly feel welcomed; build relationships with their fellow students, teachers, and staff; find their place; and gradually become active members of their school communities.

Design Rationale

Schools are dynamic and potentially vibrant places. We know that if people feel connected and can find their place, they feel valued and accepted. It only takes seconds to make a first impression. As members of our school community, we need to find ways to welcome newcomers. The first experiences of new students with our school need to be positive, welcoming and inclusive. New students enter each year. Many students enter mid-year and back to school activities are completed. The question becomes—how might members of school communities welcome new students, from a variety of cultures, economic backgrounds, and communities in a manner that creates that much needed positive first impression?

Problem Scenario

A new school is opening in your community. The purpose of this school is to accommodate the overflow student population from 10 different suburb communities across the city. Your team has been selected to develop a prototype or a metaphor of a welcoming experience that will create a sense of warmth and acceptance and will help the new students begin to form a sense of connection and acceptance towards the school and its community.

Your team needs to consider how your welcoming experience(s) will address the issues of sustainability, cost, time, and cultural sensitivity, while creating a long-lasting, positive impact on the new students, regardless of when they first visit the school.

Your welcoming experience must satisfy at least two of the following criteria:

- Be a tangible item that the new students can take home at the end of the day and that will serve a purpose
- Be enjoyable and engaging for new students (Grades 7–12)
- Be reflective of the school culture, mission, and vision
- Develop a sense of belonging and/or connection to the school community
- Foster a connection with classmates

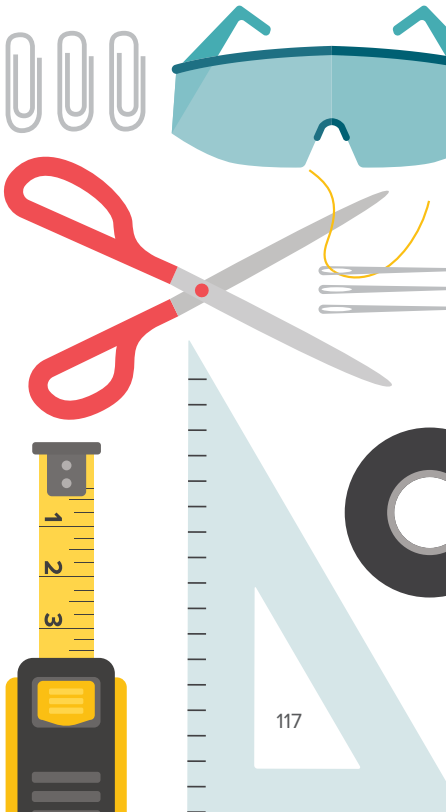
SkillsCanada Alberta

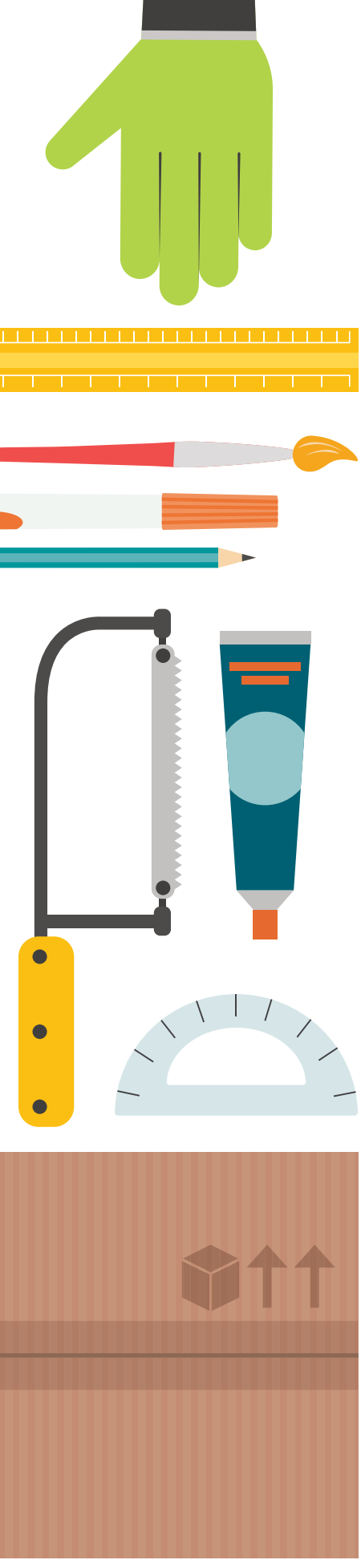
Suggested Grade Level

Grades 7–12

Suggested Subject Area

- Citizenship—including school culture / community
- ADST
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Ability of your item to help the user establish a connection
- ❒ Alignment of the prototype or metaphor with the design sketch
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which it is adaptable to all users
- ❒ Degree to which it is culturally inclusive
- ❒ Functionality
- ❒ Uniqueness
- ❒ Usability

Parameters

- ❒ You may use the tools provided to you in the classroom/pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing and usable.
- ❒ You must use some of all the items in the participant group kit in some way.

21 Growth Mindset: Electricity

A Resource for Teachers

Overview

Because of children's natural curiosity, they begin to explore electricity by watching thunderstorms, flipping light switches on and off, and other exploratory and potentially dangerous ways. Electricity is everywhere and absolutely useful, but it also can be very dangerous and electrical accidents may occur.

"In the United States, 50,900 fires each year are attributed to electrical failure or malfunction, resulting in 490 deaths and 1,440 injuries. Arcing faults are a major cause of these fires. About 3,300 residential fires originate in extension cords each year, killing 50 people and injuring about 270 others," (Retrieved January 2016, http://www.esfi.org/resource/holiday-data-and-statistics-359).

We know that the prevention of fires and accidents requires knowledge and awareness. Children can be introduced to the power and purpose of electricity in age appropriate ways, and they will take that knowledge and understanding home to their families.

There are many websites and other resources to help educators develop engaging learning experiences and connect those experiences to specific curriculum outcomes. However, educators need the time to imagine exciting and open-ended ways to introduce key concepts to their students so experimentation and exploration can take place. We know a key to developing a growth mindset toward scientific thinking is to help children to think like a scientist and develop a positive, growth-oriented attitude toward learning scientific concepts. Carol Dweck (2016), a researcher from Stanford University explains,

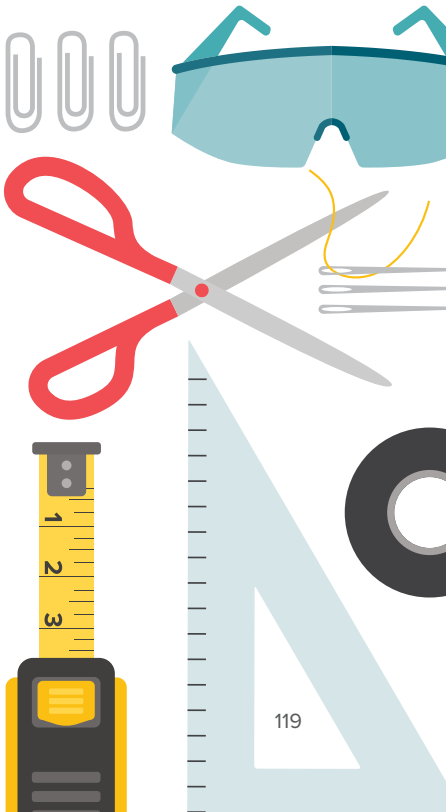
"In a growth mindset, people believe that their most basic abilities can be developed through dedication and hard work—brains and talent are just the starting point. This view creates a love of learning and a resilience that is essential for great accomplishment. Virtually all great people have had these qualities," (Retrieved January 2016, http://mindsetonline.com/whatisit/about/index.html).

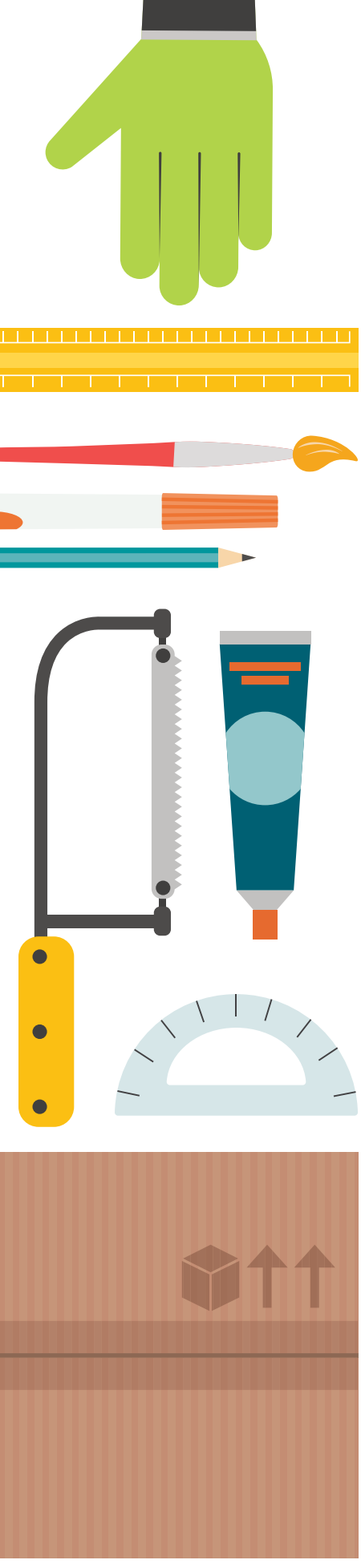
Scientific thinking refers to the process of observation, exploration and discovery by being curious, open-minded and creative (Retrieved January 2016, **http://undsci.berkeley.edu/article/think_science**).

SkillsCanada Alberta

Suggested Audience

- Curriculum leaders
- District directors of instruction/learning leaders
- Elementary classroom teachers





Design Rationale

A 2003 study (Retrieved January 2016, **https://www.researchgate.net/publication/248975096_Attitudes_towards_Science_A_Review_of_the_Literature_and_its_Implications_International_Journal_of_Science_Education_259_1049-1079**) suggests that students' attitudes toward science are impacted by the following factors:

- anxiety toward science
- attitudes of parents towards science
- attitudes of peers and friends towards science
- enjoyment of science
- fear of failure on course
- motivation towards science
- perception of the science teacher
- personal achievement in science
- personal value they place on science
- self-esteem at science
- the nature of the classroom environment

Helping students create positive attitudes toward science often falls solely on classroom educators, who themselves may not have a growth mindset about their own abilities toward tackling science concepts. Therefore, educators need opportunities to explore science in supportive, hands-on, experiential ways.

Problem Scenario

Your group has been selected to develop a sample learning activity that introduces students to a core concept about electricity in a hands-on, experiential way. Your group must design the learning activity, write it up in a way that other educators could use it in their classes, connect it to your curriculum, and complete the activity yourselves, providing a working model of the learning.

Your design challenge is situated in the topic of electricity because it is important that children understand its potential and power in safe yet challenging and engaging ways. You need to design an activity that satisfies their curiosity about electricity and fosters their love of play. An interesting starting place to explore learning activities might be the following links (Retrieved January 2016): **http://www.pbs.org/parents/adventures-in-learning/2014/02/electric-play-dough/** or **https://cset.stanford.edu/sites/default/files/files/documents/publications/Osborne-Attitudes%20Toward%20Science.pdf**).

Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Complexity and opened-ness of the learning activity—the ability of students to explore and experiment and show what they know and need to learn rather than follow a script or a recipe to complete the task
- ❒ Degree to which it is adaptable to all students at a specific learning level/stage or age
- ❒ Degree to which your activity adheres to your design sketch
- ❒ Practicality of the learning activity for the average classroom
- ❒ Uniqueness and usability of your learning activity and the degree to which it solves a curricular outcome

Parameters

- ❒ You must be prepared to explain and share your learning activity and completed project.
- ❒ You must consider how to make your learning activity safe, intriguing, informative and fun.
- ❒ You must create a lesson write up that other educators could follow and adapt.
- ❒ You must use some of all the items in your participant kit in some way.
- ❒ Your learning activity must be helpful in teaching children about electricity.

