Design-Based Learning for the Elementary School Classroom

CRITICAL & PROCESS DOCUMENT

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Critical and process document submitted in partial fulfillment of the requirements for the degree of Master of Design

Emily Carr University of Art and Design

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Acknowledgments

"Don't believe what your eyes are telling you. All they show is limitation. Look with your understanding, find out what you already know, and you'll see the way to fly."

Excerpt from *Jonathan Livingston Seagull* *by* Richard Bach

Many people over the past two years have contributed their time and knowledge to this project, for which I am sincerely grateful.

I must begin by thanking the incredible administration, teachers and students at Kenneth Gordon Maplewood School. Their unyielding enthusiasm and support drove this project forward and was a constant source of inspiration. A special thank you to Dr. Jim Christopher, Rosita Tam, Neil Pinkerton, Colleen Blackwell, Johanna Frank, Adam Lewis, Norlene Page, and John Rodgers for welcoming me into your classrooms and finding the time to speak with me on a regular basis. It has been an absolute privilege to work with you and your students.

I am also incredibly thankful to another teacher in my life, my mom, who spoke with me on a weekly, if not daily basis, about the integration of design into her own grade 4 classroom. Although initially quite skeptical about the use of design in the classroom, she quickly became one of my biggest supporters. Thank you to my dad and my sister for putting up with our endless conversations, and for the quiet yet constant support.

To Eric, whose ridiculous work schedule and incredible passion for his own work pushed me to work just as hard and to stay up just as late. Well, maybe not quite as late. Thank you for challenging me to do better, encouraging me to relax, and pretending to listen when I really needed to think out loud.

Of course, my MDes journey would not have been the same without the dynamic conversations shared with Andreas Eiken, Bree Galbraith, Michael Peterson and Christina White as we navigated this experience together. Thank you for

contributing your ideas and expertise to my project, whether that was communication design advice, video support, statistics knowledge or suggestions for how to solve the numerous challenges I encountered.

Thank you to Doris Wells-Papanek for her significant contribution to my research, for her mentorship and for inviting me to speak at the Design Learning Network Symposium.

And finally, a thank you to the design faculty at Emily Carr who first sparked my passion for design eight years ago and who continue to inspire and challenge me: Bonne Zabolotney, Deb Shackleton, Louise St. Pierre, Helene Day Fraser, Chris Hethrington, Craig Badke. To Jonathan Aitken, my supervisor, thank you for the numerous readings and edits, for keeping me on course and for your valuable guidance and insights.

Many people have been involved in supporting me with the learning and teaching of design in the past two years, but it has been the response from the students, their creativity and their enthusiasm for design that has fueled me. As one KGMS student explained, “Design is awesome and cool and there’s more to it than you think!”.

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"The future belongs to a very different kind of person with a very different kind of mind – creators and empathizers, pattern recognizers and meaning makers."

Daniel Pink, 2005

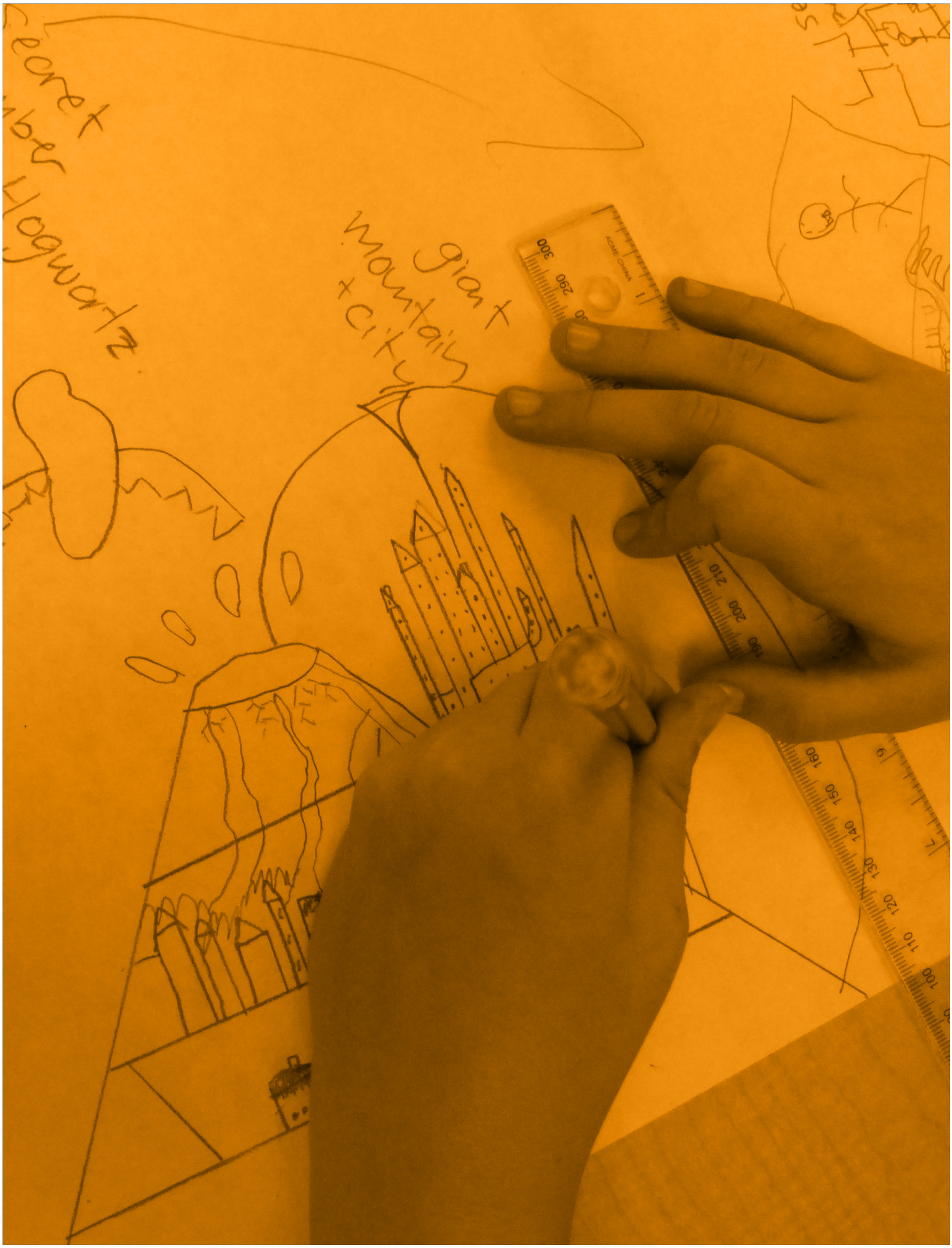
1. Abstract

As part of a two-year collaboration with over 100 students in grade 4-7 classrooms at Kenneth Gordon Maplewood School (KGMS), this thesis project introduced design-based learning as a new pedagogic approach for supporting children with learning differences. Design-based learning is the integration of design into classrooms as a means to support the learning of other subjects, skills and knowledge. It considers design as an approach to teaching and learning, not as its own subject of study.

There is growing recognition that our current educational methods and approaches need to equip children with important skills including critical thinking, creativity, collaboration and communication. The BC Ministry of Education is currently in the process of transforming the curriculum to emphasize the development of these skills as core competencies (BC Ministry of Education, 2015, p.8). The use of design as an approach to fostering these skills is gaining momentum in education discussions across North America. However, despite the growth of knowledge and research in the area of education reform, design continues to evade integration in mainstream K12 education due to a lack of available resources and training for teachers.

This document outlines the process of developing such materials. Through observations, conversations and the results of a pre- and post-design assessment the classroom teachers at KGMS saw profound benefits to the use of design as an approach to learning. To facilitate this approach, resource materials were developed to support teachers and a design coaching model was introduced as a way to provide ongoing, sustained professional development for teachers in the area of design-based learning.

Fig.1 KGMS Students


giant
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2. INTRODUCTION

Fig.2 Design drawing by KGMS student

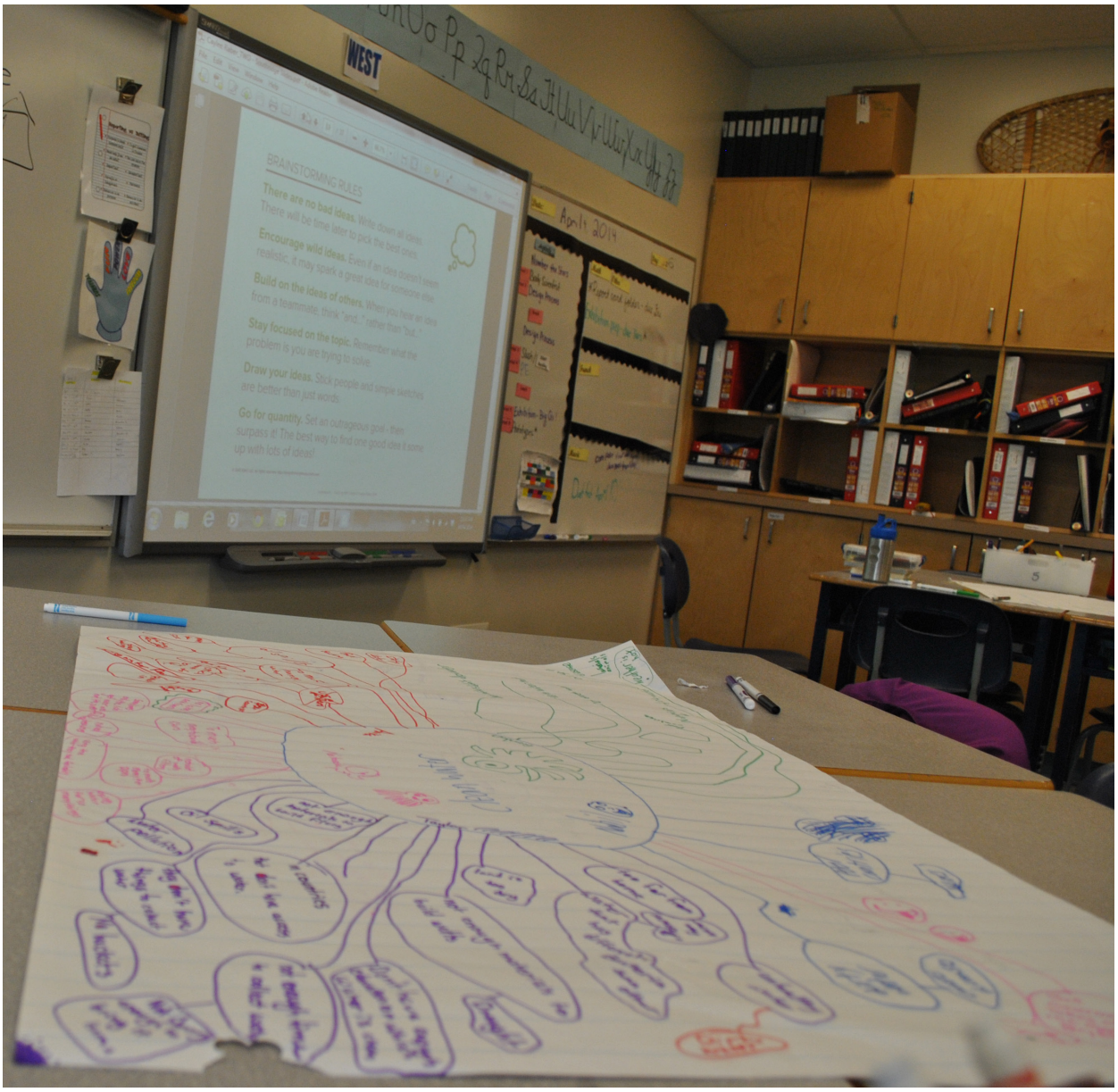


Fig.3 Design lesson with Grade 4 Students

2.1 THESIS STATEMENT

The development of design-based learning resources for teachers will allow for the integration of design into grade 4-7 classrooms as a new pedagogic approach that supports the learning of curricular subjects, skills and knowledge.

2.2 PROJECT OBJECTIVES

The objectives of this project are to:

1. **Identify the benefits of design-based learning for children in grades 4-7 with learning differences.**
2. **Provide resources to support teachers in the development of design projects that align with curricular objectives and instructional goals.**
3. **Embed the role of 'designer as coach' within a school as an approach to ongoing, sustained professional development for design-based education.**

2.3 PROJECT RATIONALE

The BC Ministry of Education is currently in the process of transforming the curriculum to emphasize the development of communication, collaboration, and creative thinking as core competencies (BC Ministry of Education, 2015). In the field of design there is recognition that the pedagogy of design can foster these skills and can provide practical strategies for achieving the goals of 21st century learning (Davis, 1998).

Organizations and designers such as Meredith Davis, IDEO, Standford d.school, Dr. Charles Burnette and the Design Learning Network, support the integration of design and design thinking into K12 education. There is a strong case for teaching design within general education, yet despite the growth of knowledge and research in the area of education reform and the parallels with design pedagogy, design continues to evade integration in mainstream K12 education in North America.

