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://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 Karimkai (**http://karimkai.com**) shares rich and engaging examples of complex problems positioned with math and science, as does the companion site Mathalicious (**http://www.mathalicious.com**). Both these sites approach 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 **http://www.learnalberta.ca/content/kes/pdf/or_ws_tea_inst_02_inqbased.pdf** and **http://www.teachingbooks.net/content/FocusOnInquiry.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/1_wicked_problems.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

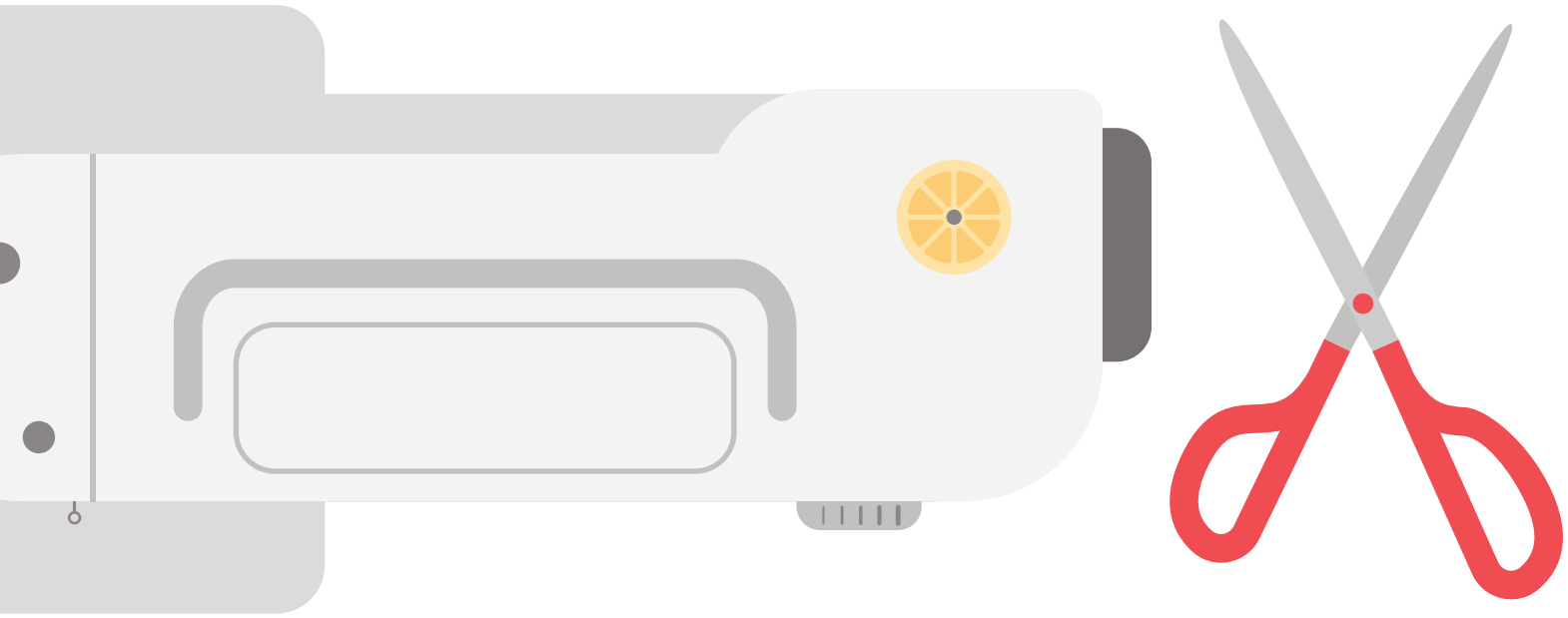
Consider ways in which you could create a complex or wicked problem that would be the focus for your school for an entire semester or school year. How might it focus fund raising, social justice initiatives, guest speakers, and community engagement activities for that time period?

...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 **http://www.teachingbooks.net/content/FocusOnInquiry.pdf**.



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.

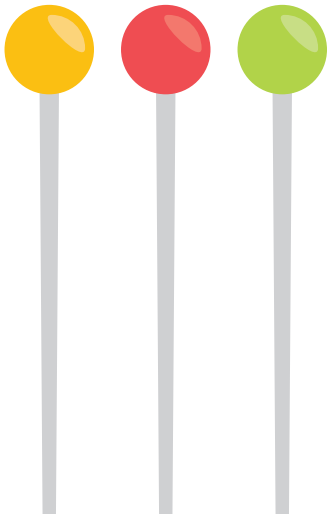
Tips on crafting each component follow.

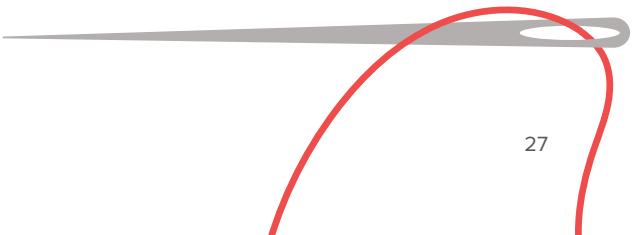
Overview

- 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. For example, please look at the teacher design WebQuest on Genetically Modified Crops (**http://webquestgmcrops.weebly.com/teachers-note.html**).

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 (**http://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 (**http://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).