22 Developing Historical Empathy

Overview

The study of a country's history and evolution requires more than the memorization of dates, names and facts. Historians need to develop a deep understanding of the confounding circumstances of events, including people, places, cultures, politics, and many other factors. Coming to know why things happened the way they did is as important as knowing what happened and when. As Jill Lepore said, "The study of our history requires investigation, imagination, empathy and respect," (The Whites of Their Eyes: The Tea Party's Revolution and the Battle over American History, 2010).

When we take the opportunity to learn about Canada's history, we can begin to understand and appreciate the struggles of the people who helped to shape Canada's identity today. As Frederick Douglas said, "Without a struggle, there can be no progress" (1857).

Design Rationale

Canada has a reputation of being a compassionate and caring country. We have a history of being global peace keepers, and our 14th prime minister, Lester B. Pearson, won the Nobel Peace Prize in 1957 for his efforts.

In the recent humanitarian crisis in Syria, Canadians have stepped up to welcome refugees and incorporate them into our communities. Canadians pride themselves in the inclusion of others. We respect diversity as a society and through our legal systems. However, we do not have an unblemished history, especially in our treatment and inclusion of Aboriginal Peoples (Retrieved July 2016, **https://www.naho.ca/retracing-aboriginal-history/**).

Problem Scenario

Your team has been selected by the Canadian Arts and Heritage organization to design an interactive, 3-dimensional depiction of a historical event that involved an injustice to Aboriginal Peoples. This depiction should help viewers to understand the what, where, when, and why of the event. Further, it should help them to gain empathy for those impacted by the event.

Your depiction must:

- be a scale model that captures the feelings and thoughts of one of the people or groups of people involved in an historical event
- communicate clearly this perspective to an audience
- have some degree of interaction
- demonstrate your knowledge of the historical event and the context in which it occurred

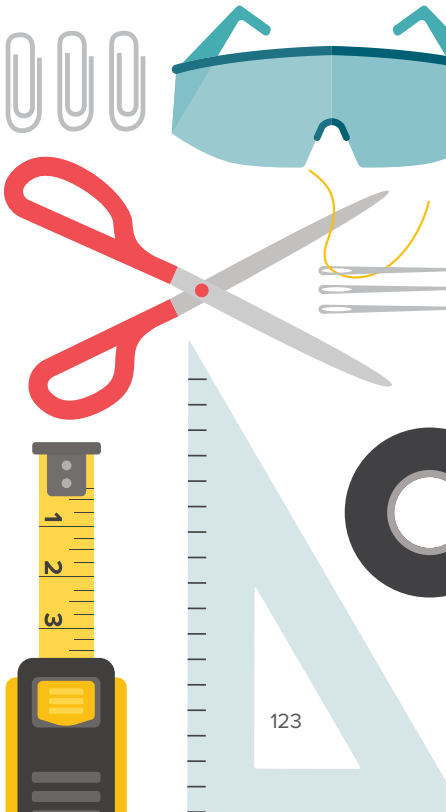
SkillsCanada Alberta

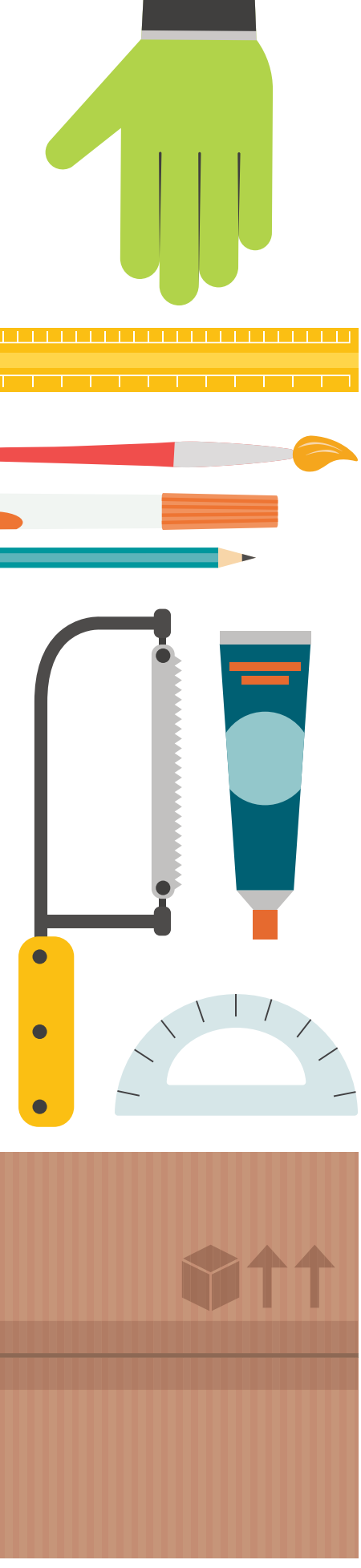
Suggested Grade Level

- Elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Ability of your depiction to capture the perspective (thoughts & feelings) of the group impacted by the historical event
- ❒ Alignment of your depiction with the design sketch
- ❒ Degree to which the event is represented in detail
- ❒ Degree to which your depiction is visually appealing (craftsmanship, attention to detail) to warrant the placement in a museum
- ❒ Purposeful use of colour/general aesthetics to capture mood and feeling
- ❒ Uniqueness and accuracy of your depiction and the degree to which it portrays a historical event

Parameters

- ❒ You may use the tools provided to you in the classroom pantry.
- ❒ You must prepare a group display which includes:
    - A monument plaque that explains the connections between the represented perspective and the historical event
    - Your team names
    - Reflection on the design process that you and your team has just completed
    - Your design thinking sketches
- ❒ You must use some of all of the items in the participant group kit in some way.

23 Eco-smart Recreation Facility

Overview

Developers are becoming increasingly interested in designing structures that are properly suited for their environments. Structures that are not designed this way are prone to damage from catastrophic environmental events such as flooding. According to the *Alberta Provincial Flood Damage Assessment Study* (http://www.alberta.ca/albertacode/images/pfdas-alberta-main.pdf), damage from flooding in Alberta has cost billions of dollars over the last decade. Without proper mitigation, cities must repeatedly repair and rebuild structures in flood areas at great expense.

In addition to flood mitigation, structures are being increasingly designed to reduce their impact on the surrounding environment. People are recognizing the importance of maintaining ecosystems in urbanized areas by considering factors such erosion, airflow, solar exposure, and pollution (i.e. chemical, light, and sound). One way of regulating building design is through certification programs such as LEED (**http://www.usgbc.org/leed**).

LEED certified buildings save money and resources overtime and are designed to have a positive impact on the health of occupants, while promoting renewable, clean energy. LEED standards influence the building design and construction, interior design, building operation and maintenance, and neighbourhood development. To obtain LEED certification, credits are given to building designs that provide:

- Access to a variety of transportation options
- Are energy efficient
- Are water efficient and reduce potable water consumption
- Create innovative solutions to problems
- Have high quality indoor air and access to daylight/views
- Minimize the impact on ecosystem and water resources
- Use sustainable building materials and reduce waste

Design Rationale

Land is in short supply and decisions made for land use must be a rigorous process involving market analysis, demographic research, education, multiple stakeholder points of view, scientific input and considerations of sustainability. Before a solution is chosen, all viewpoints, demographic and economic points of view should be considered and should be allowed to offer questions and multiple solutions/ options. Solutions should adhere to a three-prong approach using the pillars of sustainability—economic, environmental, and societal needs (Retrieved January 2016, **http://www.thwink.org/sustain/glossary/ThreePillarsOfSustainability.htm**). These pillars help guide problem finding and help planners work toward solutions that will be successful and sustainable into the future.

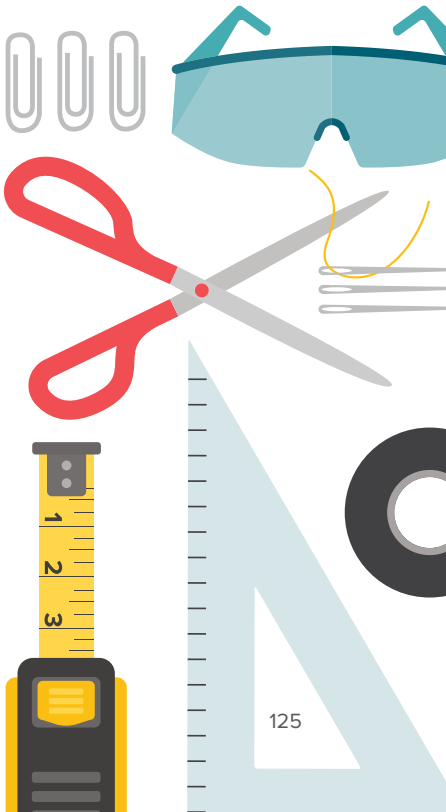
SkillsCanada Alberta

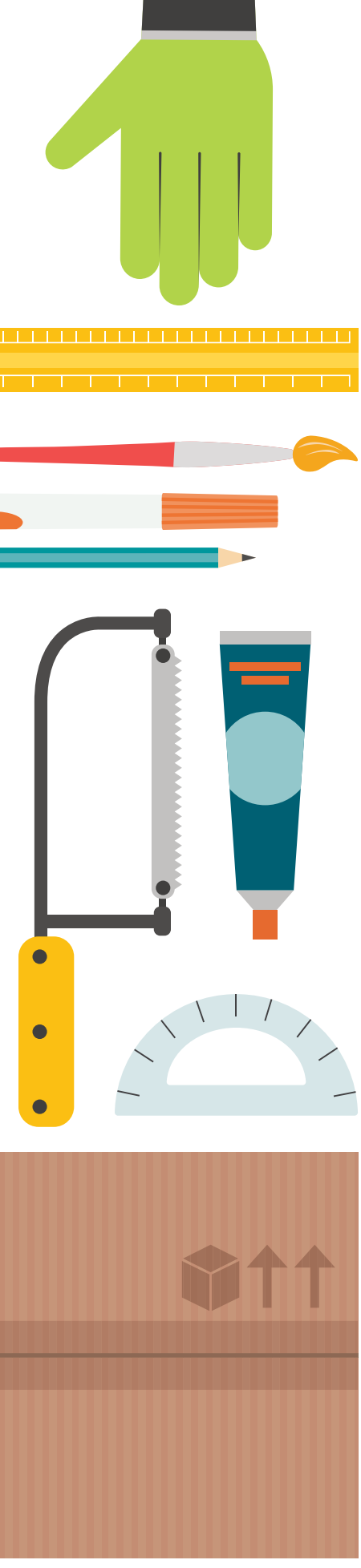
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Physical Education
- Science
- Social Studies





Problem Scenario

Your team has been selected to design and develop a proposal for a recreational facility on a plot of land. Your design must preserve the ecosystem, while minimizing environmental impact and providing opportunities for all interested stakeholders. You have an undeveloped plot of land with a creek running through it. The total area is 30 acres, and you do not have to develop it all. This is an imaginary plot of land in your community, so other than the creek and the size, you can use your imaginations to describe the property you are developing.

Your proposal must meet the following criteria:

- Development addresses the protection of the area from flood damage
- Environmental preservation is considered in the development
- Offer multiple recreation opportunities
- Provide evidence of research into the site characteristics, including size, topography, soil composition, vegetation, surrounding features, existing infrastructure
- Provide models of any structures to be built, and they must be constructed to be environmentally friendly (see LEED certification requirements as a reference)
- Year round access is provided to recreational opportunities

You will create a design document as well as a prototype or scale model that demonstrates your design. A design document is a series of sketches and written descriptions that answer the criteria presented in the problem scenario. A prototype or a model illustrates the functionality of an idea or design.

Success Determinants

Success will be determined by:

- ❒ Addresses Pillars of Sustainability
- ❒ Alignment of the design to meet the needs outlined in the problem scenario
- ❒ Alignment of the prototype and the design sketch
- ❒ Alignment to the motto: “Make it smaller, stronger, do more, be easier to use (build), be cheaper, be clean, be greener.”
- ❒ Design incorporates concepts from the course content
- ❒ Uniqueness of design and prototype

Parameters

- ❒ You may make a pitch to use the materials found in the pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must use some of all the items in participant group kit in some way.
- ❒ You should use the tools provided by the teacher.