As we begin to understand the benefits of design-based learning, we need practical strategies for the adoption of design within classroom settings. A scan of precedent materials and existing resources for teaching design to children, identified a gap between the content developed for teaching design and the delivery of that content to teachers. In order for design to be adopted by teachers, tools and resources must be developed that are accessible and adaptable. Many existing resources for teaching design provide set lesson plans that may or may not fit within teacher's instructional goals and curricular objectives. There is a need to provide teachers with flexible tools that they can use to develop their own design projects appropriate to their classroom needs. "Teachers are tasked with a difficult challenge of having to teach students all that they need to learn, and if we are to ask teachers to integrate design thinking into their own classrooms then it needs to be done in a way that synergizes instruction that is already taking place" (Carroll et al., 2010, p. 51). My thesis projects seeks to fill this gap by providing resources for teachers that will support them in the planning and development of design lessons that align with their curriculum and instructional goals.

"The lack of recognition of design and design education by university programs and the absence of resources in schools for ongoing teacher education remain serious obstacles to wider adoption of design-based instruction"

Davis et al., 1997, p.99

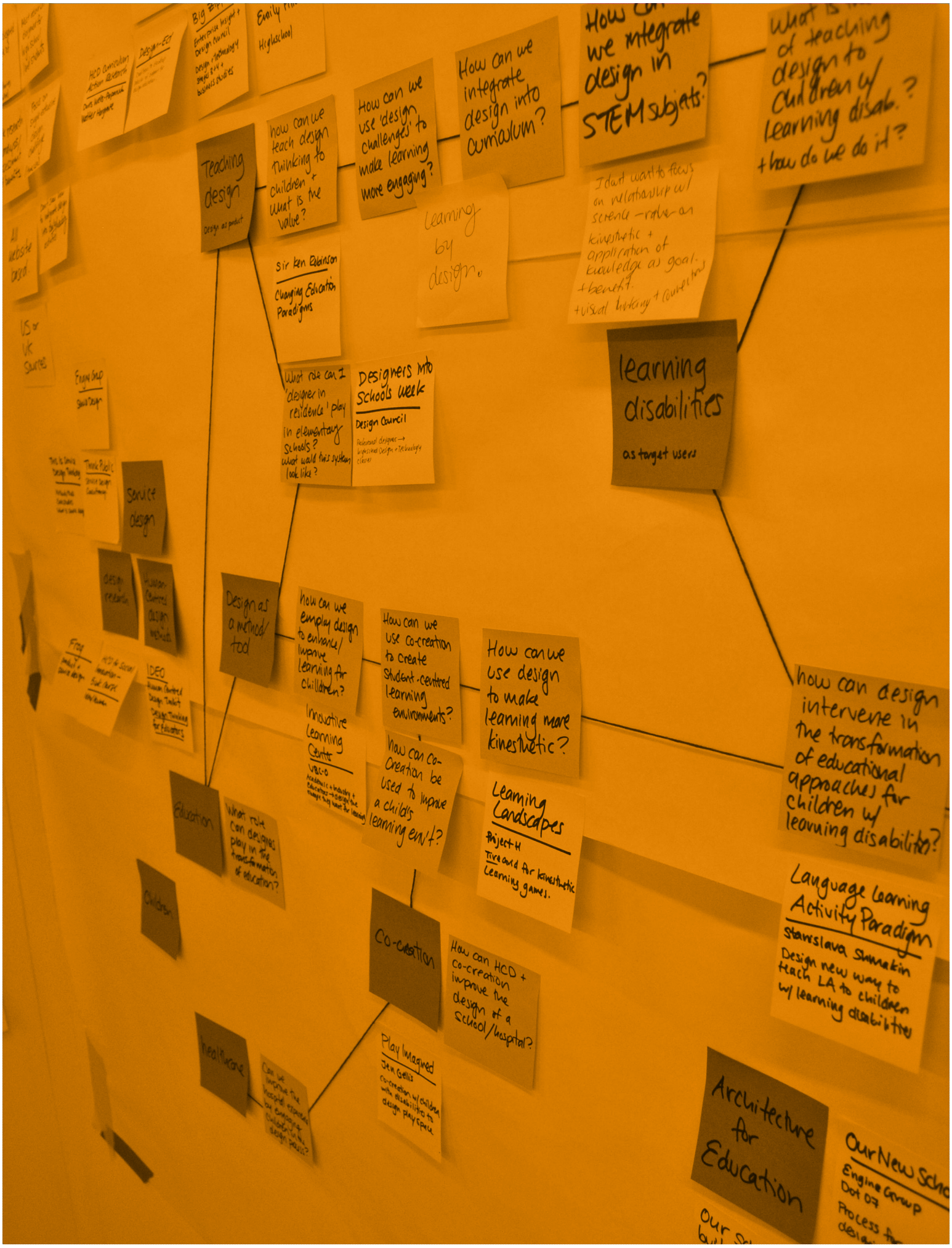
"If we are to ask teachers to integrate design thinking into their own classrooms then it needs to be done in a way that synergizes instruction that is already taking place"

Carroll et al., 2010, p.51

In addition to the limitations of existing resources, teachers lack training in the area of design-based education. "The lack of recognition of design and design education by university programs and the absence of resources in schools for ongoing teacher education remain serious obstacles to wider adoption of design-based instruction" (Davis, Hawley, McMullan & Spika, 1997, p.99). Several organizations in the US are now offering design workshops for teachers. This is a start, but research shows that in-service workshops and short-term training are not sufficient for creating sustained changed (Davis et al., 1997; Vega, 2013). "To truly use design problem solving, these teachers need ongoing professional critique of their assignments and teaching practices as well as assistance in developing new facilitation skills" (Davis et al., 1997, p.108). Having identified these opportunities, the objective of this thesis project was to identify the benefits of design-based learning for children with learning differences in grades 4-7, and to identify ways to encourage the adoption of this approach through resources and training for teachers.

Though design-based learning can benefit all students there is little to no research or resources developed that discuss the benefits for children with learning differences. My thesis considers the use of design-based learning for students in grades 4-7 with a specific research emphasis on the benefits of this approach for children with learning differences. In education we traditionally emphasize academic ability and linear thinking, yet "it is neither accurate nor responsible to judge children's intellectual abilities in general on the basis of these abilities alone" (National Advisory Committee on Creative and Cultural Education, 1999, p. 39). Children with learning differences often struggle with academic skills, yet they may have a natural affinity for creativity and lateral thinking. My thesis explores the ways in which design-based learning may impact children with learning differences.

Fig.4 Student sketching with chalk


Teaching design
Design as product
How can we use 'design challenges' to make learning more engaging?
How can we integrate design into curriculum?
How can we integrate design in STEM subjects?
What is the value of teaching design to children w/ learning disab.? + how do we do it?
Learning by design.
Sir Ken Robinson
Changing Education Paradigms
I don't want to focus on relationship w/ science — rather an kinesthetic + application of knowledge as goal. + benefit. + visual history + counter tool
learning disabilities
as target users
Designers into Schools week
Design Council
What role can I 'designer in residence' play in elementary schools? what would this system look like?
Service design
Design as a method/ tool
How can we employ design to enhance/ improve learning for children?
How can we use co-creation to create student-centered learning environments?
How can we use design to make learning more kinesthetic?
how can design intervene in the transformation of educational approaches for children w/ learning disabilities?
Innovative Learning Centre
Learning Landscapes
Project H
Tire card for kinesthetic learning games.
How can co-creation be used to improve a child's learning env't?
Education
What role can designers play in the transformation of education?
Children
Co-creation
How can HCD + co-creation improve the design of a school/hospital?
Play Imagined
Jean Gelli
co-creation w/ children with disabilities to design play space
Healthcare
Language Learning Activity Paradigm
Stanislava Sumakin
Design new way to teach LA to children w/ learning disabilities
Architecture for Education
Our New Scho
Engine Group
Dot 07
Process fo
desig

3. SECONDARY RESEARCH

Fig.5 Mapping of potential design opportunities

3.1 Education Reform Context

"Creativity is now as important in education as literacy and we should treat it with the same status."

Sir Ken Robinson, 2006

The education community across North America is currently undergoing a movement to consider how to better prepare children for contemporary contexts. "Advanced economies, innovative industries and firms, and high-growth jobs require more educated workers with the ability to respond flexibly to complex problems, communicate effectively, manage information, work in teams and produce new knowledge" (Carroll et al., 2010., p. 38). Traditionally, education systems have emphasized the learning of core subjects commonly referred to as the 3Rs (reading, writing, arithmetic). Today, there is growing recognition for the need to develop other learning, innovation, technology and life skills, including what are now referred to as the 4 C's: critical thinking, communication, collaboration and creativity.

Sir Ken Robinson, a recognized international advisor on education in the arts, is a well known advocate for creativity. In his 2006 Ted Talk, "How Schools Kill Creativity", he talks about the importance of the education system to foster rather than suppress creativity; "we are now running national education systems where mistakes are the worst thing you can make. And the result is that we are educating people out of their creative abilities" (Robinson, 2006).

Historically, educational approaches such as Montessori, Reggio Emilia, Waldorf education have placed an emphasis on the role of creativity and discovery for learning yet these forms of progressive education have often come under critique (Krechevsky, Mardell, & Seidel, 2002). Today there is now gaining recognition of the importance of these approaches in the 21st century.

In 2009, Sir Ken Robinson chaired the US National Advisory Committee on Creative and Cultural Education. During this time the committee produced a report to the US Secretary of State for Education and Employment and the US Secretary of State for Culture, Media and Sport. This report recommends a stronger emphasis and increased priority on creative and cultural

education, and a better balance between teaching skills and knowledge with opportunities to innovate and experiment. The report begins by recognizing "the urgent need to develop 'human resources', and to promote creativity, adaptability and better powers of communication" (National Advisory Committee on Creative and Cultural Education, 1999, p. 9).

Although there is increasing recognition of the value of creativity and the creative arts in education, there stills remains a gap in current curriculum (Ohler, 2013). In "The Uncommon Core", Jason Ohler (2013) states that there is a significant relationship between creativity and critical thinking and that it is important to teach an integrated approach. He suggests that children's creative thinking should be spurred by encouraging them to be innovators and by helping them to identify solutions for complex society challenges (Ohler, 2013). This presents a key opportunity for design-based learning.

The BC Ministry of Education is currently in the process of transforming curriculum and assessment across the province. One of the key elements in the new BC Education Plan is a movement towards personalized learning and an emphasis on core competencies including: collaboration, creativity, innovation, critical thinking and problem solving (BC Ministry of Education, 2015). These competencies strongly parallel the core skills of design education. As Davis (1998) explains in her article, "Making a Case for Design-Based Learning", "the learning outcomes of a design education are consistent with what experts agree are necessary skills, knowledge and attitudes for individual success and the nation's global competitiveness for the next century" (p.1).

"The learning outcomes of a design education are consistent with what experts agree are necessary skills, knowledge and attitudes for individual success and the nation's global competitiveness for the next century"

Davis, 1998, p.1

3.2 Design-Based Learning

In the text *Designerly Ways of Knowing*, Nigel Cross (2006) calls for design integration into general education. He identifies the following areas of justification for this argument: design develops innate abilities in solving real-world ill defined problems; design sustains cognitive development in the concrete/iconic modes of cognition; and design offers opportunities for development of a wide range of abilities in nonverbal thought and communication.

In the article, "Destination, Imagination and the Fires Within: Design Thinking in a Middle School Classroom", the authors agree that there is great value in teaching design at a younger age in order for students to develop cognitive and social skills. They state, "students need both the skills and the tools to participate

Fig.34 Student and teacher working together to build a mason bee home

actively in a society where problems are increasingly complex and nuanced understandings are vital. Design thinking provides a powerful alternative to this model by challenging students to find answers to complex and difficult problems that have multiple viable solutions and by fostering students' ability to act as change agents" (Carroll et al., 2010, p. 38).

In addition to the skills and competencies taught through design, Davis (1998) suggests that rather than try to introduce another subject into the curriculum, design educators "seek to expand the pedagogical repertoire of teachers to improve the delivery of whatever content teachers must impart and to demonstrate the application of creative problem solving to improved student performance in any subject area in daily life" (p.1). Design-based learning isn't about teaching design as its own subject; rather it's about using design to support the teaching of other subjects and curricular content. In her article, "Wicked Insights into Design Learning", Wells-Papanek (2014) explains "Always keep in mind "little d" and "big L" – design serves pedagogy for learning, rather than being taught as a subject" (p.58).

The inherent multidisciplinary nature of design allows for easy application of design projects to curricular content. Challenges that we face in the world are not compartmentalized into science, math or social studies, rather we must use a variety of skills, knowledge and strategies to address them. Design projects allow students to connect what they've been learning with real-world challenges and to make cross-curricular connections.