24 Water Conservation

Overview

There are millions of litres of water wasted each day in schools across North America. Think about how much water is wasted when you take a drink from a water fountain, flush a toilet, or wash your hands. A recent statistic suggests that almost 95% of the water that enters a home is wasted (Retrieved January 2016, **http://www.huffingtonpost.com/2008/07/30/10-facts-about-wasted-wat_n_115642.html**). We know, "783 million people worldwide do not have access to clean water. 6 to 8 million people die annually from the consequences of disasters and water-related diseases," (Retrieved May 2016, United Nations, 2016, **http://www.unwater.org/**). Clean water is related to health and wellness, and water usage directly impacts water quality and quantity.

Design Rationale

Canada has 1/5 of the world's fresh water. We need to become leaders in the conservation and stewardship of this vital resource the world shares. We have a responsibility to examine every opportunity to conserve and reuse water. Many of us have no idea how much water we consume and waste in our everyday activities. Online tools like the Water Footprint Calculator can help (Retrieved January 2016, **http://www.gracelinks.org/1408/water-footprint-calculator**).

Problem Scenario

Your team has been selected to develop a working prototype of a water conservation solution for your school. Your prototype might include ways to capture and filter existing water in your school. The purpose of the prototype should be to minimize the amount of water that is wasted in and around your school. It must satisfy the following concerns:

- Must address the need for sanitation, if necessary (potable vs non-potable water)
- Must be safe (someone cannot fall into it)
- Should be protected from extreme temperatures and the environment
- Should include a distribution component
- Should include water collection/reuse from a variety of sources (rain, water fountains, etc.)
- Should limit or reduce evaporation

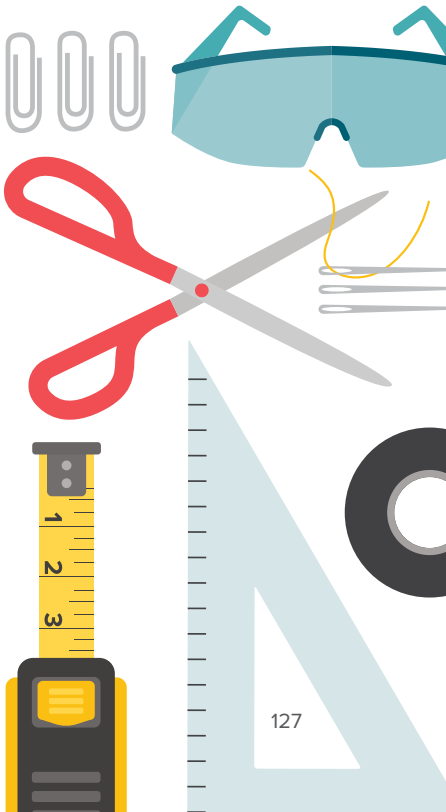
SkillsCanada Alberta

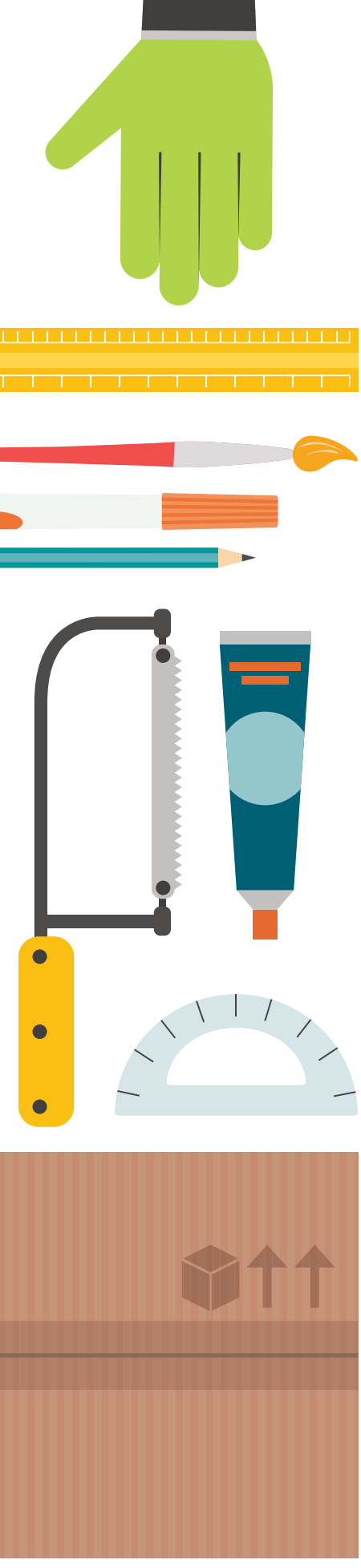
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Science
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Functionality
- ❒ Low maintenance—easily sustainable and maintainable
- ❒ Must fit in to existing structures without being an eye sore
- ❒ Prototype is aligned with design
- ❒ Should address problems and concerns from the problem scenario
- ❒ Simplicity of design

Parameters

- ❒ You may use the tools located in the shared tool area.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing and ergonomic.
- ❒ You must use some of all the items in the participant group kit in some way.

25 Alternative Dwellings

Overview

Most of our building supplies come from natural resources—trees, stones, brick, adobe, etc. Unfortunately not all of the resources available are suitable for building materials (Retrieved January 2016, **https://en.wikipedia.org/wiki/Natural_building**). As these natural resources are being consumed, builders are beginning to question how might they use alternative materials or unusual materials to build homes within our communities.

Design Rationale

People around the world live in a variety of structures—some structures are highly portable and mobiles while others are more permanent. Climate, culture, political and economic stability, and geography impact how and where people live.

Problem Scenario

Your team has been selected to develop a prototype or scale model of a dwelling that might be unique in your community. It needs to be movable and/or portable and able to withstand the climate and geography of your area. Your team needs to consider the availability of materials, local and traditional designs, and the needs of the ideal family who might live in the structure.

Your prototype or scale model must satisfy at least two of the following identified concerns:

- Be able to house families of different sizes
- Be able to withstand climate and natural events of the area
- Be accessible for a variety of family members
- Be portable
- Replace natural resource available in your community/region

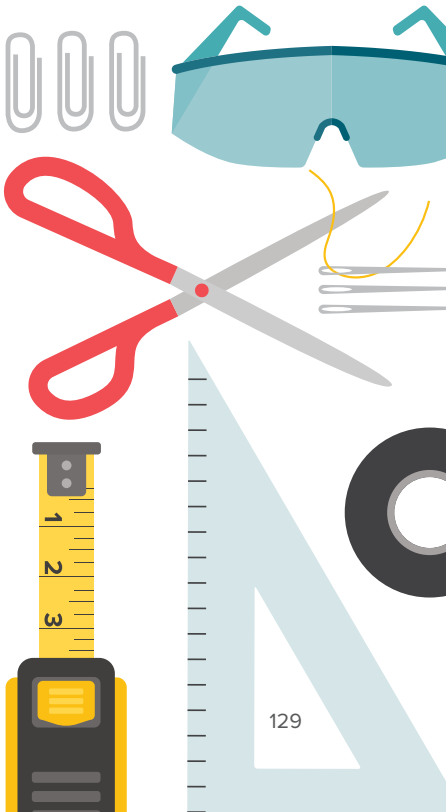
SkillsCanada Alberta

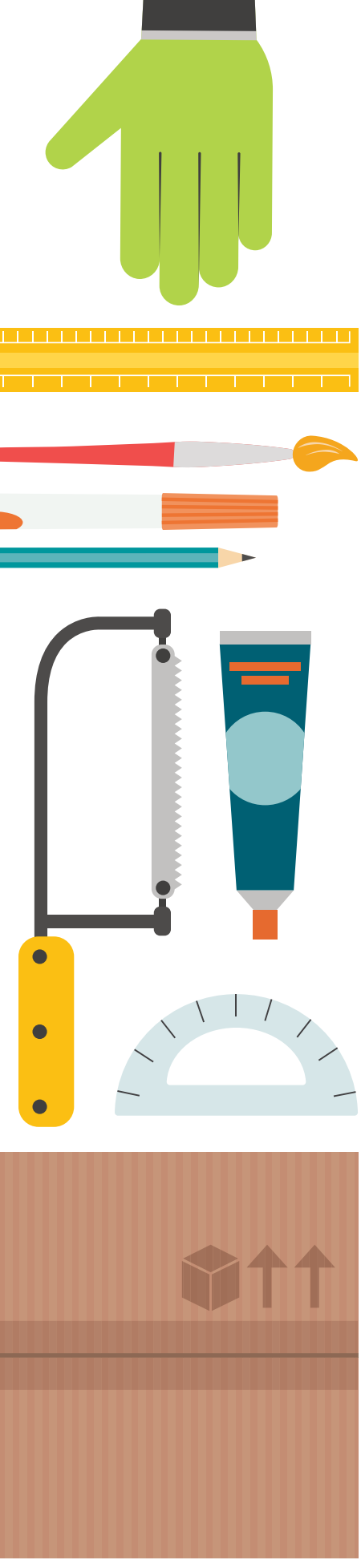
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Geography
- Science
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Alignment of the prototype with the design sketch
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener”
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Ease of long term maintenance and durability
- ❒ Functionality
- ❒ Is able to fit with other buildings in the area (colours, design, structure)
- ❒ Shows understanding of the geography of the land for which the structure is being built
- ❒ Uniqueness and usability of your prototype and the degree to which it solves an actual problem

Parameters

- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing and ergonomic.
- ❒ You must present your design thinking sketch, your prototype and design notes.
- ❒ You must use some of all the items in the participant group kit in some way.
- ❒ You should use the tools located in the shared tool area.

26 Mars Shelter and Transportation

Overview

NASA is preparing to send humans to an asteroid by 2025 and to land on Mars in the 2030's (Retrieved January 2016, **http://mars.nasa.gov/programmissions/science/goal4/**). NASA has been sending robotic explorers to Mars for years with the intention of eventually sending humans there (Retrieved January 2016, **http://mars.nasa.gov/odyssey/**). Globally, teams of engineers, designers, inventors, scientists, and others are developing technologies and tools to help us achieve the goal of humans living and working on Mars.

Design Rationale

Historically, humans have been curious about other places. We have the desire to explore and discover (Retrieved January 2016, **http://www.newworldencyclopedia.org/entry/Human_migration**). Our fascination with space and space exploration extends our natural curiosity to migrate from where we evolved. Naturally, we may expect human presence on a planet other than Earth to be a logical step for human advancement and discovery. However, many issues need to be considered: the environmental concerns on other planets (i.e. air pressure, gravity, heat, etc.), basic human needs (i.e. food, water supply, etc.), transportation issues (i.e. how to get there and back), and what might constitute quality of life on a new planet (Retrieved January 2016, **http://www.simplypsychology.org/maslow.html**).

Problem Scenario

Your team has been selected to design a lightweight, portable shelter or personal transportation vehicle for use on Mars. Your team has been tasked with developing a prototype that can be assembled quickly and withstand the rigours and challenges of the Martian environment.

Your prototype needs be made of individual components for easy storage and transportation to Mars. Your team needs to consider the added value of your components being lightweight, compact, and highly functional. Your Martian prototype must be able to satisfy one or more of the following concerns:

- Appropriateness for the Martian atmosphere
- Cost efficiency
- Quality of life

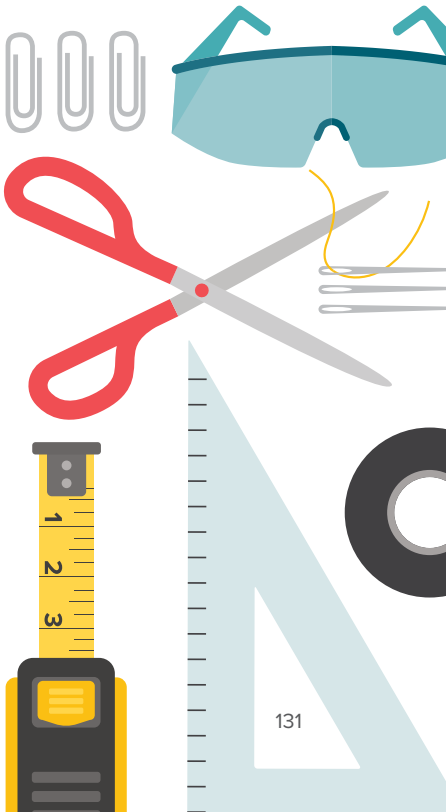
SkillsCanada Alberta

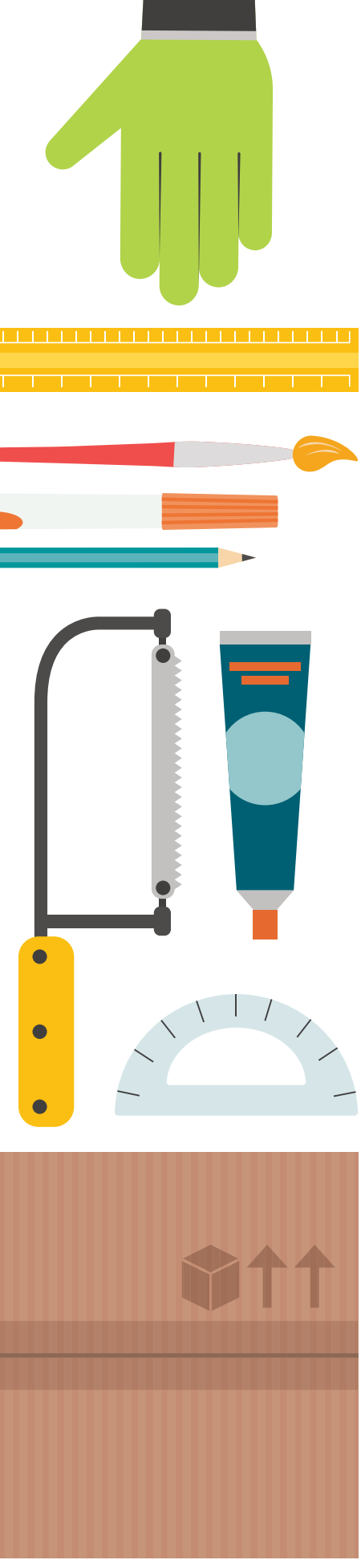
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Physics
- Language Arts
- Social Studies
- Science 7–9





Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Completion of a detailed blueprint/plan before beginning construction
- ❒ Degree to which your prototype is adaptable to Martian conditions and multiple users
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Ease of long term maintenance and durability
- ❒ Functionality of your prototype
- ❒ Uniqueness and usability of your prototype and the degree to which it solves an actual problem

Parameters

- ❒ You may use the tools provided to you in the classroom pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing, and usable.
- ❒ You must use some of all the items in the participant group kit in some way.

27 Stimulating Our Senses

Overview

Many schools have students with diverse learning needs. Sometimes, it is the simplest of tools or toys that can make a difference and support a student's learning in wonderful and powerful ways. For example, students who have sensory processing challenges struggle to learn through their senses as the majority of us do.

"Sensory processing is how we transform sensory information from within our own bodies and the external environment into messages we can act on. It's tempting to think of senses (touch, sight, sound, movement, body awareness, taste, and smell) as separate channels of information, but they work together to give us a reliable picture of the world and our place in it," (Retrieved January 2016, **http://www.sensorysmarts.com/signs_of_spd.html**).

Design Rationale

Lindsey Biel and Nancy Pesk have written a checklist to determine our "sensory smarts" (Retrieved January 2016, **https://www.sensorysmarts.com/sensory-checklist.pdf**). Temple Grandin, in her compelling TED Talk (Retrieved January 2016, **https://www.ted.com/talks/temple_grandin_the_world_needs_all_kinds_of_minds?language=en**), talks about what is to live and learn with autism.

"We all learn through our senses. ... Right now your senses are working together. You hear background sounds and feel your clothing, chair, and the floor beneath your feet. You resist gravity to stay seated. You see letters on the screen. You filter out unimportant sensory input so you can make sense of what you are reading. If you occasionally lose focus because your shirt label is itchy, you may have a mild sensory issue. If you keep sliding off your chair, look away when you hear any noise, feel like your shirt is hurting you, or the words you are reading pulsate, you may have sensory processing disorder, also known as sensory integration dysfunction. Sensory issues affect all kinds of people—from those with developmental delays, attention and learning problems, autistic spectrum disorders and other diagnoses to those without any other issues," (Retrieved January 2016, **https://www.sensorysmarts.com/signs_of_spd.html**).

Problem Scenario

Your team has been asked to develop a toy or tool that would help a student with a sensory processing challenge improve their ability to learn in school. You will probably need to research sensory processing issues and then focus on one sense or sensory challenge. You team is required to create a prototype of the toy or tool.

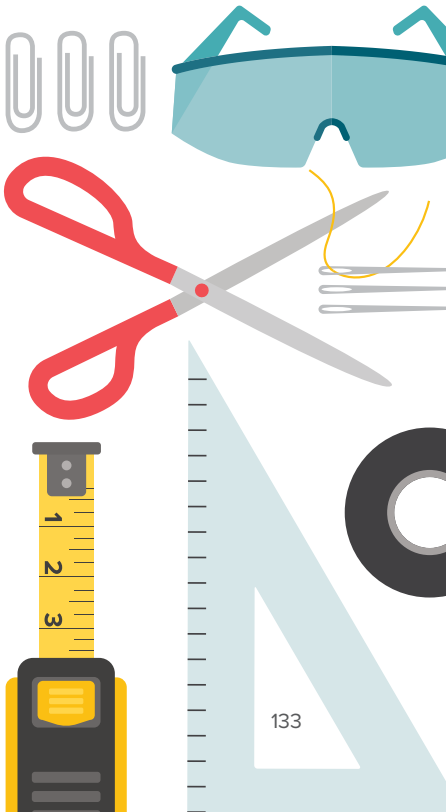
SkillsCanada Alberta

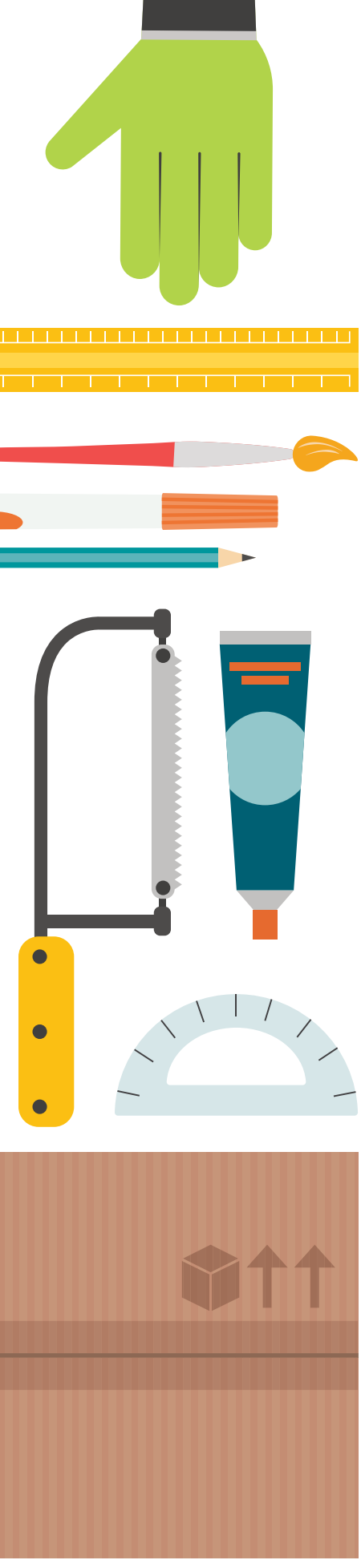
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Physics
- Science
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Ability of your prototype to help a child learn
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which it is adaptable to the user
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Ease of long term maintenance and durability
- ❒ Functionality
- ❒ Uniqueness and usability of your prototype and the degree to which it solves an actual challenge

Parameters

- ❒ You may use the tools provided to you in the classroom pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing, and ergonomic.
- ❒ You must use some of all the items in your participant group kit in some way.

28 Inclusive Playgrounds

Overview

"Children with disabilities are often excluded from or restrained in play activities because of the physical barriers of play structures and the surrounding environment," (Ripat & Becker, 2012). Organizations and foundations, like the Rick Hansen Foundation, (Retrieved July 2016, **https://www.rickhansen.com/Our-Work/School-Program/Accessible-Play-Spaces/Lets-Play-Inclusive-Playgrounds**) recognize children with disabilities require active play opportunities.

Design Rationale

Canadians pride ourselves in our respect and inclusion of others. However, 1 in 7 people with disabilities are excluded from enjoying playgrounds and parks. We need to consider what inclusion and accessibility might mean to people of all ages and abilities across our communities.

Problem Scenario

Your team has been selected to develop an amazing playground structure or a component of a playground that is inclusive, safe, fun, and engaging. Your team's design needs to include your ideas of fitness, flexibility, and a joy of play. You must consider issues of mobility, access, sensory challenges, etc.

Success Determinants

Success will be determined by:

- ❒ Ability of your prototype to help the users enjoy playgrounds
- ❒ Addressing the design challenge by creating something that is helpful, functional, and unique
- ❒ Following the design motto: "Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener."

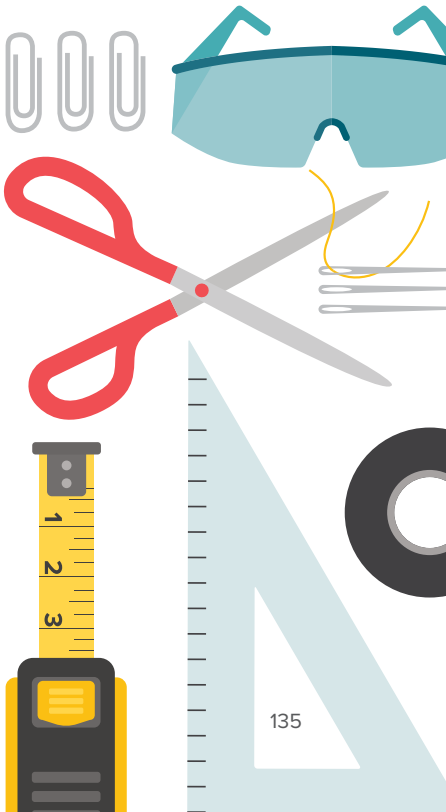
SkillsCanada Alberta

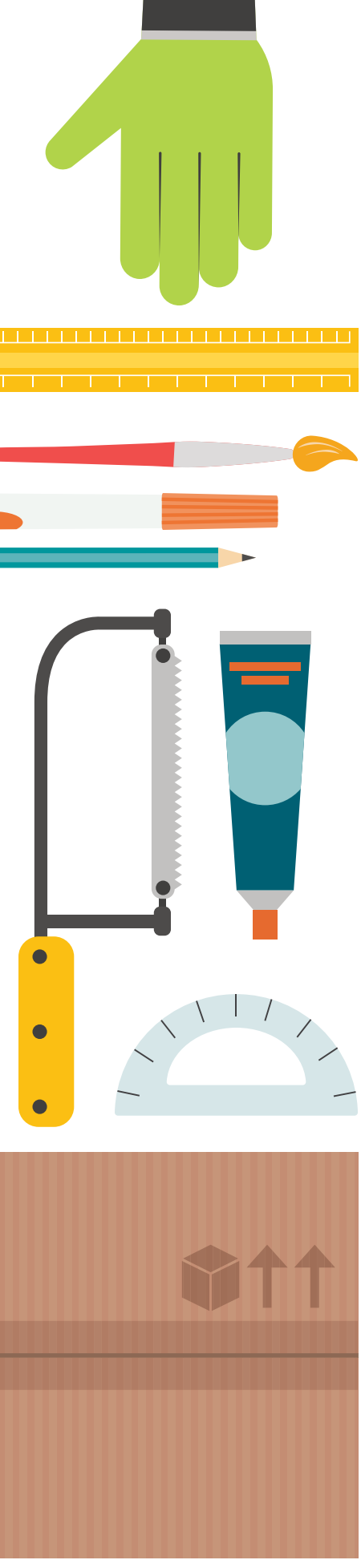
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Physical Education
- Science
- Social Studies





Parameters

- ❒ You may exchange items from the pantry.
- ❒ You must use some of all the items in the participant group kit in some way.
- ❒ Your small-scaled playground structure or component of a playground must include at least two of the following concerns:
    - Be accessible for someone with mobility issues
    - Be accessible for users of variable heights/sizes
    - Be accessible for someone with sensory issues
    - Be accessible for someone with cognitive challenges
    - Be enjoyable for users of all ages

29 Outdoor Classroom

Overview

What is an outdoor classroom? It is a gathering place for teachers and students to integrate nature into learning within the school grounds. It brings learning to life by situating formal learning within a school's natural environment and giving students the opportunity to get outside and experience nature.