Design-based learning is also an effective strategy for reaching a wider range of learners than tradition methods of instruction (Davis et al., 1997). "Design helps me to be a more effective teacher, because not everyone learns in the same way...if I didn't use design, I would not reach many of the students in my class" (Teacher as cited in Davis et al., 1997, p.45).

The benefits of design-based learning as cited in research are numerous and diverse, yet design continues to evade integration into mainstream K12 education due to a lack of effective design-based learning resources and training programs.

"Design allows the academically frustrated student to realize that 'intelligence' is not confined to textbooks. Design in my classroom allows the spotlight to be turned on students who have formed negative opinions about their role in the educational process."

Teacher, as cited in Davis et al., 1997, p. 103

3.3 Learning Differences

The BC Ministry of Education (2013d) defines learning disabilities in the following way:

> "Learning disabilities refers to a number of disorders that may affect the acquisition, organization, retention, understanding or use of verbal or nonverbal information. These disorders affect learning in individuals who otherwise demonstrate at least average abilities essential for thinking and/or reasoning. As such, learning disabilities are distinct from global intellectual disabilities"(p. 55).

Children with learning disabilities often struggle with processing such as: language processing, phonological processing, visual spatial processing, processing speed, memory and attention, and executive functions (e.g. planning and decision-making) (BC Ministry of Education, 2013d).

According to data published by the Vancouver Sun in 2014, the number of children with learning disabilities in BC is increasing. In 2013-2014 approximately 18, 412 students (3.3%) in BC were identified as having learning disabilities (Sherlock, 2014). This number only includes students officially identified through a psych-ed assessment.

Although the BC Ministry of Education uses the term 'learning disabilities', many people prefer the term 'learning differences'. This term is used to help describe students who have significant difficulties within existing knowledge acquisition frameworks. The term 'learning differences' acts to destigmatize. It places emphasis on the fact that these students learn differently and require a different type of support, but these differences do not, or should not, disable them as learners. "Many accommodations allow bright students with learning challenges to demonstrate their knowledge without being hindered by the effects of their difficulties" (Weinfeld et al., 2013, p.86). The term 'learning differences' will be used throughout this document.

Strategies encouraged for students with learning differences include: differentiated instruction, multi-sensory instruction, guided discovery, hands-on experiences and varied modes of communication (Weinfeld et al., 2013).

According to the authors of *Smart Kids with Learning Difficulties*, teachers can help students to succeed by providing alternatives to writing as a means of communication. Further they explain, "it is also crucial that the instruction emphasizes problem solving, reasoning, and critical thinking, as well as extending and elaborating the regular curriculum" (Weinfeld et al., 2013, p.84).

These recommendations align well with the design-based learning approach. The research by Davis et al.,(1997) identified that design strategies were effective for engaging reluctant learners and were successful for gifted/talented students, as well as students with learning disabilities. "One of the greatest benefits [of design] for students is providing an opportunity for all students, not just the gifted/talented students, to experience higher-level learning by doing. Many of my most enjoyable teaching experiences have been with learning disabled students who have their greatest success using the design process and then seeing the 'ah ha'." (Teacher as cited in Davis et al., 1997, p.103).

In their 1999 report, the National Advisory Committee on Creative and Cultural Education, explained, "the tendency now is to think of children as 'able' or 'less able', primarily on the basis of academic performance...but it is neither accurate nor responsible to judge children's intellectual abilities in general on the basis of these abilities alone. It would be more accurate to think of all children having a profile of abilities across a wide range of intelligences" (National Advisory Committee on Creative and Cultural Education, 1999, p.39). For children with learning differences, design-based learning may be a way to showcase their abilities outside of traditional academics and may lead to greater overall motivation in education (National Advisory Committee on Creative and Cultural Education, 1999).

"Every child has capabilities beyond the traditional academic. Children with high academic ability may have other strengths that are often neglected. Children who struggle with academic work can have outstanding abilities in other areas"

National Advisory Committee on Creative and Cultural Education, 1999, p.14

3.4 Existing Design-Based Learning Resources

Through my research I have come across many organizations that promote teaching design in K12 education environments, and many print and web resources for teaching design currently exist. Despite the surprising number of existing resources available, my research identified various gaps and opportunities for improvement.

INTEGRATION

Many existing resources encourage teachers to run a single design challenge with their students and do not discuss how design can be integrated throughout the school year. The Design Learning Network (DLN) (Wells-Papanek, 2010-2014), is an example of an organization that encourages teachers and their students to take on a single, large-scale design challenge. In partnership with the Industrial Design Society of America the DLN puts out a yearly challenge to schools, such as "The Honeybee 2050 Challenge".

Design for Change is another organization with such an approach (Riverside, 2013). Design for Change is an initiative that aims to encourage children, and their parents and teachers, to lead and inspire change through the use of design. Their website encourages teachers and students to take on a design challenge based on a problem that students identify and want to solve within their own school or community. Again, there is a focus on completing a single design challenge rather than integration into curriculum throughout the school year. "The Ten Step Guide to Running a Design Workshop" (UK Design Alliance, n.d.), is a simple design guide produced by The Design Council that also supports teachers with running a single design project.

These organizations encourage teachers to run design projects at a single point within the school year. In order for children to build the competencies of creativity, innovation, problem solving and critical thinking, design thinking should not be taught

as a stand-alone activity but rather as an embedded approach to learning. Further, design integration with curriculum is an important strategy for adoption especially in schools throughout North America where design is not a part of current curriculum.

DELIVERY OF CONTENT

The Cooper-Hewitt, Smithsonian Design Museum (n.d.) hosts a website for Educators (http://dx.cooperhewitt.org/lesson-plans) that includes detailed lesson plans that connect with curricular subjects (see fig.6). The lesson plans can be sorted by subject or grade, ranging from grade K-12, and each lesson plan provides detailed information including how the lesson links to US national standards. Of all of the resources I have come across I find these lesson plans best align design projects with curriculum, however I see opportunities to improve the delivery of this content. The Cooper-Hewitt lesson plans do not include any visuals and are very text heavy. Though rich in content, the quantity of information may actually deter teachers from using the resources. Each lesson plan includes detailed step-by-step instructions, rather than supporting teachers with the development of their own lesson plans.

Unfortunately many resources for teaching design seem to be poorly designed for accessibility; ease of use for teachers is not adequately addressed. There is a huge gap between the content developed for design education and the delivery of that content. The Design Learning Network (http://designlearning.us), Next.CC (http://next.cc), IDESIGN (http://idesignthinking.com) and the K12 Lab Network (http://k12lab.org), are all examples of websites that provide a vast amount of information and knowledge about design-based learning, but which are extremely challenging to navigate.

IDESIGN is a teaching resource developed by Dr. Charles Burnette (2005), a design-based educator at the University of the Arts in Philadelphia. His website provides information about design-based learning but does not include examples of design projects which is a major limiting factor for its use. In contrast to this, Next.cc, a website created by Linda and Mark Keanne contains hundreds of design related activities but the content

Figure 6 has been removed due to copyright restrictions.
The information removed is a screen shot from the website:
http://dx.cooperhewitt.org/lesson-plans/

Figure 7 has been removed due to copyright restrictions.
The information removed is a screen shot from the website:
http://www.next.cc

Fig.6 Cooper Hewitt Lesson Plans for Educators

Fig.7 NEXT.cc homepage

is confusing to navigate and the target audience is not clearly defined (see fig.7). The Design Learning Network (Wells-Papanek, 2010-2014), as mentioned previously, provides information and links to excellent research around design-based learning. Although extensive resources are provided, the website is challenging to navigate and difficult to use. For teachers who are unfamiliar with design and who have not participated in a DLN workshop or symposium, the website may be overwhelming and difficult to engage with.

The Design Thinking for Educators toolkit and (http://designthinkingforeducators.com) website, by IDEO and Riverdale County School (2013), introduces educators to design processes and methods. The website and toolkit are well developed and easy to navigate; however the length of the toolkit may make it overwhelming as a resource for teachers. Additionally, the resources are intended to support teachers with the use of design, but are not specifically intended to support the use of design by students.

Finally, the Stanford d.school has established the K12 Lab Network, which provides a variety of resources including design activity lesson plans for teachers through the K12 Lab Wiki (http://dschool.stanford.edu/groups/k12). Unfortunately, materials on this Wiki are accessed through a variety of individual links rather than a through single cohesive document or web page.

The dissemination of resources is a critical component of increasing the engagement of educators in design-based learning. As designers, in addition to using our skills to produce content about why or how to teach design, we also need to create and deliver resources that are useful for teachers. If teachers are not provided with materials that are accessible and easy to use then there is little hope for the adoption of design into classrooms. This thesis project uses a human-centred design approach to inform the content and delivery method for resources that will be effective for teachers and their ways of working.

3.5 Teacher Education & Resources

DESIGN OF CURRICULAR RESOURCES

In the research paper, "Teaching As Design", produced by The Center for Learning Technologies in Urban Schools (LeTUS) the authors begin their research by asking the question, can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice? (Brown & Edelson, 2003, p.iii). The report begins by acknowledging teaching as a design activity; "Teachers must perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance trade-offs and devise strategies – all in the pursuit of their instructional goals. These are the characteristics of design" (p.1). They suggest that if we view teachers as designers then we can shift our view of curricular resources from "transmitting instruction to transforming it by serving as a catalyst for local customization" (Brown & Edelson, 2003, p.1).

Depending on a teacher's personal resources and knowledge he/she may interact with a curricular resource in a variety of ways including offloading (following the resource directly), adapting or improvising. This is described as the *Design Capacity for Enactment Framework*. Understanding a teacher's pedagogical design capacity (PDC) is important to understanding how they will make use of a curricular resource.

"Rather than designing "one-size-fits all" documents, efforts must be made to make visible the various ways they might be used to accomplish curricular goals."

Brown & Edelson, 2003, p.7

The authors recommend that teachers should be provided with professional development support to help link their instructional goals with curricular resources, with the recognition that different teachers may require different types of resources depending on their knowledge, skills and commitments. They suggest that "rather than designing curriculum materials as "one-size-fits-all" documents, efforts must be made to make visible the various ways they might be used to accomplish curricular goals" (Brown & Edelson, 2003, p.7). Furthermore, curricular resources should be designed to support a variety of uses and should support teachers with customization of the

Figure 8 has been removed due to copyright restrictions. The information removed is a diagram adapted from Brown, M., & Edelson, D. (2003). Teaching As Design. The Center for Learning Technologies in Urban Schools.

Fig.8 Design Capacity for Enactment Framework adapted from Brown and Edelson, 2003.

resource based on their instructional goals and student needs. This research has encouraged me to develop design resources for teachers that support them in developing their own design projects rather than providing them with detailed step-by-step lesson plans.

A similar emphasis on adaptable resources is discussed in the document "Exploring Curriculum Design: Transforming Curriculum and Assessment", produced by the BC Ministry of Education (2013). As part of their current initiative to transform curriculum and assessment across the province they have outlined the following objectives: make curriculum more flexible to better enable teachers to innovate and personalize learning; reduce the prescriptive nature of current curricula; focus new curricula on higher order learning; and make explicit the cross-curricular competencies that support life-long learning.

There is a clear opportunity to develop design-based learning resources that are in alignment with these objectives.

PROFESSIONAL DEVELOPMENT & TEACHER EDUCATION

In addition to the need for quality resources that encourage adaptation and modification, teachers also require education in the area of design-based learning. Currently design-based learning is not an approach taught in University education programs within North America.

"While educators are somewhat divided on how best to achieve reform in teacher education, many agree that in-service workshops are insufficient in creating sustained change in teaching practices"

Davis et al., 1997, p. 96

Several organizations throughout the US currently offer workshops for teachers, such as the Stanford d.school, The Cooper-Hewitt Smithsonian Design Museum and The Henry Ford Learning Institute. However in the book, *Design as a Catalyst for Learning*, the authors identify that existing workshops typically range from one day to summer institutes, but there is limited opportunity for follow-up once teachers return to their classrooms;"while educators are somewhat divided on how best to achieve reform in teacher education, many agree that in-service workshops are insufficient in creating sustained change in teaching practices" (Davis et al., 1997, p. 96).