Design Rationale

Studies have shown that outdoor classrooms can make learning more effective because they allow students to explore and learn in a more comfortable and relaxed outside setting—especially on nice days. Imagine being able to have your math class outside while you get fresh air while you learn. Imagine how your powers of observation would increase as the seasons change and birds and bugs fly by. Imagine planting your own gardens and landscaping your learning space in harmony with native plantings.

Problem Scenario

Your teacher has invited your group to design an outdoor classroom for your school. This space must be accessible to all students, be functional for teachers to conduct a lesson, and be must sustainable and easily maintained by you, the students, with minimal assistance from your teacher, staff, and community volunteers. You must create a prototype of your design and share it with the class.

Success Determinants

Success will be determined by:

- ❒ Alignment of your ultimate prototype to your design
- ❒ Alignment to design motto: "Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener."
- ❒ Appropriateness of the plantings to your local environment and weather conditions
- ❒ Functionality of the classroom
- ❒ Originality and creativity of the design
- ❒ Sustainability and ease of maintenance

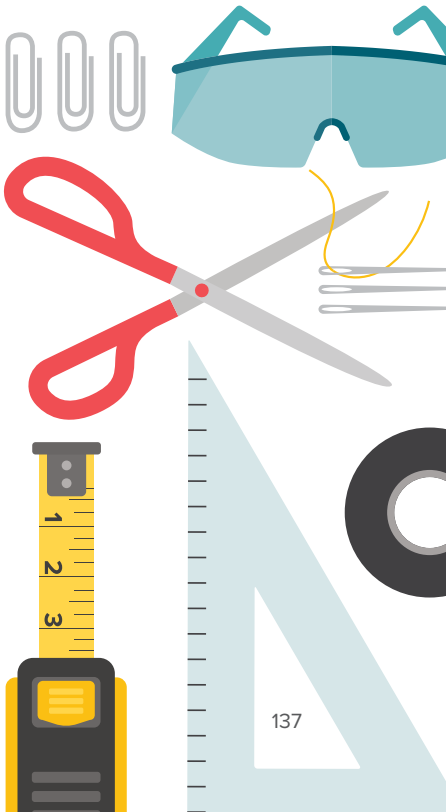
SkillsCanada Alberta

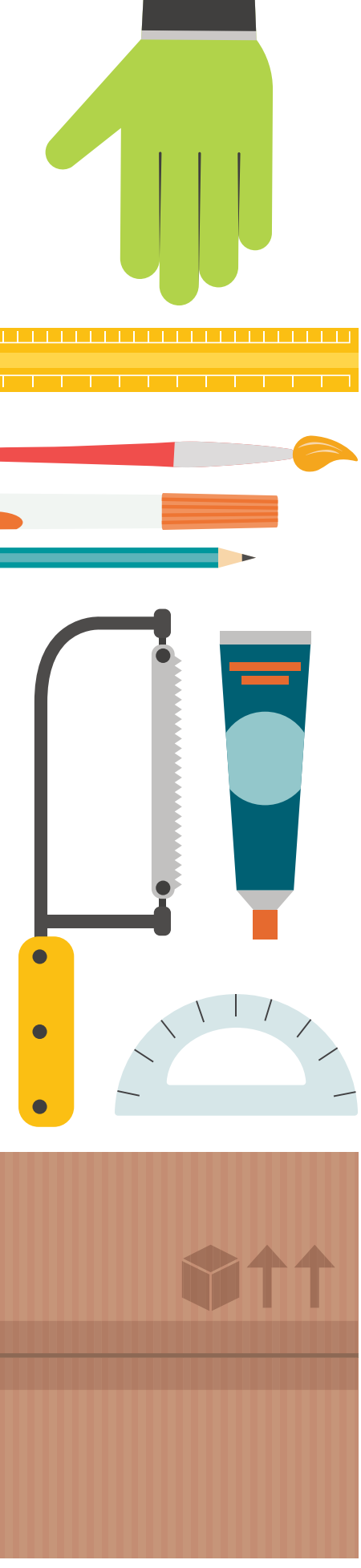
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Citizenship—including school culture/community
- ADST
- Science
- Social Studies





Parameters

- ❒ You may use the tools provided to you in the classroom pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing, and sustainable.
- ❒ You must use some of all the items in the participant group kit in some way.

30 Outdoor Learning Spaces

Overview

Students have limited opportunities to learn outdoors. For example, one school representative reported four picnic tables for 1,250 students. So when these students might have times during the day to enjoy the benefits obtained from learning outside, there were few places to sit or study or enjoy a conversation. While picnic tables have typically been used as outdoor furniture, they are not the most flexible or comfortable form of seating. Also, they are not necessary ergonomically sound or easily moved! Over time, schools would like to increase outdoor learning opportunities by creating learning spaces that support learning, healthy lifestyles, and fitness.

Design Rationale

According to research, outdoor learning spaces can improve student learning. A recent article entitled *Peaceful Learning in Outdoor Spaces* is a good introduction to the topic (Retrieved January 2016, **https://www.naesp.org/resource/peaceful-learning-in-outdoor-spaces/**). Sound research cites the many benefits of outdoor learning including better health, better grades, decreased stress, increased motivation, better behaviour, improved memory, and increased appreciation for the environment (Retrieved January 2016, **http://www.englishoutdoorcouncil.org/research.in.outdoor.learning.html**). However, seating is an issue due to cost, flexibility, long-term maintenance, and ergonomic issues.

Problem Scenario

Your team has been selected to develop a prototype for an outdoor learning space that is functional and will allow students to benefit from the outside environment. Your team needs to consider issues of wellness, usability, functionality, durability, long-term maintenance, and aesthetic appeal.

Your outdoor learning space prototype must be a small-scaled prototype of a space or element of the space that can accommodate learning.

It must satisfy at least two of the following identified concerns:

- Adhere to safety codes/permits
- Be accessible to all students, of all abilities
- Encompass more than just a structure (greenery, plantings, art, etc.)
- Encourage movement and flexible learning
- Enhance/support learning already taking place in the school/classroom
- Support fitness and attend to ergonomic issues

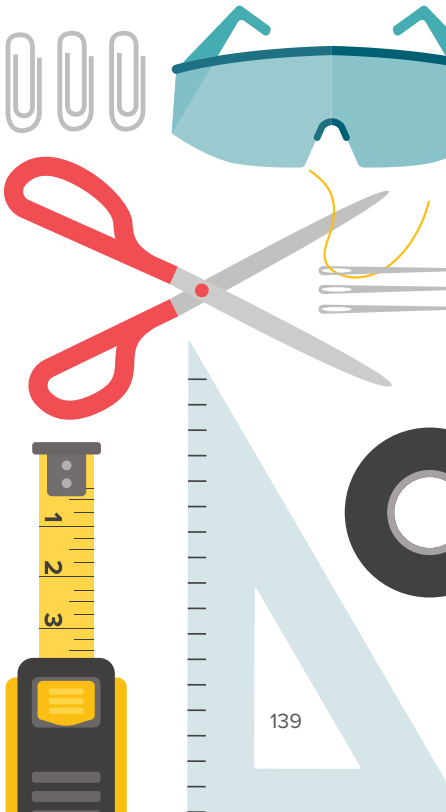
SkillsCanada Alberta

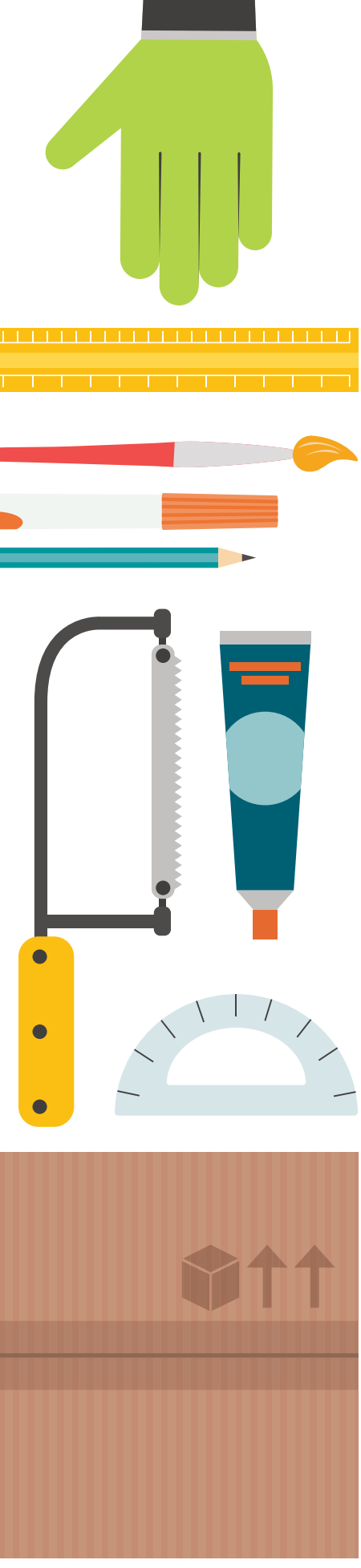
Suggested Grade Level

- Upper elementary through to secondary school
- Possibly primary grades with adult assistance

Suggested Subject Area

- Agriculture
- Citizenship—including school culture/community
- ADST
- Physical Education
- Science
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Ability of your prototype to help the users enjoy outdoors
- ❒ Alignment of the prototype with the design sketch
- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener”
- ❒ Colorfulness / design to match environment and attract users
- ❒ Degree to which it’s intuitive to all users
- ❒ Ease of long term maintenance
- ❒ Ergonomic / learning-friendly design
- ❒ Functionality
- ❒ Intriguing enough to hold users’ attention
- ❒ Uniqueness

Parameters

- ❒ You must consider how to make your prototype colourful, intriguing and ergonomic.
- ❒ You must prepare a group display which includes your design notes, your design thinking sketches and your prototype.
- ❒ You must use some of all the items in the participant group kit in some way.

31 Up-cycling Fashion

Overview

One of the growing trends in fashion is called up-cycling. Up-cycling gives old or discarded clothing a better purpose through a process which converts it into something useful and often beautiful. From Triple Pundit website:

"There are more textiles produced in the world today than realistically can be used—many of the large clothing chains can produce as many as a half a billion garments a year. A question you have to ask is 'What happens to those clothes after they have fulfilled their "useful" lives?' About 14.3 million tons of textiles were sent to the landfill in 2012, or around 5.7 percent of total municipal solid waste generation in the U.S., according to the Environmental Protection Agency (Retrieved January 2016, **https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/textiles-material-specific-data**). If not discarded as trash, unwanted apparel is often donated to thrift stores. Though a good step toward avoiding the landfill, this is not as beneficial as people think as only about
20 to 30 percent of donated clothing is actually re-sold (Retrieved January 2016, **https://greenthreadblog.wordpress.com/2014/02/20/the-afterlife-of-our-closets/**). Part of the reason such a low percentage of re-sale exists is due to the drastic increase in second-hand clothing stores in the past 15 years which leaves thrift store with cheap fashion and junky basics instead of vintage gems,"(Retrieved January 2016, **http://www.triplepundit.com/special/sustainable-fashion-2014/upcycling-new-wave-sustainable-fashion/**).

Design Rationale

How might we up-cycle textile waste in our world? We all have garments that have worn out or gone out of style. Typically, these items will end up in a landfill, even if they make a brief stop in a thrift store first. One of the first things we learn as we try to be greener is to try to reuse items before recycling them. Fascinating sites like *40 Mind blowing Ways to Repurpose Old Clothing* (Retrieved January 2016, **http://www.trendsandideas.com/40-mindblowing-ways-to-repurpose-old-clothing/**) provide some interesting ideas for consideration.

Problem Scenario

Every year the school ends up with lots of unclaimed clothing in its lost and found collection. Your team has been given the task of designing something useful that could be made from that collection. It could be an item for a vulnerable member of our community (i.e. a homeless person, a person in a shelter, a person in a care facility, a person receiving medical treatment, etc.). You need to design a prototype of your item.

Your design sketch and prototype must meet the following criteria:

- It should be appropriate, functional and attractive
- It might be designed for a specific season or purpose

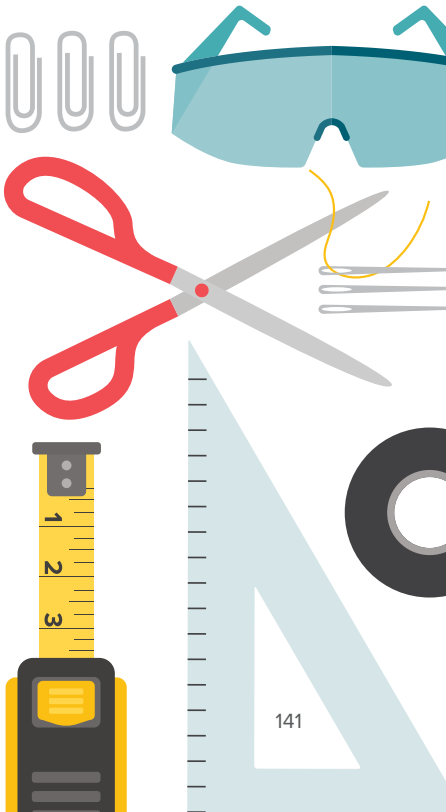
SkillsCanada Alberta

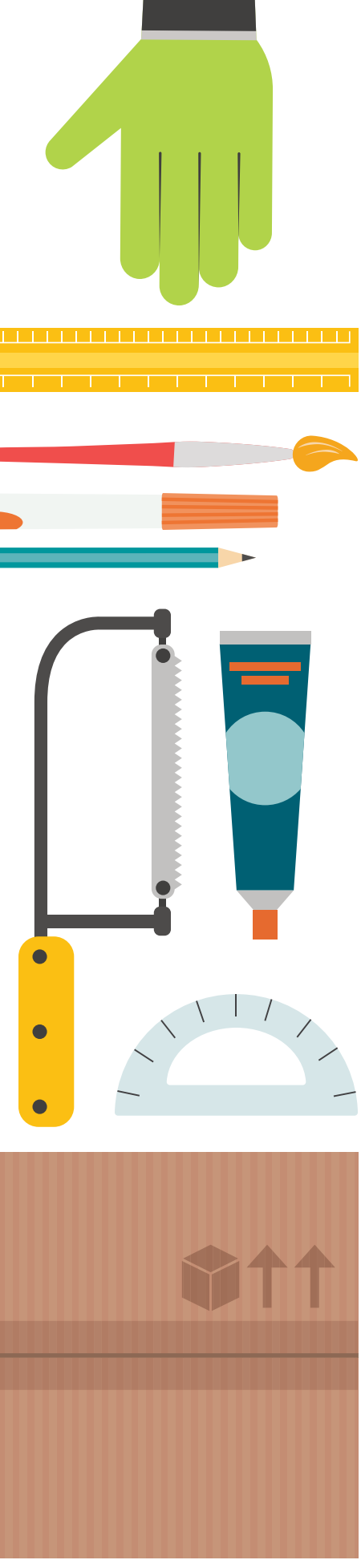
Suggested Grade Level

Upper elementary through to secondary school

Suggested Subject Area

- ADST
- Fabric and Textiles
- Home Economics
- Social Studies





Success Determinants

Success will be determined by:

- ❒ Alignment to design motto: “Make it smaller, stronger, do more, be easier to use, be cheaper, be clean, be greener.”
- ❒ Degree to which your prototype looks like your design sketch
- ❒ Ease of long term maintenance and durability
- ❒ Functionality of the design and prototype
- ❒ Uniqueness and originality of the design
- ❒ Usability of your prototype and the degree to which it solves an actual problem

Parameters

- ❒ You may use the tools provided to you in the classroom pantry.
- ❒ You must complete a display panel, which includes your design thinking sketch, your prototype, your design notes, and your reflections on the activity.
- ❒ You must consider how to make your prototype colourful, intriguing, and ergonomic.
- ❒ You must use some of all the items in the participant group kit in some way.

32 Design Challenge: Helping Our Friends, the Wrens

Overview

There are a number of small birds that used to live in our meadows, marshes, and forests. Now that we have built our homes and communities in their former habitats, we need to enjoy those small birds to return and live amongst us. Small birds, like the House Wren (**https://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=HOWR&lang=en**), are valuable friends. They help control the spread of weeds by eating the seeds and they maintain a balance of nature by eating pests such as bugs, worms and mosquitos.

Small birds like the House Wren need our help. They are losing their natural habitats. Many of the pesticides we have used on our crops and gardens have threatened the lives of Wrens, and our urban development has forced them to live further away from us.

Design Rationale

Wren houses can be constructed to support and encourage Wrens, and other small birds, to return in our neighbourhoods. Wrens need access to water and food. The houses we build to attract them can be installed any time of the year but when the Wrens are preparing for nesting is probably the best time to introduce a Wren house. Wrens are not too picky about homes but the size of the entrance and protection from predators such as neighborhood cats is important.

For suggestions on the actual construction of the optimal bat house, please check out the resource Interactive Workbook – Bird House, which is available from **https://theelementarywoodshop.ca/**. This workshop offers design tips, lessons, patterns and various support materials. Other references are available from sites such as the National Wildlife Federation (**https://www.nwf.org/News-and-Magazines/National-Wildlife/Birds/Archives/2010/Winter-roosts-for-birds.aspx**).

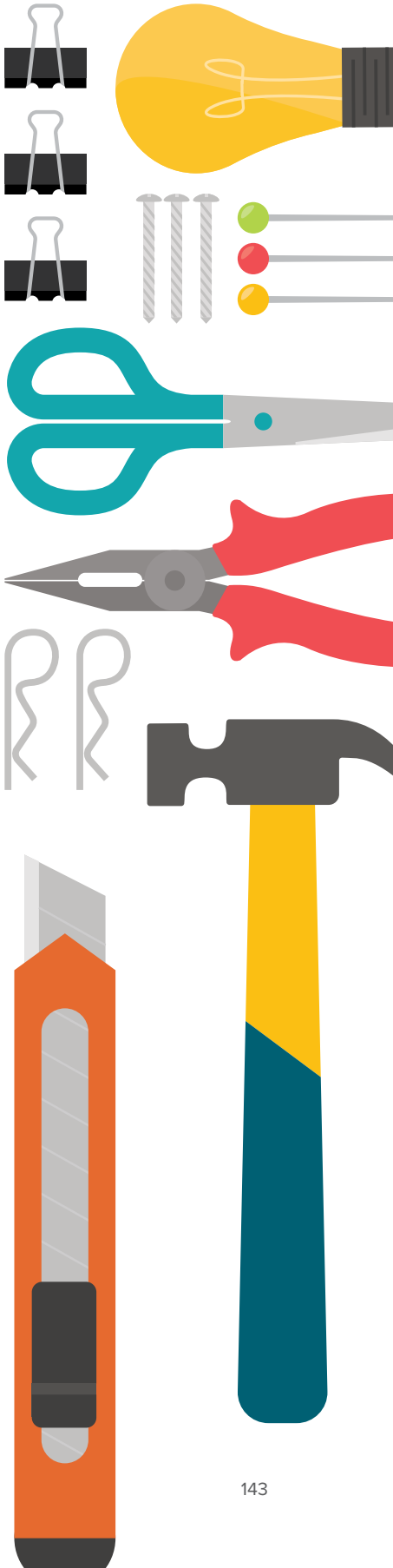
Problem Scenario

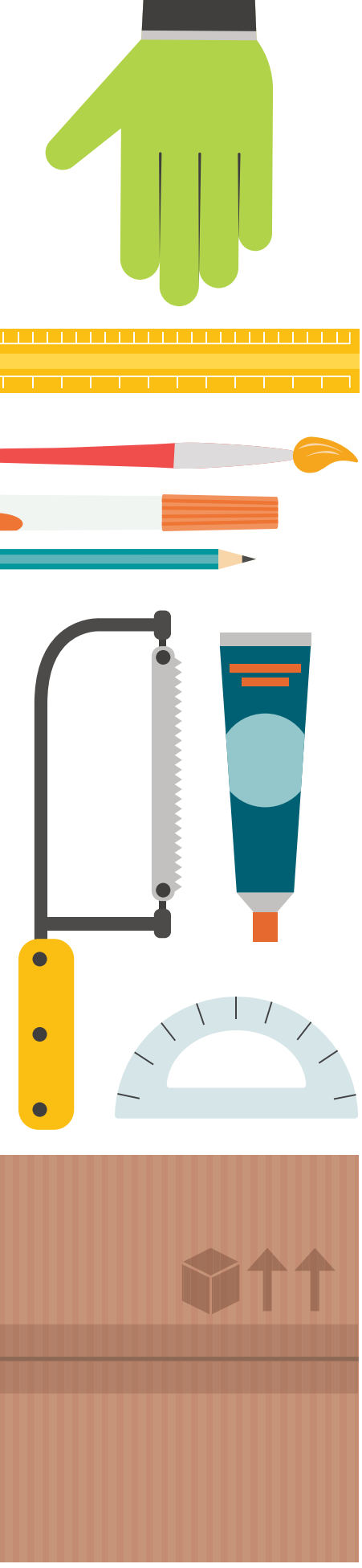
Your team has been selected to design an attractive Wren house that will attract Wrens or other small birds to our neighbourhood. Your Wren house design should reflect our community and environment. It should meet and / or exceed the key criteria for successful Wren nesting areas. Your team will build a prototype from your final Wren house design sketch using cardboard and the materials provided by your teacher. Successful prototypes will be selected for construction using durable materials.

Success Determinants

Success will be determined by:

- ❒ Meets the key criteria for a successful Wren house
- ❒ Is attractive
- ❒ Reflects our community
- ❒ Can ultimately be built using more durable materials (i.e., wood)





Parameters

- ❒ Use items and materials found in your Participant Group Kits and the ***Shared Pantry***.
- ❒ Use the tools that have been provided at the ***Shared Tool Station***.

33 Design Challenge: Helping Our Friends, the Bats

Overview

Bats are valuable members of our communities.They are good neighbours because they can consume their body weight in mosquitos! They are natural predators of many of the night flying insects that bite us and carry disease.They also help to maintain the balance of nature because they consume many lawn and garden pests.

Bats need our help. They are losing their natural habitats. Many of the pesticides we have used on our crops and gardens have threatened the lives of bats.

Design Rationale

Bat houses can be constructed to support and encourage bats in our neighbourhoods. Bats choose to live within proximity to water. They prefer streams, rivers or lakes. Bat houses can be installed any time of the year but late spring or early summer is best. While there is no perfect design for a bat house, it should be painted. The colour you pick should be based on temperature in July in your area. Can you think of why this time of year is a critical factor?

For suggestions on the actual sizing of the optimal bat house, please check out A Guide for Bat Houses in BC (**http://www.bcbats.ca/attachments/Bat_houses_in_BC_2015.pdf**) or Build a Bat House prepared by the US National Wildlife Federation - Grade Level 2 to 8 (**https://www.nwf.org/~/media/PDFs/Be%20Out%20There/Schoolyard%20Habitats/buildbathouse.pdf**).