In his article, "Those Who Understand: Knowledge Growth in Teaching", Shulman (1986) suggests that there are three categories of knowledge that are important for teaching: content knowledge, pedagogical content knowledge and curricular knowledge. Teachers must have strong knowledge of the content they are teaching as well as the ability to explain it and make it comprehensible to others. In the case of design-based learning, most teachers do not have the relevant content knowledge, pedagogic knowledge or curricular knowledge. Shulman also identifies that strategic knowledge is an important element to teaching. "Strategic knowledge comes into play as the teacher confronts particular situations or problems, where principles collide and no simple solution is possible" (Shulman, 1986, p.13). When guiding students through design projects this type of strategic knowledge is highly relevant and critical and teachers can not be taught all of the ways to respond to possible situations. To this point Shulman (1986) suggests that rather than 'training' teachers we should be focusing on how to educate or expand their knowledge; "reinforcement and conditioning guarantee behaviour, and training produces predictable outcomes; knowledge guarantees only freedom, only

the flexibility to judge, to weight alternatives, to reason about both ends and means and then to act while reflecting upon one's actions" (p.13). Shulman suggests the use of case method in teacher education as a way to develop strategic understanding and extend the capacity of teachers' professional judgement and decision-making. With the absence of case literature in design-based learning, longer term professional development or coaching may help teachers to develop this strategic knowledge over time.

The book, *Design as A Catalyst for Learning*, summarizes the research conducted by The OMG Center for Collaborative Learning in 1993 through an engagement with The National Endowment for the Arts. The research included: a review of literature on the use of design within classrooms; a national qualitative survey of teachers currently using design with their students; and site visits to ten schools representing a range in uses of design. Their research identifies that in-service programs encourage change within the first year, but the use of new methods decline dramatically in subsequent years. They suggest, "to truly use design problem solving, these teachers need ongoing professional critique of their assignments and teaching practices as well as assistance in developing new facilitation skills." (p.108). They recommend an immersive approach where educators are provided opportunities to continue their learning following workshops.

According the T*eacher Development and Leadership Research Review*, "when teachers receive well-designed professional development, an average of 49 hours spread over six to 12 months, they can increase student achievement by as much as 21 percentile points" (as cited by Vega, 2013, p.2). Short, one-off workshops on the other hand showed no significant improvement to student learning. New approaches to educating teachers in design-based learning should be considered beyond short-term workshops. There is an opportunity to consider a job-embedded professional development model that supports sustained learning by teachers.

"Immersion creates a more supportive environment and makes change a way of life."

Instructional Coordinator at Willamette Primary school, as cited by Davis et al., 1997, p.97

4. PRIMARY RESEARCH

Fig.9 KGMS student building a design prototype

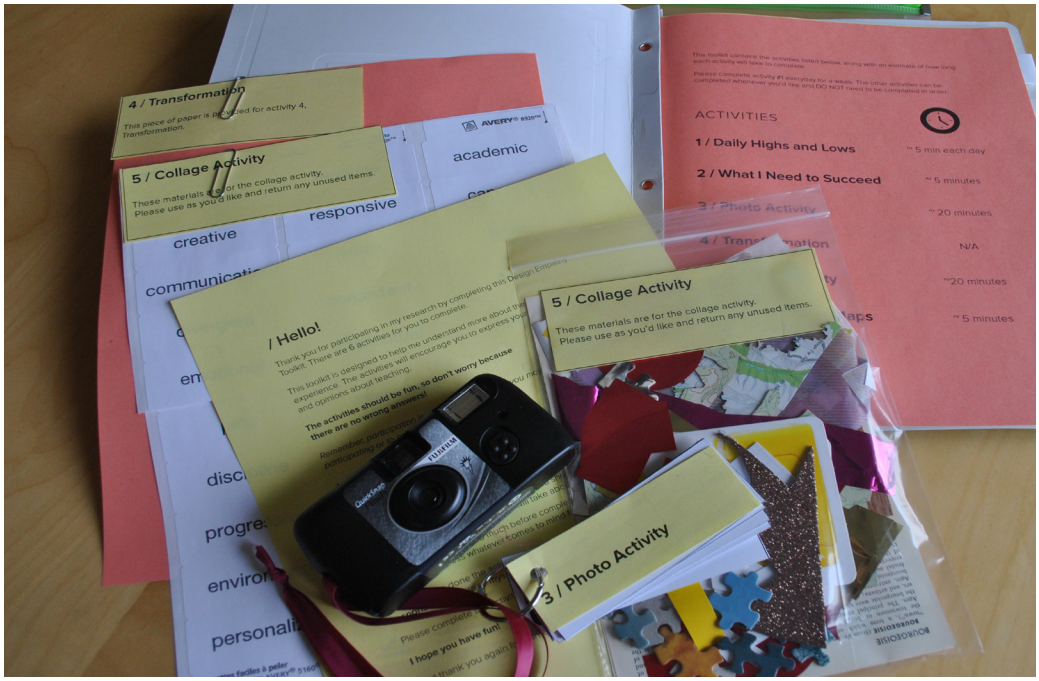


Fig.10 Cultural probe

Fig.11 Teaching design at KGMS

4.1 Research Methodology

From September 2013 until June 2015, I conducted primary research at Kenneth Gordon Maplewood School in eleven classrooms with over 100 students in grades 4-7. My research methodology included a combination of exploratory, generative and evaluative approaches. I used an action research and participatory design approach, which included collaboration with teachers and students at KGMS with a mission of creating change through the design research intervention.

My thesis project is grounded in an action research framework. Action research is unique from other research methodologies in that inherent within it is the idea that new knowledge or research is generated through action, or in this case, through my design practice. Action research "is differentiated from many 'objective' methods of research inquiry that seek only to describe, understand, and explain, in its explicit mission to actually change the community, parties, or policies under study" (Martin & Hanington, 2012, p. 126). Through my thesis project I am looking to create change in the field of education with the introduction of design as a pedagogic approach.

My research methodologies also included participatory design research including a high level of collaboration with teachers through observations, interviews, cultural probes and co-creation workshops.

A two-year collaboration at Kenneth Gordon Maplewood School (KGMS) is a central component of this thesis project. KGMS is a private school for children with learning differences in grades K-11. Students at KGMS have average to superior intelligence but face challenges in the way that they learn (KGMS, n.d.). These students have a wide range of abilities and challenges including: autism, dyslexia, ADHD, and gifted characteristics.

KGMS is referred to as a "school of second choice". It provides an alternative for children with learning differences when public and other private schools are not able to meet their needs.

"Participatory design is a human-centred approach advocating active user and stakeholder engagement throughout all phases of the research and design process, including co-design activities"

Martin & Hanington, 2012, p. 128

In design, we often talk about designing for extremes; in the development of a product/service it is often useful to consider the needs and wants of the most extreme users within a population. In this case, designing for children with learning differences is similar to designing for extremes. At KGMS, the student's abilities vary dramatically from student to student but also from task to task even for the same student. For example, "twice-exceptional" students are those who are gifted but also have learning disabilities (Weinfeld et al., 2013). As a case study, this student population allowed me to consider how design could be taught, and how it could benefit a wide range of students.

A small portion of research for this project was also conducted at Southridge School, a University preparatory day school that is part of the International Baccalaureate Programme. Southridge is academically rigorous with a selective and competitive admission process based on students' academic record, assessment scores, extra-curricular activities and demonstrated character (Lepp, n.d). Southridge generally has very few students with significant learning differences, nonetheless it is important to recognize that as with many other private and public schools it has a segment of their student population who do learn differently.

The school culture at Southridge is significantly different than at KGMS yet both schools had interest in exploring the integration of design thinking into their classrooms. Researching and designing for both of these schools provided an opportunity to recognize the benefits, impact and barriers that may come with the integration of design thinking across different learning environments and school cultures.

While there is the possibility for design education to benefit all children, this thesis project places emphasis on the unique opportunity to consider the role and significant potential that design can play in education for children with learning differences. As such, KGMS served as my primary research site and source of inspiration for this thesis project.

4.1.1 Timeline of Major Research Activities

My work at KGMS throughout the past two years involved working directly with students to teach design, and working with teachers to develop design-based learning resources. The key research activities and insights from these two groups have been summarized in this document in *Section 4.2: Working with Students*, and *Section 4.3: Working with Teachers*.

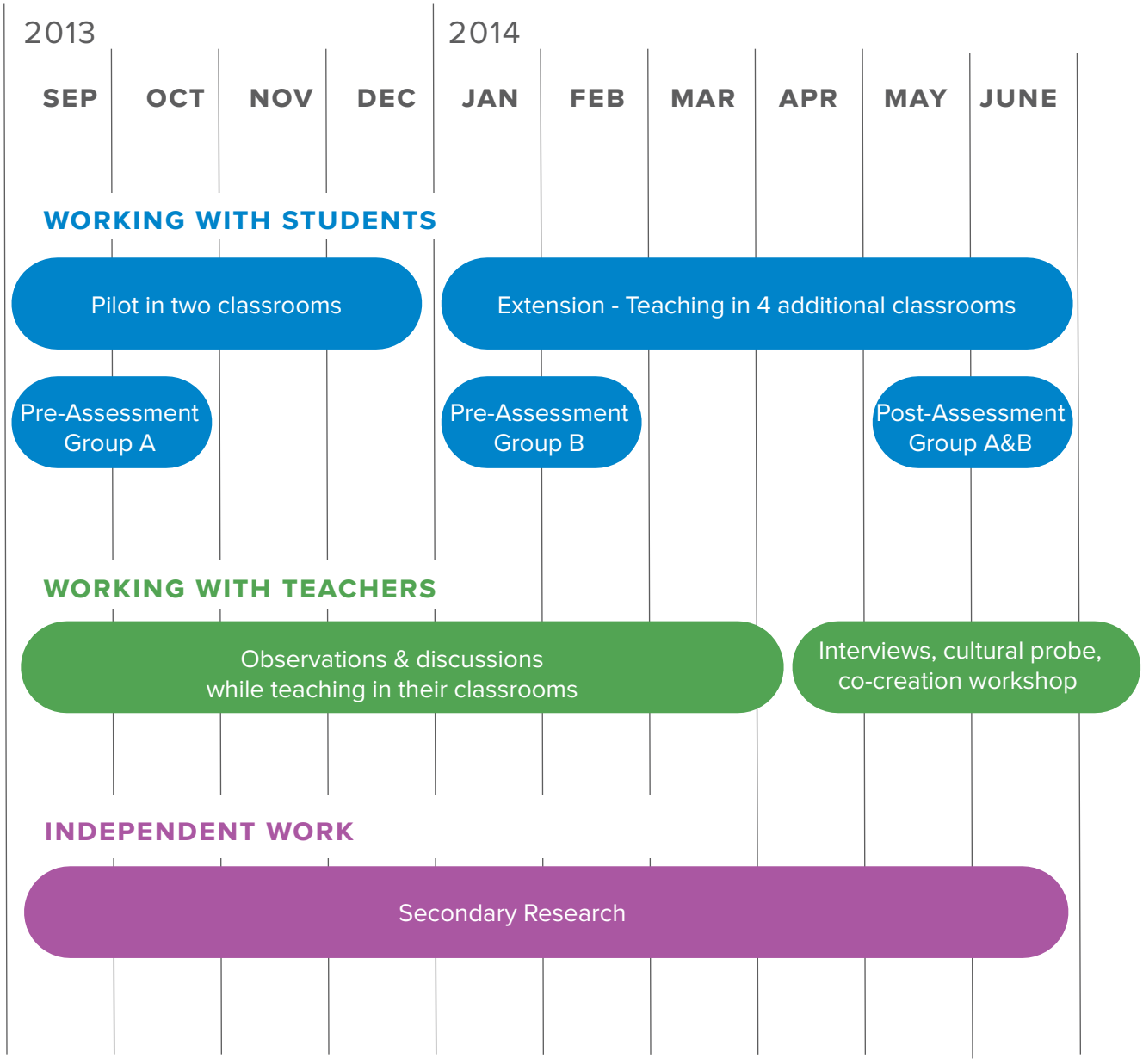
In September 2013 I began teaching design once a week in a grade 5/6 class and a grade 6/7 class at KGMS. By December we were beginning to see positive results of the lessons and we decided to expand the pilot project to four additional grade 4-7 classrooms. From January to June 2014, I worked with six grade 4-7 classes and approximately 100 students at KGMS. During this time I explored ways to introduce design to the students and had weekly discussions about the design-based learning approach with teachers. Students also completed a pre- and post-design assessment, which is described in *Section 4.2.2: Pre- & Post-Design Assessment*.

From April to June 2014, I began conducting more focused research with the teachers to better understand the type of resources and support they would need in order to teach design on their own. This involved interviews, cultural probes and a co-creation workshop.

During July and August I synthesized the research gathered to identify key findings and establish design criteria.

From September 2014-December 2014, rather than teaching in the classrooms at KGMS myself, I met with teachers on a bi-weekly basis to support them with the development and integration of their own design projects as relevant to their curricular and instructional goals. During this time teachers also tested and provided feedback on the resource prototypes. In December 2014, several additional teachers at KGMS joined the T*eaching With Design* group. As new teachers to the design-based learning approach they provided feedback on the resources from a new perspective. User testing and design coaching at KGMS continued from January until April 2015.

Timeline of Major Research Activities



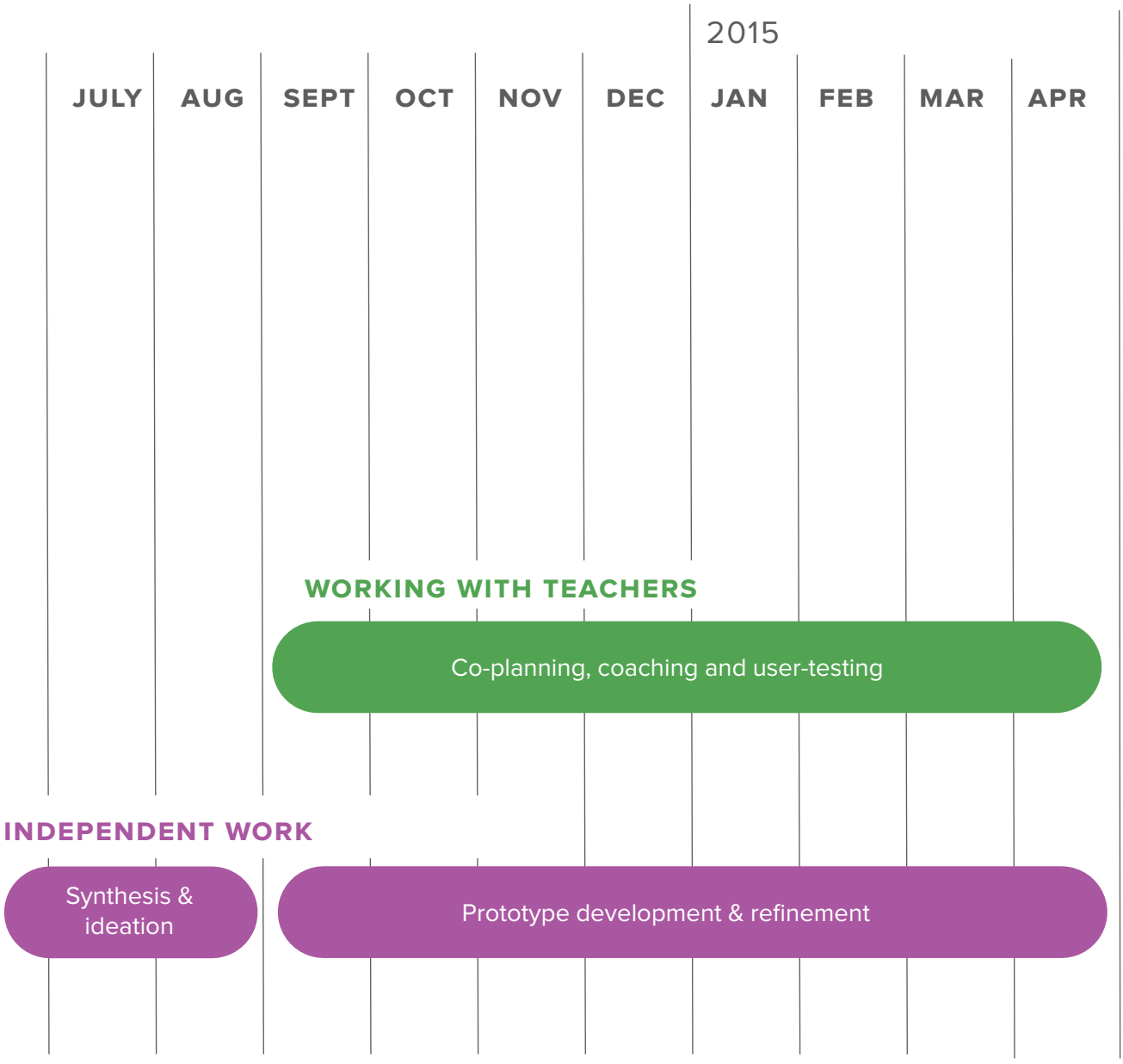


Fig.12 Timeline of major research activities


time machine
Saucer
umbrella
Solar bag
scarecrow
shoes

4.2 Working With Students

4.2.1 Teaching Design in the Classroom

In September 2013 I began working as a Designer in Residence at KGMS. The initial goal of the project was to introduce design to students to boost their confidence in their creative abilities and to provide opportunities for them to demonstrate their knowledge in new ways. “Because they think differently they’ve been pushed under the pack. At KGMS we try to provide them with a new start. We want to boost their confidence and give them opportunities to show they are capable” (Adam Lewis, personal communication, October 3, 2013).

Initial lessons introduced students to basic design skills such as brainstorming, drawing and making. These lessons emphasized that in design there is no right or wrong answer, but rather multiple possible solutions. Students were encouraged to experiment, to share ideas, and to be creative. They designed tin can robots, brainstormed 100 new uses for CDs, created upside-down drawings, and imagined playgrounds for the future.

Design Rules

Don’t doubt yourself.
Explore lots of ideas.
Solve problems creatively.
Improve constantly.
Good designers share.
No wrong answers.

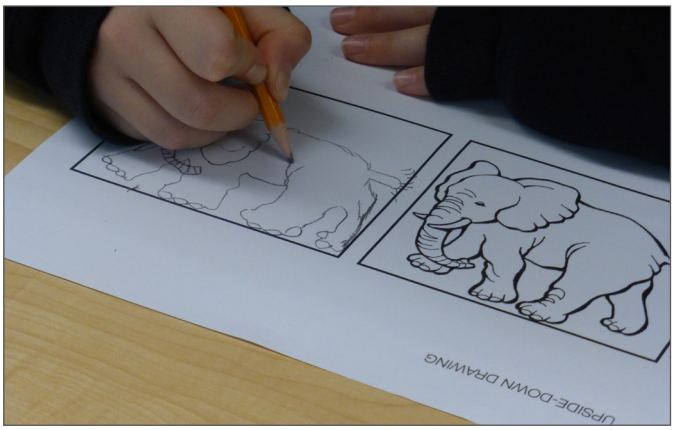


Fig.14 Design rules

Fig.15 Upside-down drawing

Fig.13 Group brainstorm

After initial introductory lessons and observations of social studies and science lessons in these classrooms, it was evident that there was an opportunity to introduce design projects to support the learning of curricular content being taught.

"If these three animals were in one egg, it would evolve like this..."

Grade 5 student

The first curricular design project that I taught in a grade 5/6 class and a grade 6/7 class was linked to their current science unit, where they were learning about animals. In this Unit students were learning about where animals live, what they eat, and how they survive. For our design project I asked each student to pull three photos of animal features from a hat. The students were then asked to combine these features to create a new animal (see figure 16). They were first asked to come up with at least 3 ideas of what their animal might look like, then they had to build a model of their animal using salt dough (see figure 17 & 18). Finally they were asked to consider how their hybrid animal would live and survive given its physical characteristics. The students had to apply their current knowledge of the individual animals to the design of a habitat that would support the hybrid animal. In doing this, students had to make a connection between their design and the science curriculum. In addition to science, further curricular connections could be made. For example, students could write stories about their animals to meet prescribed learning outcomes for Language Arts, or students could draw their animal's habitat to scale using their math skills of scale and measurement. In this way a single-design project can achieve curricular objectives in science, language arts, math and fine arts.

Over the past two years at KGMS we led a variety of such design projects with students. Students designed sustainable homes to demonstrate their understanding of renewable energy resources; they designed outfits to represent their families' heritage after learning about traditional aboriginal dress; they designed imaginary worlds and considered the impact of colonization and exploration; they looked at the evolution of everyday objects from ancient civilizations and redesigned them for the future. Over 35 different design projects were completed at KGMS during this time.

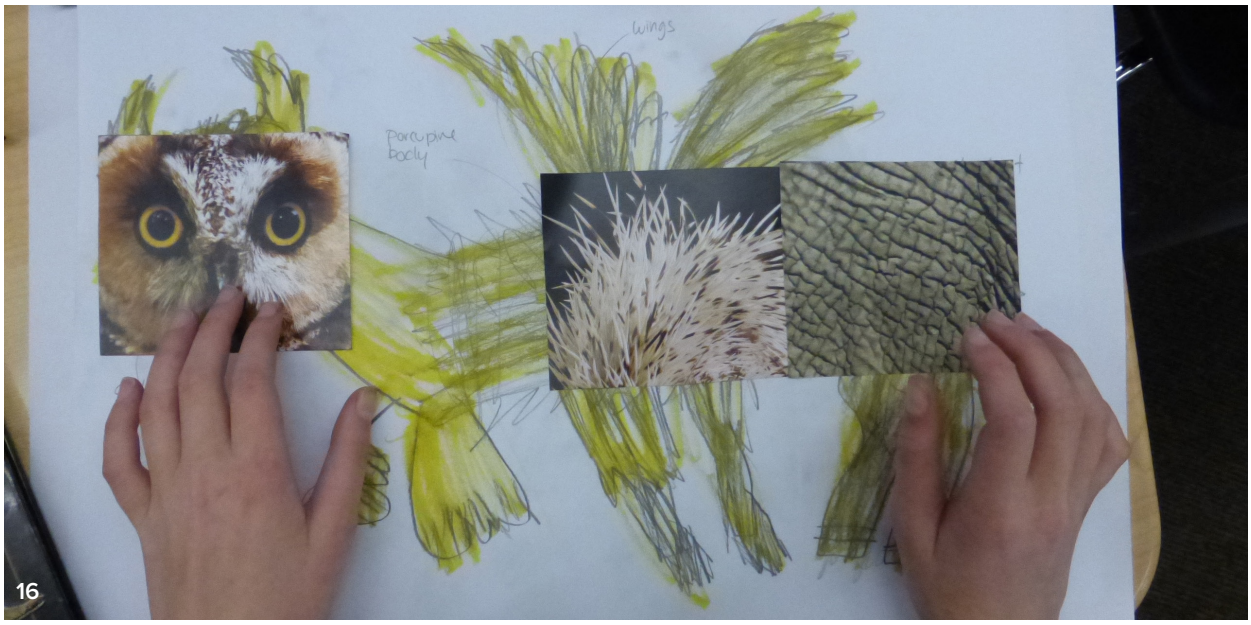


Fig.16 Hybrid animal sketch

Fig.17, 18 Hybrid animal models from salt dough

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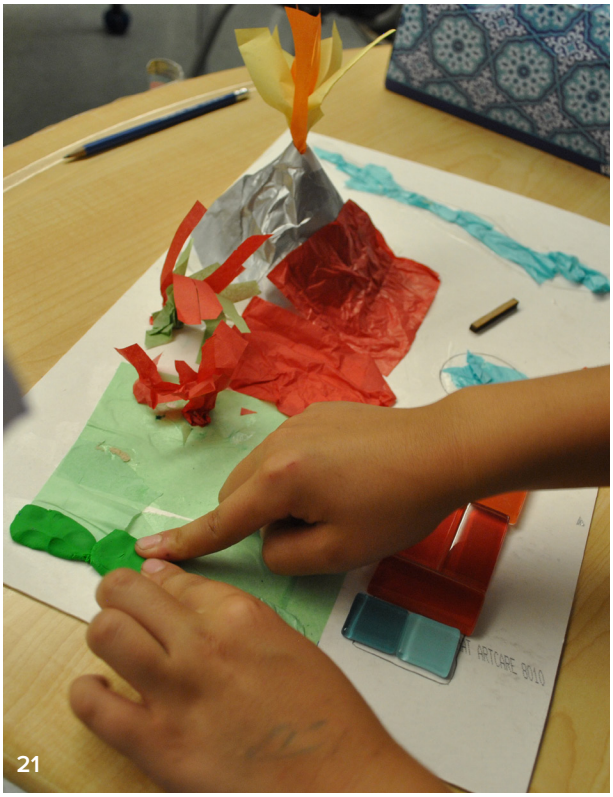
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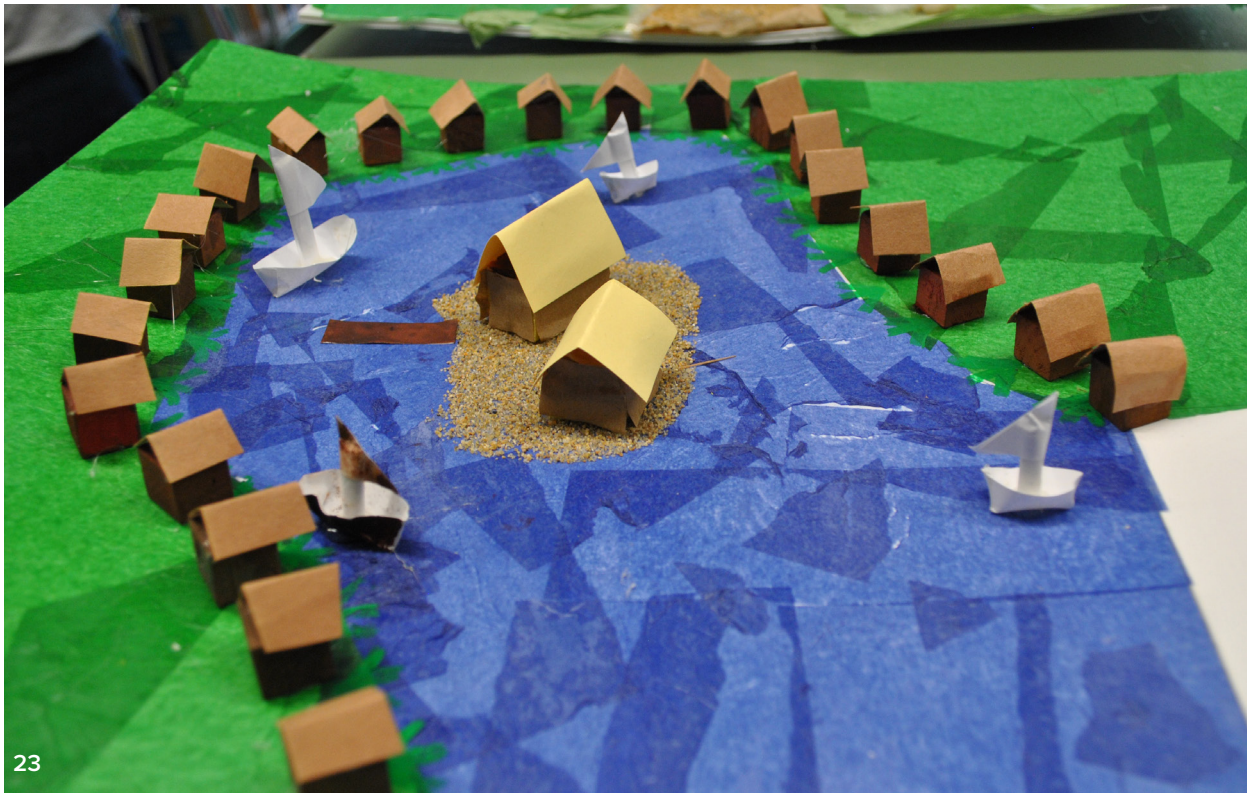