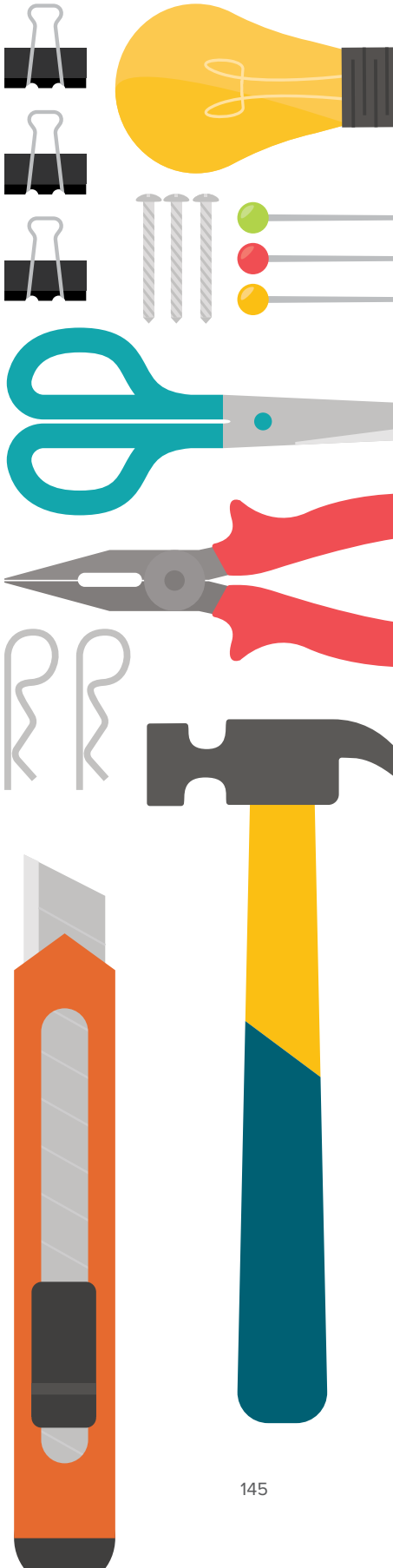
Problem Scenario

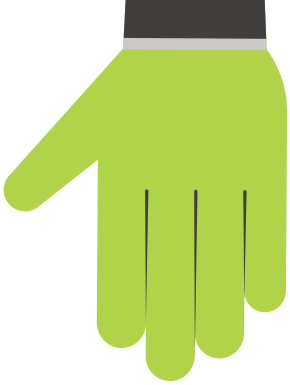
Your team has been selected to design an attractive bat house that will attract bats to our neighbourhood. Your bat house design should reflect our community and environment. It should meet and / or exceed the key criteria for successful bat houses. Your team will build a prototype from your final bat house design sketch using cardboard and the materials provided by your teacher. Successful prototypes will be selected for construction using durable materials.

Success Determinants

Success will be determined by:

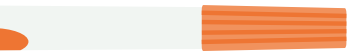
- ❒ Meets the key criteria for a successful bat house
- ❒ Is attractive
- ❒ Reflects our community
- ❒ Can ultimately be built using more durable materials (i.e., wood)

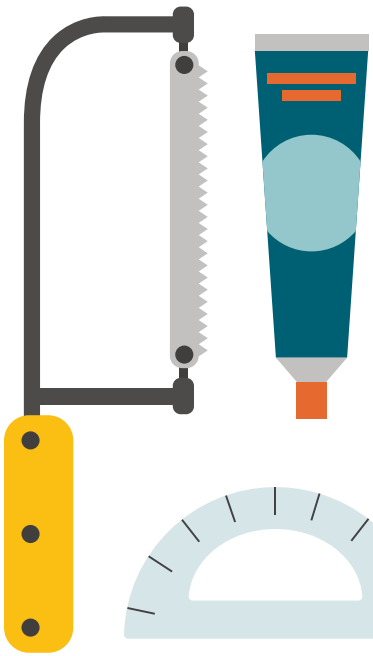




Parameters

- ❒ Use items and materials found in your Participant Group Kits and the ***Shared Pantry***.
- ❒ Use the tools that have been provided at the ***Shared Tool Station***.





SECTION 13

EXAMPLES OF AMAZING ACTIVITIES IN SEARCH OF MEANINGFUL CURRICULAR LINKS AND DESIGN CHALLENGES

Throughout this toolkit we have stressed that the difference between making in a makerspace and *Taking Making into Classrooms* is intent. In Section 7 we described four learning intentions that utilized a variety of tools, materials and resources. In this section, we offer our favourite links to projects and activities, trusting you will turn them into fabulous design challenges, taking making with intention into your own classrooms. You may want to do these activities for your own interest and skill development, but we caution against simply giving your students these projects or activities as they tend to be formulaic and too generic. It is our role as teachers to think through the intent and curricular connections and craft our design challenges in meaningful and relevant ways.

Giant Jenga

https://jengagiant.com/jenga-giant-js4-stacks-3-premium-hardwood-game-bag/

There are large versions of Jenga (**https://en.wikipedia.org/wiki/Jenga**)—it might be a fun initial maker activity; good way to learn to use a chop saw, sand paper and have some fun.

Instructables

http://www.instructables.com/

Online community sharing projects and ideas. Originated in MIT Media lab and grew into Squid Labs. Required free membership but a premium membership allows for downloads and enhanced access.

Makezine Project Archives

http://makezine.com/projects/

Another amazing collection of intriguing ideas.

Mini-Educator Guides

http://www.nexmap.org/

PDFs and downloads that help teachers learn circuitry, microcontrollers, and other cool tips.

Pitsco Kits

https://www.pitsco.com/project_kits

Thanks to a display of Pitsco kits at ISTE 2016 in Denver, we learned a simple joinery technique using everyday straws and pipe cleaners. They have kits, resources, and lessons that can be purchased and they are linked to US curriculum standards for STEAM education.

ProD Resources for Maker Teachers

https://www.edsurge.com/research/guides/what-s-next-for-maker-education#%23Professional-Development-for-Makers

EdSurge and **Maker Ed** collaborated on a list of valuable resources for educators interesting in getting started with making.

The Tinkering Studio

http://tinkering.exploratorium.edu/projects

An open source resource of R&D ideas straight from Exploratorium—author of the tremendous book *The Art of Tinkering*.

Thingiverse

https://www.thingiverse.com/

An amazing collection of intriguing ideas.

SECTION 14

SUGGESTIONS FOR THE HANDS-ON TAKING MAKING INTO CLASSROOMS

Suggestions and Rationale by Intention

When you are taking making into your classroom in meaningful and exciting ways, you need to give yourself time to play and explore; tinker and thinker with new ideas, resources, tools and materials.

This section offers a starting place for considering tips, tricks, resources and materials. There is no way we could make an exhaustive list, and part of the fun is finding and sharing new ideas. But, we also recognized everyone needs a little help to get started! Here's a starting gift to you because we know craft stores, conferences, Maker Faires, and Internet sites like Exploratorium (**http://www.exploratorium.edu/**), Instructables (**http://www.instructables.com/**), Smithsonian LearnLab (**http://www.smithsonianeducation.org/educators/index.html**), etc. are inspiring labyrinths of wonderful ideas where good teachers could disappear!

Taking Making into Classrooms is designed around using readily available participant group kits and shared pantry items in classrooms, so we wanted to offer suggestions for using ordinary objects in interesting ways. In time, we hope this section of the online *Taking Making into Classrooms* resource will have a place for sharing tips and ideas amongst teachers.

Tips for Structures and Stability

Use of Cotter Pins, Washers and Disks for Articulate Joints

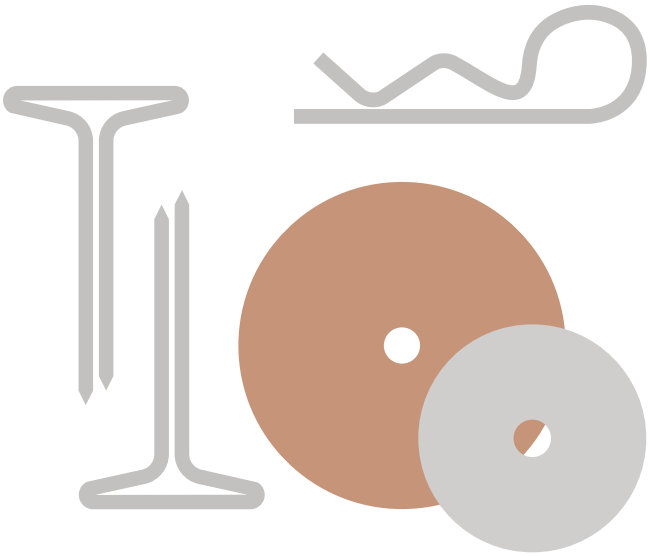
When you want to hold material together (i.e. cardboard, fabric, plastic, etc.) and still be able to move the pieces similar to the shoulder joint of an articulated toy bear, cotter pins, washer and rigid disks are the answer. Please watch this video to see how this can be done. The example in the video is creation of a bear with movable arms, but you can adapt this tip for use with plastic pipe to make prototype crane and a million other things (**https://www.youtube.com/watch?v=9rW004vw88w**).

Substituting Brads/fasteners for Cotter Pins

If the material you are fastening is light weight (i.e. thin cardboard or heavy paper), simple brass-plated fasteners or brads will work. However, they lack the structural integrity of cotter pins and washers and will wear holes in thin materials.

Hydraulic and Pneumatic Ideas

Rubber Band Engineer by Lance Akiyama provides amazing structural ways to make hydraulic and pneumatic machines that propel inventions in sustainable ways. The book is well worth the purchase price and Lance's work should be supported. To whet your curiosity, check out **https://books.google.ca/books/about/Rubber_Band_Engineer.html?id=t_z9CwAAQBAJ&source=kp_book_description&redir_esc=y** for downloadable project lessons. There are numerous ideas available including Pyramid Catapult, Hydraulic Judo Bots, Pneumatic Machine, and Siege Engines for Kids.



Participant Group Kits and Shared Pantry Contents

Since starting *Taking Making into Classrooms* in 2013, we have worked hard to ensure that the materials and resources used on our work are affordable, accessible and appropriate. We never wanted students and their teachers excluded from making due to access or cost issues. In Sections 7–9, we suggest that making can take place amid a variety of learning intentions, noting that each intention prompts the need for different tools and safety conditions.

Common to the intentions is the use of a participant group kit, shared pantry, and shared tool station. We recommend these three components to support the design and tinkering process and to ensure classrooms can support the ideas provoked from the design challenges.

The participant group kit is used as a disrupter. Design thinking is fundamentally about divergent, lateral thinking that disrupts designers from rushing to solutions and to engage in human centred thinking that enables problem finding (Sections 3 and 6). Once students have completed their initial design thinking work and before they begin prototyping, we suggest providing them with a participant group kit. You will note that each of the design challenges offered in Section 12 states in the parameters that your team "Plan how to use something of every consumable item in the participant group kit provided." We are passionate that adding this final disrupter into the design process is important. Once again, groups are required to consider their design, ideating and iterating ways in which to use the new resources for best advantage and functionality.

We offer the following suggestions for participant group kits by learning intention. Please note, these are only suggestions and should be modified according to availability of materials, budget considerations, recycling/reuse options, culture, location, etc. We also offer a suggestion for tools to support a mobile maker configuration for classrooms.

Table 14-1: Suggested Participant Group Kits by Learning Intention

We suggest one participant group kit for each group of 4 students. Quantities of each consumable item are less important as students do not have to use all the items and additional items are available from the shared pantry. A complete listing with suggested quantities can be found in *Maker Day Toolkit V2* (**https://media.royalroads.ca/owl/media/takingmakingwordpress/makerday-2-toolkit.pdf**).