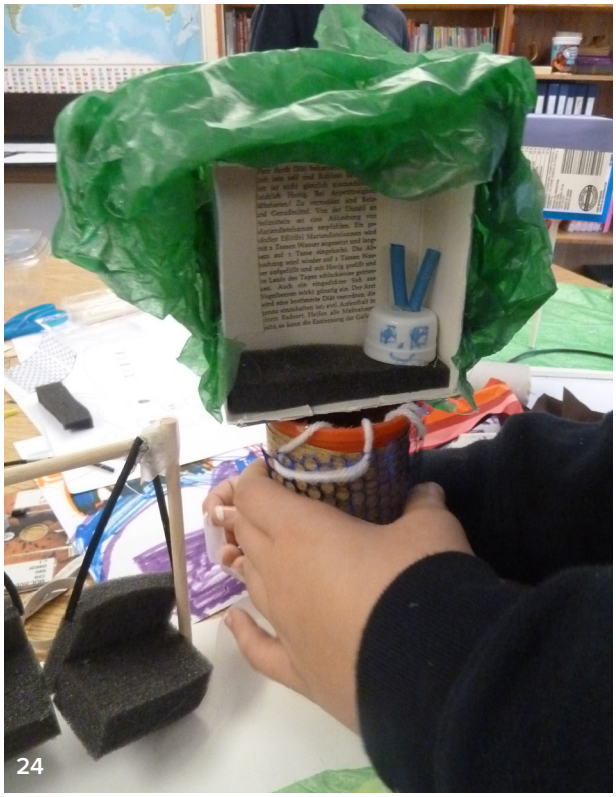


Fig.19 Sustainable home designed by grade 5/6 students

Fig.20 Grade 5 student sketching with chalk

Fig.21 Grade 4 student designing an imaginary world for future exploration

Fig.22 Grade 6 student designing clothing to represent his family's culture and traditions

Fig.23 Design of a 'new' ancient civilization by a grade 7 student

Fig.24 Grade 7 student designing a treehouse playground

4.2.2 Pre- and Post-Design Assessment

In October 2013, Doris Wells-Papanek, MEd, the Director and Founder of the Design Learning Network, and Dr. Robert K. Greenleaf, the President of Greenleaf learning, co-developed an assessment tool to evaluate students' learning progress in the area of spatial orientation and visualization skills at KGMS. The students in the six classes that I worked with took the pre-assessment before learning design, and a post-assessment following several months of design lessons and projects. The objective of the assessment was to give us a sense of each student's spatial orientation and visualization skills and to identify if there was any measurable improvement in these skills as a result of the design lessons.

WHY ASSESS SPATIAL ORIENTATION AND VISUALIZATION?

The ability to visualize and make sense of space in our minds is a critical skill in design, as well as in many other disciplines and subjects. Betty Garner (2007), in her book, *Getting To Got It* describes visualization as the ability to mentally represent and manipulate information, ideas, feelings and sensory experiences. Spatial orientation is the ability to identify and compare where objects and places are in relationship to each other and to oneself. She explains that these are essential skills for comprehension, planning, behaviour control, computations, motivation etc. The pre- and post-assessment were developed based on Betty Garner's body of work.

ASSESSMENT INSTRUCTIONS

The pre- and post-assessment were identical and included two central activities. The first activity asked students to draw a floor plan of their classroom. The floor plans were evaluated based on their accuracy, level of detail identified, attention to scale and understanding of perspective. This activity was intended to test students' ability to visualize space in their minds and to communicate that understanding through drawing.

The second part of the assessment asked students to look at four individual images (images are shown in figure 25). Students received a point for each answer they wrote in response to the question, "What do you notice about this image? Identify as many things as you can". Students were then asked to identify similarities between a set of two images.

Students were given a point for each response, and an additional point for each response that went beyond a comparison of physical attributes. For example, when comparing the box image (#3) to the highway image (#4), students were given one point if they said they both had square shapes. However, if students identified that items in both images were man-made, two points were given because this response showed that the students could connect the images to their personal experiences and knowledge. The purpose of this activity was to assess the students' ability to make sense of what they saw, to think divergently and to make connections.

The pre- and post-assessment was completed by 86 students in six classes at KGMS. The assessment was administered by KGMS tutors. In some cases the tutors scribed the student responses for the image comparison activity to ensure that students were not deterred by the written component of the activity.

These classes at KGMS referred to as divisions. Below is an explanation of the grade levels within each division:

Division 3 - grade 4
Division 4 - grade 4/5
Division 5 - grade 5/6
Division 6 - grade 5/6
Division 7 - grade 6/7
Division 9 - grade 7

Figure 25a has been removed due to copyright restrictions. The information removed is a photo of a tree. Source: Leslie. (2009). Snips and Snails and Puppy Dog Tails: Autumn's Arboreally Cool Falling Leaves. Retrieved from http://www.snipsandsnailsandpuppydogtails.com/2009/11/autumns-arboreal-leaves.html

Figure 25b has been removed due to copyright restrictions. The information removed is a photo of Otty Lake. Source: Norm Hull. (n.d.). Otty Lake Management Plan. Retrieved from http://www.dnetownship.ca/content/otty-lake-management-plan

Figure 25c has been removed due to copyright restrictions. The information removed is a photo of boxes. Source: Pile of boxes. (n.d.). Retrieved from http://pixgood.com/pile-of-boxes.html

Figure 25d has been removed due to copyright restrictions. The information removed is a photo of a highway. Source: Ramanathan Kathiresan. (2008). Airborne View of US Highway System in Seattle City. Retrieved from https://www.flickr.com/photos/rampix/2983350797/

Fig.25 The image comparison activity involved these four images.

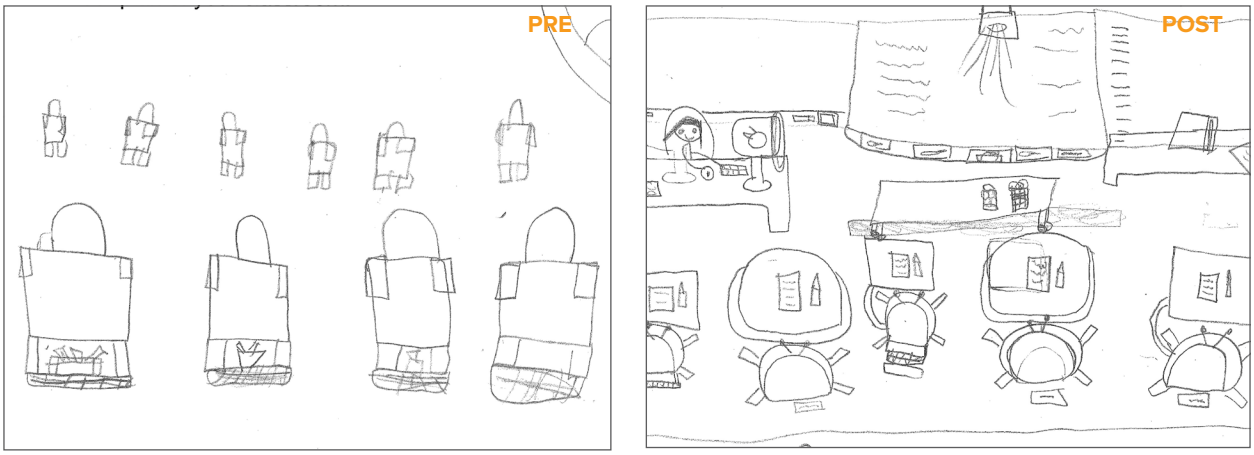


Fig.26 Pre- and post-assessment results from a student who participated in four months of design lessons. Significant improvement was shown in the floor plan activity, as demonstrated by the level of accuracy and detail.

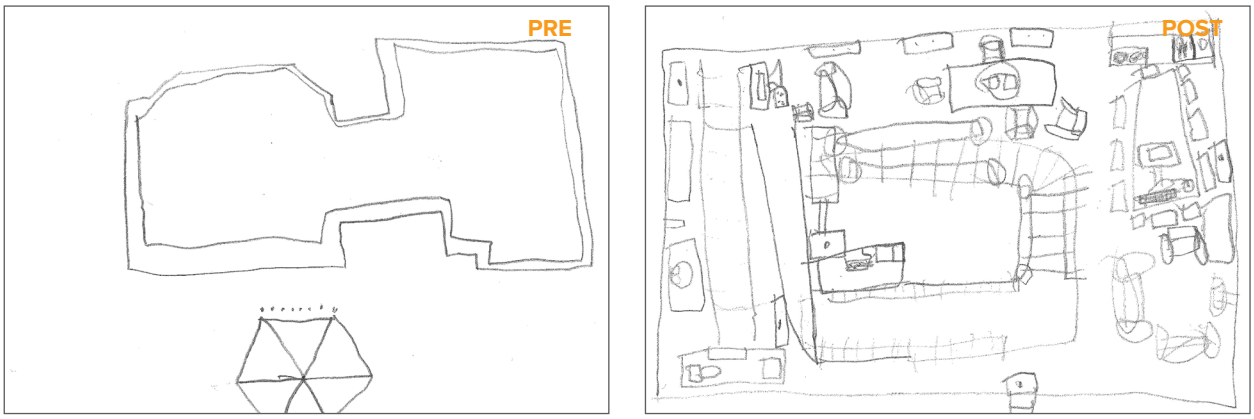


Fig.27 Pre- and post-assessment results from a student who participated in seven months of design lessons. Significant improvement was shown in the floor plan activity, as demonstrated by the level of accuracy and detail.

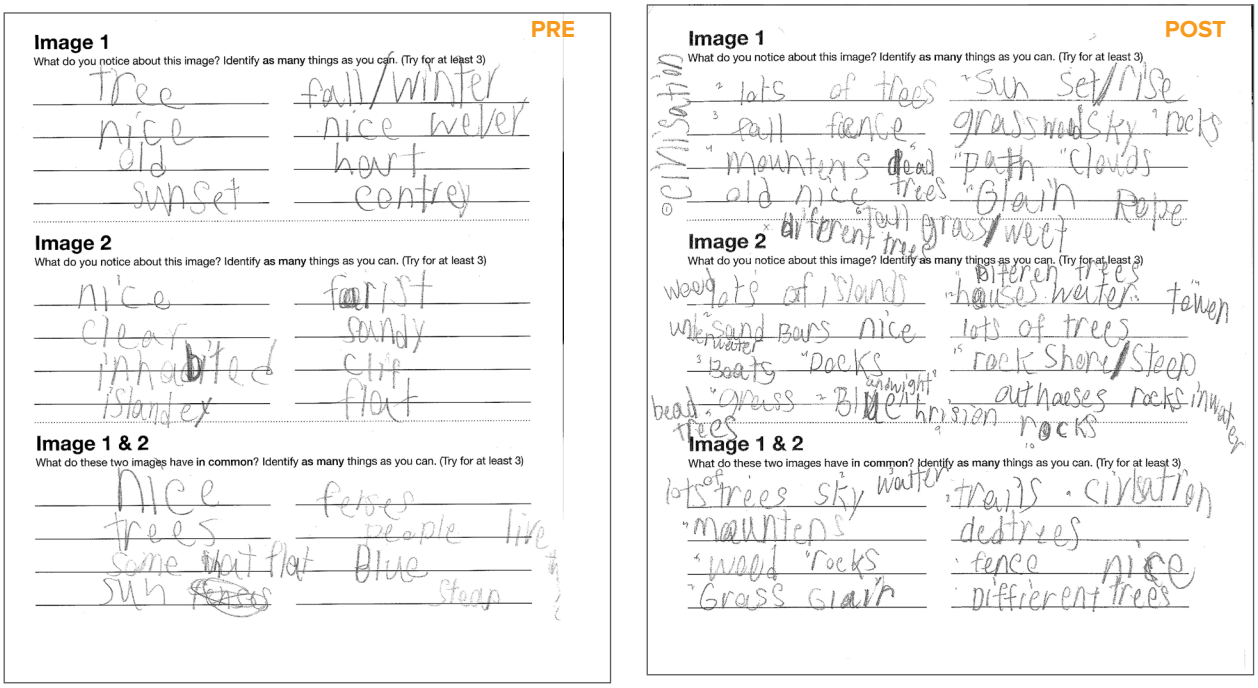


Fig.28 Pre- and post-assessment results from a student who participated in four months of design lessons. Significant improvement was shown in the quantity of responses generated when comparing the tree to lake.

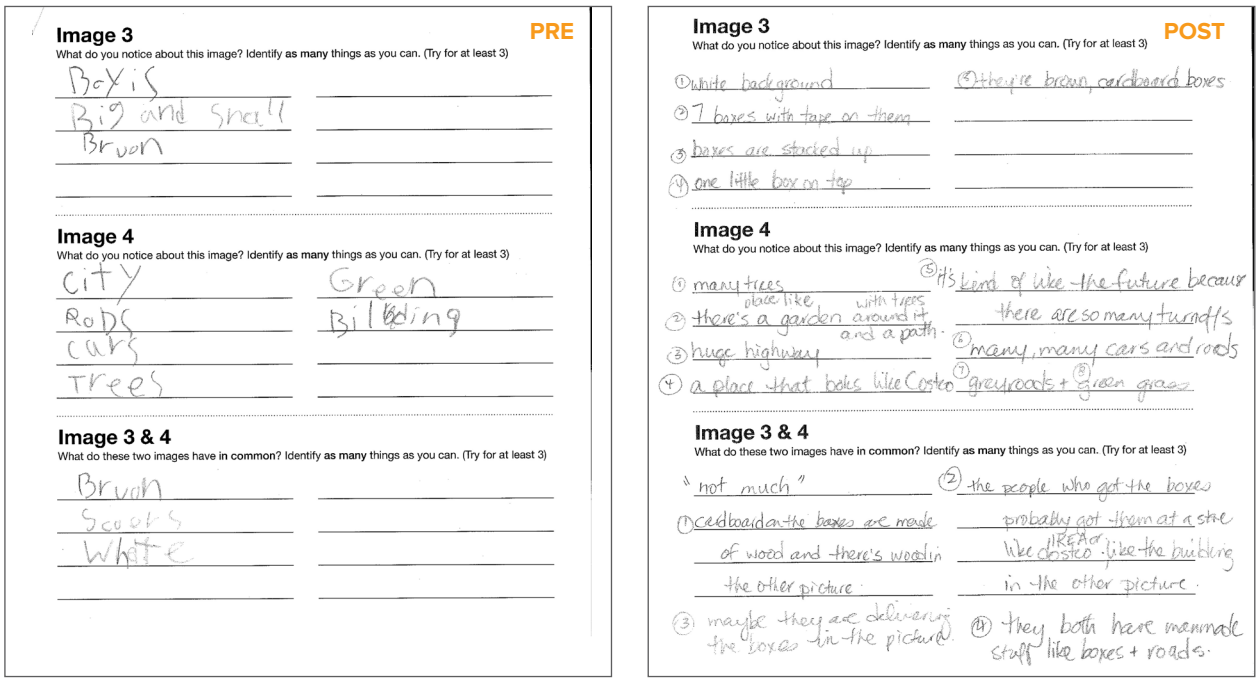


Fig. 29 Pre- and post-assessment results from a student who participated in four months of design lessons. Significant improvement was shown in the quality of responses generated when comparing the box to highway.

Virginia Tze, a school psychologist with a PhD in School and Clinical Child Psychology, provided consultative support for the development of the measurement tool and scoring of the assessment. After the first round of testing with Divisions 6 and 7, the assessment tool was modified slightly based on her suggestions. Students in Division 3, 4, 5 and 9 were administered the updated version of the assessment. Because of the changes to the assessment tool we cannot directly compare results across all six divisions.

Tze also conducted the statistical analyses of the pre- and post-assessment results. A detailed description of the assessment and results can be found in the Appendix on page 120.

RESULTS: PRE- AND POST-ASSESSMENT COMPARISON

"Maybe that tree was this highway before they put in all the highways and stuff."

Student comparing the tree image to the highway image

Results from the pre- and post-assessments showed that design-based learning had a significant impact on these students' spatial visualization and spatial orientation skills. In the floor plan activity students showed improvement in their level of detail and accuracy when drawing their classrooms. In the image comparison we saw an improvement in the quantity of responses that students provided as well as in the quality of the responses provided.

"People make businesses out of both (farm and stores)"

Student comparing the tree image to the highway image

Tze's analysis showed that in the floor plan activity, Divisions 6 and 7 showed statistically significant improvement in their scores, and growth at a similar rate, after seven months of design lessons. Students in Divisions 3, 4, 5 and 9 took the post-assessment after only four months of design lessons. In this case, Division 5, the lowest scoring class in the pre-assessment, was the only class to show significant improvement.

In the image comparison activity the analysis showed a statistically significant improvement in Divisions 6 and 7, and growth at a similar late, over a seven month period of learning design. A significant improvement was also shown by Divisions 4 and 5, after only four months of design lessons. In Divisions 3 and 9 there was no overall improvement in the image comparison activity.

RESULTS: COMPARISON BETWEEN DIVISIONS

When comparing scores between classes, research findings showed a wide variance of scores in the floor plan activity between the class scores. However, in the image comparison activity there was no significant difference between the average score in each class. Wells-Papanek (Personal Communication, 2013) explained that the ability for students to score similarly in the image comparison activity, despite the significance difference in floor plan scores, demonstrates that students with weak functional mapping skills were still able to show flexibility with their imagination (the ability to consider many alternatives).

"How am I going to find three things that are similar? I can't even find one!"

Student comment while working on the image comparison activity

Students in Division 7 at KGMS are cognitively weaker than the students in Division 6 based on their Psycho-Educational Assessments (a psychological test to analyze a child's mental processes that underlie his or her educational performance (CounsellingBC, 2000)). In the floor plan activity it was therefore not surprising to see that Division 6 was much stronger overall than Division 7, however it was surprising that in the image comparison activity both divisions scored within the same range. This was of particular interest to the administration at KGMS, who hope these visual spatial assessments may help to indicate that even though students may be academically or cognitively weak, they can still be successful in other skills and ways of thinking. These finding were also true for division 3, 4, 5 and 9 in the pre-assessment, where the research showed a significant difference in the scores for the floor plan activity, but no significant difference in scores for the image comparison activity. In the post-assessment there was no significant difference between the scores in Division 3, 4, 5 and 9 in either activity. These initial findings present an opportunity for further research.

"Trees have trunks kind of like the concrete posts holding up the ramps"

Student comparing the tree image to the highway image

4.2.3 Benefits of Design-Based Learning at Kenneth Gordon Maplewood School

"As a teacher we are always on the look out for anything that can really get the kids thinking outside the box and really bring their energy and enthusiasm for learning right to the forefront. As a learning tool it was absolutely astonishing. "

Neil Pinkerton, KGMS Teacher

In order to identify further benefits of design-based learning at KGMS qualitative research was conducted through observations of design lessons in six classrooms. Additionally, discussions with teachers about the impact of the design-based learning approach occurred weekly, including three sets of formal interviews. Students were asked to complete a questionnaire to provide their feedback about the design lessons and projects they participated within. Parents also completed questionnaires in order to identify if the design lessons were having an impact on students outside of the school environment.

The information gathered through the observations, discussions, interviews and questionnaires was synthesized through affinity diagramming; a process of using post-it notes to externalize and meaningfully cluster observations and insights to form research-based themes (Martin & Hanington , 2012). This allowed for triangulation of research from teachers, students, parents and secondary sources. Many of the benefits that were identified by teachers at KGMS were corroborated by literature on the topic of design-based education. Through the analysis and synthesis of the research ten key benefits of design-based learning were identified. The following summary of benefits emphasizes those that had the most impact for children with learning differences at KGMS.

Design-Based Learning:

1. Provides opportunities for students to apply their knowledge
2. Supports multidisciplinary learning
3. Allows students to demonstrate their abilities in new ways
4. Is flexible for a wide range of students and abilities
5. Increases student engagement
6. Is student centred
7. Provides a balance of freedom and structure
8. Encourage collaboration
9. Fosters creativity & divergent thinking
10. Builds student confidence

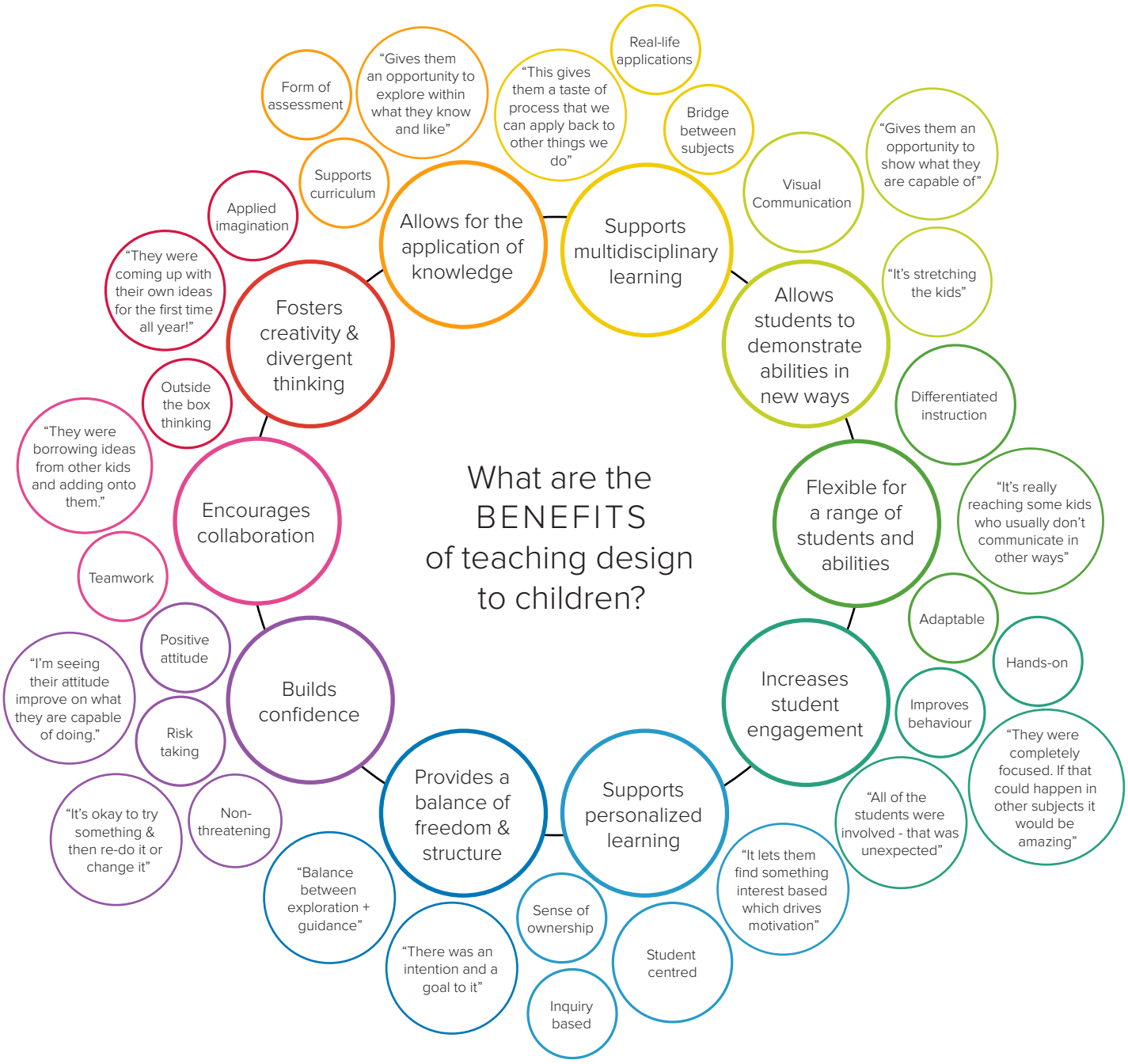


Fig.30 Benefits of design-based learning identified by research at KGMS

"Design has offered to the kids a way to apply the skills that they have been learning in social studies or science to real world problems, and come up with new ways of thinking as well."