Learning Intention	Description	Participant Group Kits
Design and Basic Making	Introduction of design thinking and making. Simple, tangible items to illustrate design ideas in 3D.	• Lunch sized brown paper bag to hold contents • Small piece of hook and loop stick-on strips (Velcro) • Jute or string (1–3 meters) • Pipe cleaners • Straws • Miscellaneous coloured paper • Coloured pompoms • Foam pieces or small piece foam core • Toothpicks • Bamboo skewers • Modeling clay

Learning Intention	Description	Participant Group Kits
Design and Simple Prototyping	Introduction and continued use of design thinking and more elaborate prototyping of ideas to scale.	• Lunch sized brown paper bag to hold contents • Small piece of hook and loop stick-on strips (Velcro) • Jute or string (1–3 meters) • Pipe cleaners • Straws • Miscellaneous coloured paper • Coloured pompoms • Foam pieces or small piece foamcore • Toothpicks • Bamboo skewers • Modeling clay • Kitchen garbage sized plastic bag • Marbles • Springs (small) • Tie Wire (1 meter) • Wood pieces (tongue depressor type) • Coloured wooden pieces (craft items from dollar stores) • Zip tie
Design and Fabrication	Use of design thinking and introduction of fabrication to create working prototypes at scale.	Same as for **Design and Simple Prototpying**

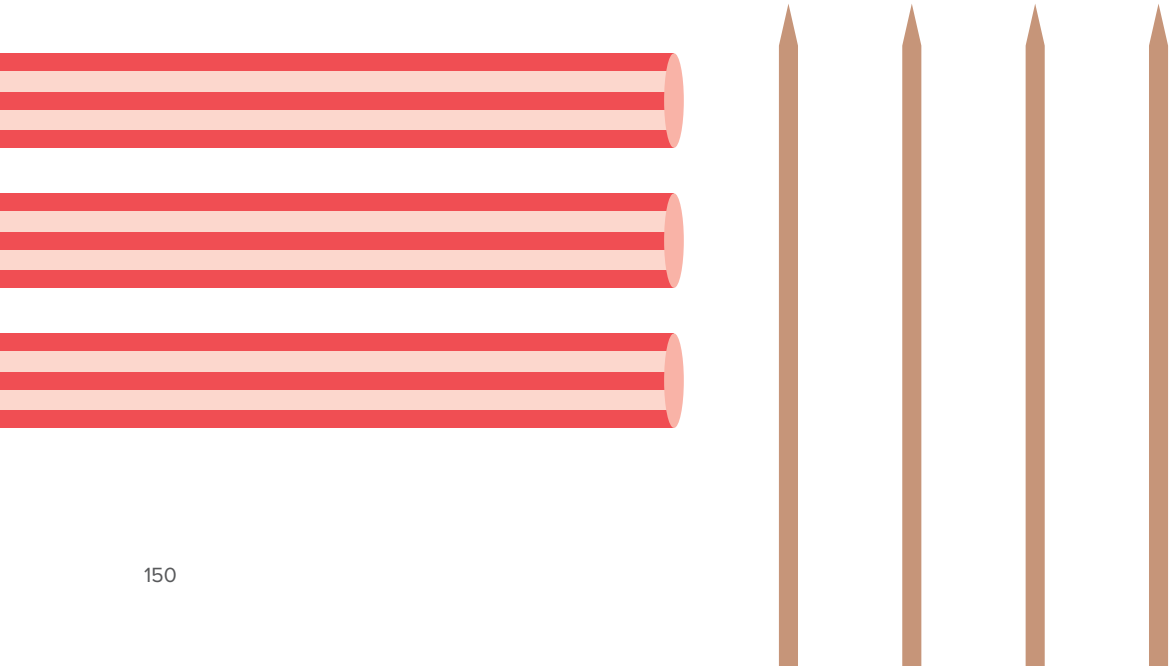


Table 14-2: Suggested Shared Pantry by Learning Intention

Complete listing with suggested quantities can be found in *Maker Day Toolkit V2* (**https://media.royalroads.ca/owl/media/takingmakingwordpress/makerday-2-toolkit.pdf**).

Learning Intention	Description	Pantry Items
Design and Basic Making	Introduction of design thinking and making. Simple, tangible items to illustrate design ideas in 3D.	• Cardboard boxes (recycling or from big box stores) • Cardboard pieces • Egg cartons (paper and foam) • Magnets (pieces and sheets) • Modeling clay • Paper scraps and sheets • Styrofoam (recycling) • Tape (duct, electrical, coloured, clear) • Fabric • Miscellaneous found and fun items
Design and Simple Prototyping	Introduction and continued use of design thinking and more elaborate prototyping of ideas to scale.	• Cardboard boxes (recycling or from big box stores) • Cardboard pieces • Egg cartons (paper and foam) • Magnets (pieces and sheets) • Modeling clay • Paper scraps and sheets • Styrofoam (recycling) • Tape (duct, electrical, coloured, clear) • Fabric • Miscellaneous found and fun items • Irrigation pipe with appropriate fittings • Doweling (miscellaneous sizes)
Design and Fabrication	Use of design thinking and introduction of fabrication to create working prototypes at scale.	Same as for **Design and Simple Prototyping** • Depending on access to tools, consider dimensional lumber and scrap wood • Structural materials (pieces of acrylic sheeting, etc.)

Learning Intention	Description	Pantry Items
Design, Prototyping, Circuitry and Coding	Use of design thinking with the addition of coding and circuitry to add functionality to prototypes.	Same as for **Design and Simple Prototyping** Refer to *Coding & Microcontrollers in Design Thinking* for Ardruino and simple circuit ideas (**https://issuu.com/ubcedo/docs/diy_guidebook**). Also refer to the Ardruino site for suggested activities and resources (**https://www.arduino.cc/**).

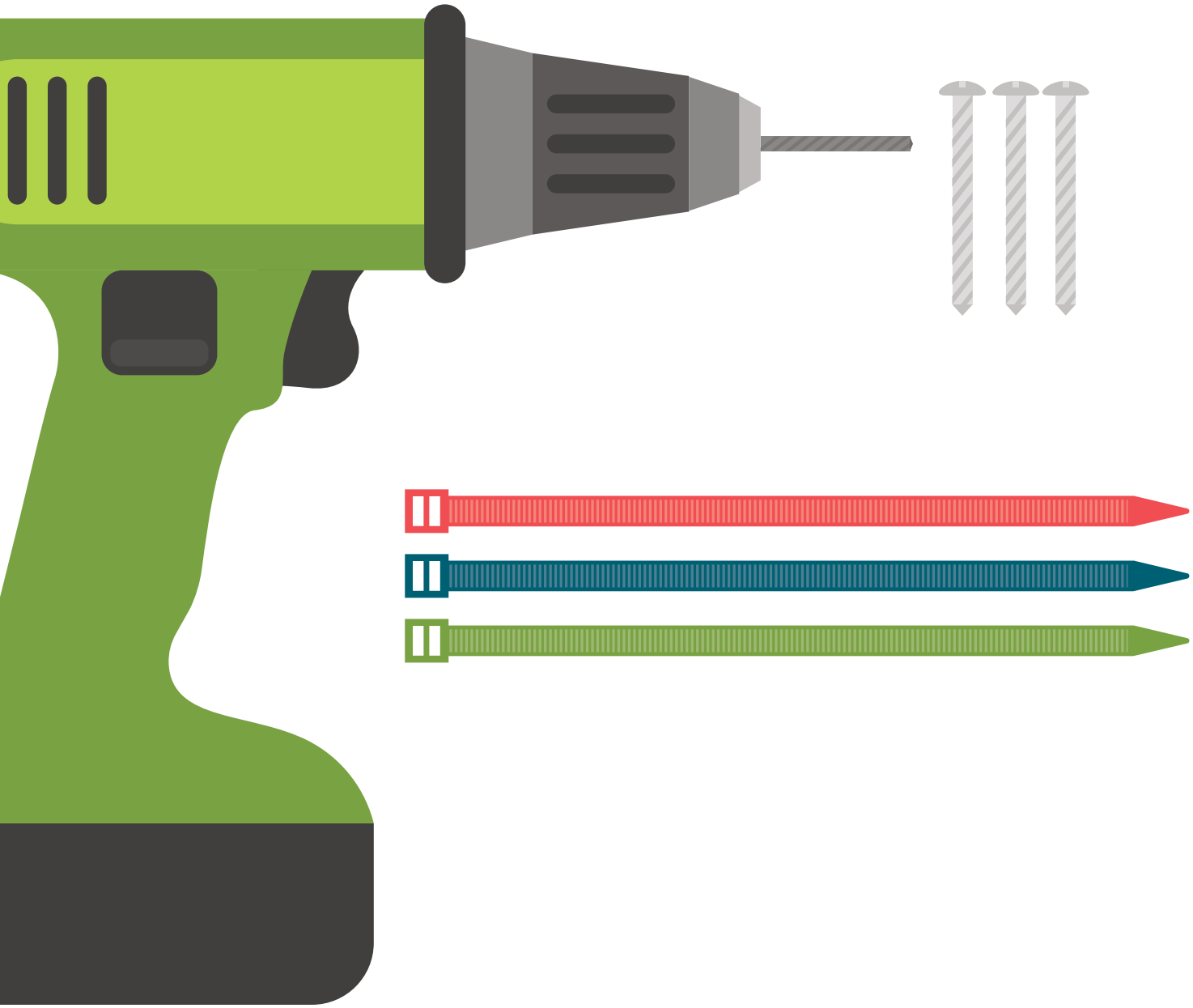


Table 14-3: Suggested Shared Tool Station by Learning Intention

Complete listing with suggested quantities can be found in *Maker Day Toolkit V2* (**https://media.royalroads.ca/owl/media/takingmakingwordpress/makerday-2-toolkit.pdf**). Ensure there are adequate power bars available to power tools as required.

Learning Intention	Description	Shared Tool Station Items
Design and Basic Making	Introduction of design thinking and making. Simple, tangible items to illustrate design ideas in 3D.	• Box cutters (utility knives) • Glue guns (mini craft size) • Replacement mini glue sticks • Pencils with erasers • Felt markers • Pliers • Metal rulers • Scissors • Measuring tape
Design and Simple Prototyping	Introduction and continued use of design thinking and more elaborate prototyping of ideas to scale.	• Box cutters (utility knives) • Glue guns (mini craft size) • Replacement mini glue sticks • Pencils with erasers • Felt markers • Pliers • Metal rulers • Scissors • Measuring tape • Drywall straight edge • Hand held Dremel tool • Dremel tool • Dremel Rotary Tool Work Station • Dremel Flex Shaft Attachment • Dremel tool accessories (bits, etc.) • Hand saw • Small drill (battery powered) • Wooden v-blocks with clamps (turns almost all flat surfaces into a vise for holding items to be cut or drilled)

Learning Intention	Description	Shared Tool Station Items
Design and Fabrication	Use of design thinking and introduction of fabrication to create working prototypes at scale.	Same as for **Design and Simple Prototyping** • Depending on materials and technical support, consider chop saw and other power tools
Design, Prototyping, Circuitry and Coding	Use of design thinking with the addition of coding and circuitry to add functionality to prototypes.	Same as for **Design and Simple Prototyping** • Soldering iron • Flux • Sphero • LittleBits • Lily Pad Ardruino • Fabric and sewing supplies

Table 14-4: Mobile Maker Kit (Toolkit V2.1) for Use in Classrooms with 40 Students

Kit Items	Quantity	Notes
Clamps, Rachet	2	6"/150mm quick ratcheting bar clamp, used to make cutting safer; use with a v-block to hold round material
Clamps, Ratchet	3	Used to make cutting safer; use with a v-block to hold round material
Dremmel Kit*	1	*Dremmel brand is quite expensive. We have used Rotary Tool Kit (ROK 80501). Dremmel or Dremmel-like tools offer numerous attachments for cutting, drilling, and sanding options. The tool is small, easy to use, and accessible for reluctant tool users. For STEMx projects, might use 2 Dremmel tools (replaces power drill). For ADST projects, 1 Dremmel and 1 power drill.
Drill Bits	1 Kit	Various sizes—if possible, keep in drill kit
Drill, Cordless Electric	1	For STEMx projects, might use 2 Dremmel tools (replaces power drill). For ADST projects, 1 Dremmel and 1 power drill.
First Aid Kit	1	Basic kit

Kit Items	Quantity	Notes
Glue Gun, Mini	4	Lower heat and longer to heat up—used for tongue depressors, etc.
Glue sticks, Mini	1 package	Refills
Glue Gun, Rapid Heat	1	Heats faster and hotter than mini glue guns—used for Doweling, Plastic, Metal
Glue Stick, Rapid Heat	1 package	Refills
Hammer	1	
Pliers	4	Preferred: Needle Nose with wire cutter
Power Bar	1	Preferably 6 foot reach and at least 6 plug-ins
Rulers, 12"	5	Recommend: Steel rulers to use with utility box cutters
Saw, Fine-tooth Hand	3	Folding pruning saw also works well
Saw, Hack	2	Easier to cut with than wood saws
Scissors	5	Preferred: various sizes/functions
Squares, Quick Angle	5	Good for complex mathematics measuring and angle cuts
Tape Measure	5	
Utility Box Cutters	5