Colleen Blackwell, KGMS teacher

1. Provides opportunities for students to apply their knowledge

The teachers at KGMS identified that the design projects were extremely effective when linked to curricular topics as they provided opportunities for students to apply their content knowledge from the subject in creative ways. For example, when students were learning about energy and renewable resources, we ran a summative design project that asked students to apply what they had learned to the design of a sustainable home (see figure 31). One teacher explains, "we started off looking at green energy and the goal was, can we create a functional living space that uses only green energy to power it? Once the kids were given all of the knowledge they needed, they then essentially applied their knowledge in a project...it was interesting the way the kids were showing me their learning and their knowledge; it was way outside of the box"(Adam Lewis, personal communication, June 25, 2014).

The teachers also found that design projects linked to curriculum were an effective form of assessment, as design asks students not to copy or replicate what they've been taught but rather it asks them to apply what they've learnt towards thinking about what could be.

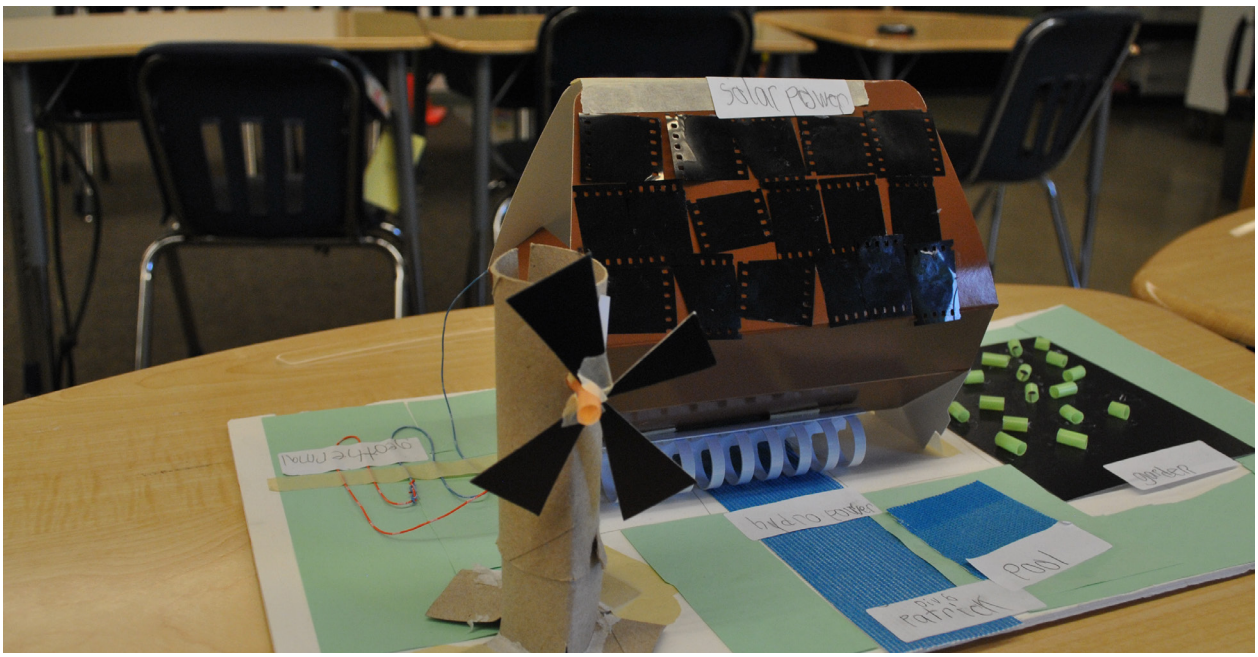


Fig.31 Eco-friendly home designed by grade 5/6 students

2. Supports multidisciplinary learning

Design projects that link to curriculum can also support multidisciplinary learning as they allow students to integrate and apply their knowledge from multiple areas into a single project. For example, when students in a grade 4 class at Kenneth Gordon were learning about Canadian geography, they were asked to design their own countries that included at least three different types of regions that they had been learning about (social studies curriculum). The students were then asked to give a weather report about their country based on what would make sense for their regions and climate (science curriculum). In this way the project allowed students to make a connection between weather and geography. Students were also asked to complete a writing assignment about their country, (Language Arts).

"Perhaps the most striking characteristic of the use of design activities in schools is the ability to integrate knowledge across the boundaries of traditional school subject"

Davis et al., 1997, p.52

3. Allows students to demonstrate their abilities in new ways

The design projects provided opportunities for students to demonstrate their knowledge through means beyond written and verbal communication. By encouraging visual communication such as drawing and building, the teachers at KGMS noticed an unexpected output and capacity from many students. "It's really reaching some kids who usually don't communicate in other ways" (John Rodgers, personal communication, November 29, 2013). Design-based learning provided opportunities for students with a tendency to think divergently to succeed. As opposed to traditional education which encourages a linear form of thinking, design celebrates the natural affinity of these students and helps them understand that they are, in fact, capable.

"They respond to it in much different ways than other assignments. There is no sense that they could fail."

Adam Lewis, KGMS Teacher

4. Flexible for a wide range of students and abilities

"It was a pretty overwhelming response that kids loved [the design lessons]; they were excited"

Adam Lewis, KGMS Teacher

The teachers observed that the design lessons were accessible to varying student abilities and the projects could be easily adjusted for differentiated learning. For students at KGMS who are in the gifted program and have strong creative abilities, the design projects were challenging enough to keep them interested. On the other hand the projects were also approachable enough for students with limited creative thinking and fine motor skills. "All year art has been a struggle for us. I haven't had a single breakdown since [Caylee] has been teaching. Usually a handful of kids are resistant or frustrated over not being able to do it, or there are some students who just aren't interested or engaged" (Colleen Blackwell, personal communication, March 10, 2014).

5. Increases student engagement

An increase in student focus and engagement was another benefit identified by teachers. They observed that students were able to focus for longer periods of time than in traditional classroom activities, even when the design activities involved an academic focus. "They were completely focused. If that could happen in other subjects it would be amazing" (Adam Lewis, personal communication, November 29, 2013). The teachers explained that student engagement is an important factor in developing life-long learners.

6. Student-centred

"You showed me as a teacher, how to incorporate an open-endedness into science curriculum."

Colleen Blackwell, KGMS Teacher

The design projects gave students a more personalized learning experience and a greater sense of ownership. "It let's them find something interest based which drives motivation" (John Rodgers, personal communication, June 20, 2014). Teachers provide students with the design challenge but students drive the solution. "It seems to follow the whole idea of inquisitive learning. Its great for them to come up with their own ideas and see it through to an end result." (Johanna Frank, personal communication, June 9, 2014).

7. Provides a balance of freedom and structure

The design process provides a framework that guides students, while allowing them to explore within the constraints of the challenge. When teachers at KGMS were asked how the design

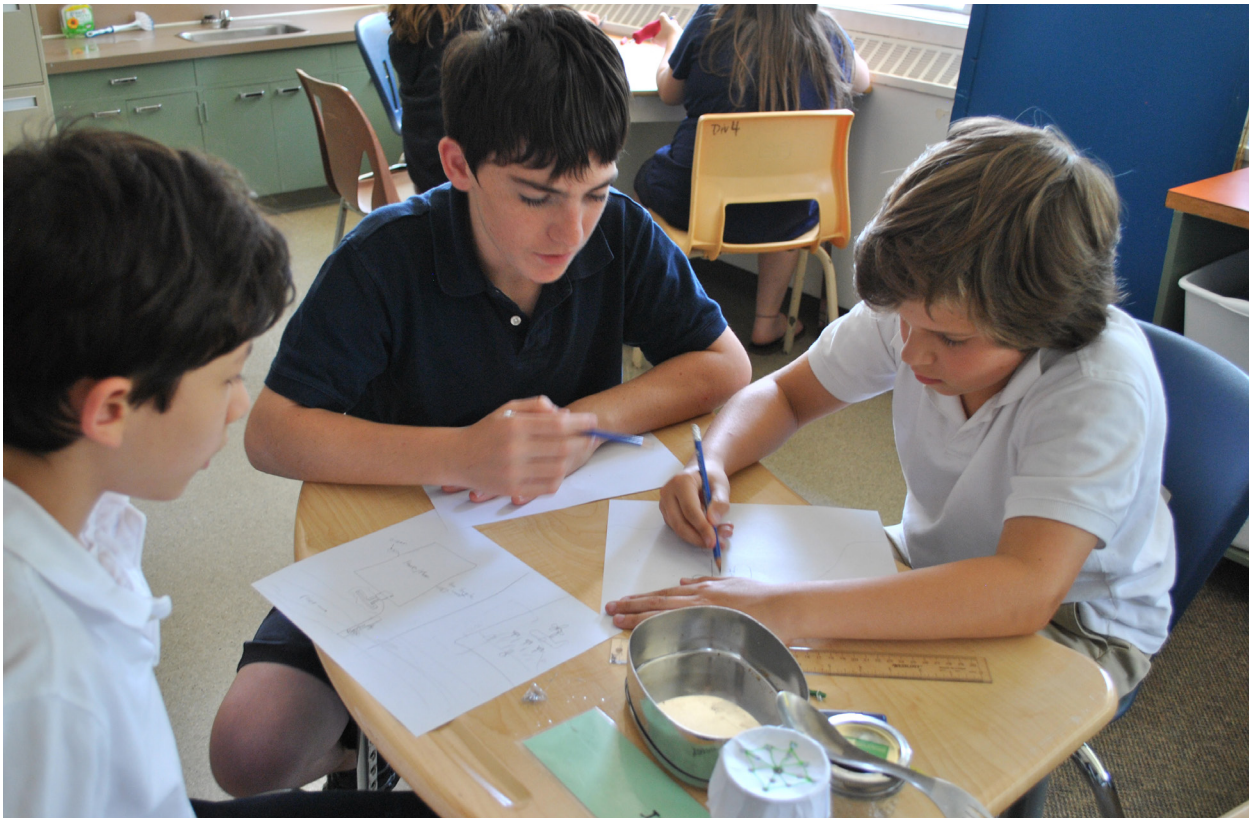


Fig.32 Students working on design project

lesson were different from the way that they typically teach many of them expressed that when they had tried to do 'free-form' or opened-ended activities in the past they were less successful. The design projects however allowed for exploration within a clear set of guidelines so that students still felt supported.

8. Encourages Collaboration

In addition to encouraging personalized and student centred learning, the design projects fostered a collaborative learning environment. Students were taught that design is a collaborative process and they were encouraged to share ideas to generate solutions. This was in contrast to the beginning of the school-year when students were very possessive of their ideas and concerned about copying. "...By the end of the year kids were essentially borrowing ideas from other kids and adding onto them, and telling each other, 'I did this, you should also try this.' 'Oh that's a great idea, what if we also added this?'" (Adam Lewis, personal communication, June 25, 2014). The sharing

"They really didn't know how to build some of these things and so it became a sort of co-creative process with each other. "

Neil Pinkerton, KGMS Teacher

of ideas allowed for a lot of rich discussions to occur among students. Even when students were working on individual projects they were sharing ideas and learning from each other.

9. Fosters creativity and divergent thinking

"The kids who generally would not give an idea, who you never hear speak in class, were coming up with their own ideas for the first time all year."

Johanna Frank, KGMS Teacher

Through design projects students are encouraged to think divergently, to explore multiple ideas and to generate creative solutions. Teachers observed that the design lessons gave students who were naturally creative the permission to think in ways that were natural to them. "It really fit with who they are" (Neil Pinkerton, personal communication, June 9, 2014). On the other hand, for students who typically did not show a lot of creativity, the teachers noticed a significant improvement in their ability to generate ideas for themselves.

In the pre- and post-design assessment, as well as in group brainstorming activities, we saw an improvement in students' abilities to generate multiple solutions. We observed an emergence of non-dualistic thinking, and the acceptance that there can be more than one possible solution. One teacher at explained, "I had some kids in my class earlier in the year who were quite rigid, quite black and white…I saw such a switch in the way that they saw things. They were able to see that they could use their creativity, and they could use their imagination and it's okay – it was encouraged!"(Colleen Blackwell, personal communication, June 25, 2014).

10. Builds student confidence

"It was a very good confidence booster and really beneficial for them to see that their success was not based on their proficiency of doing something. It was based on how they could explore a problem."

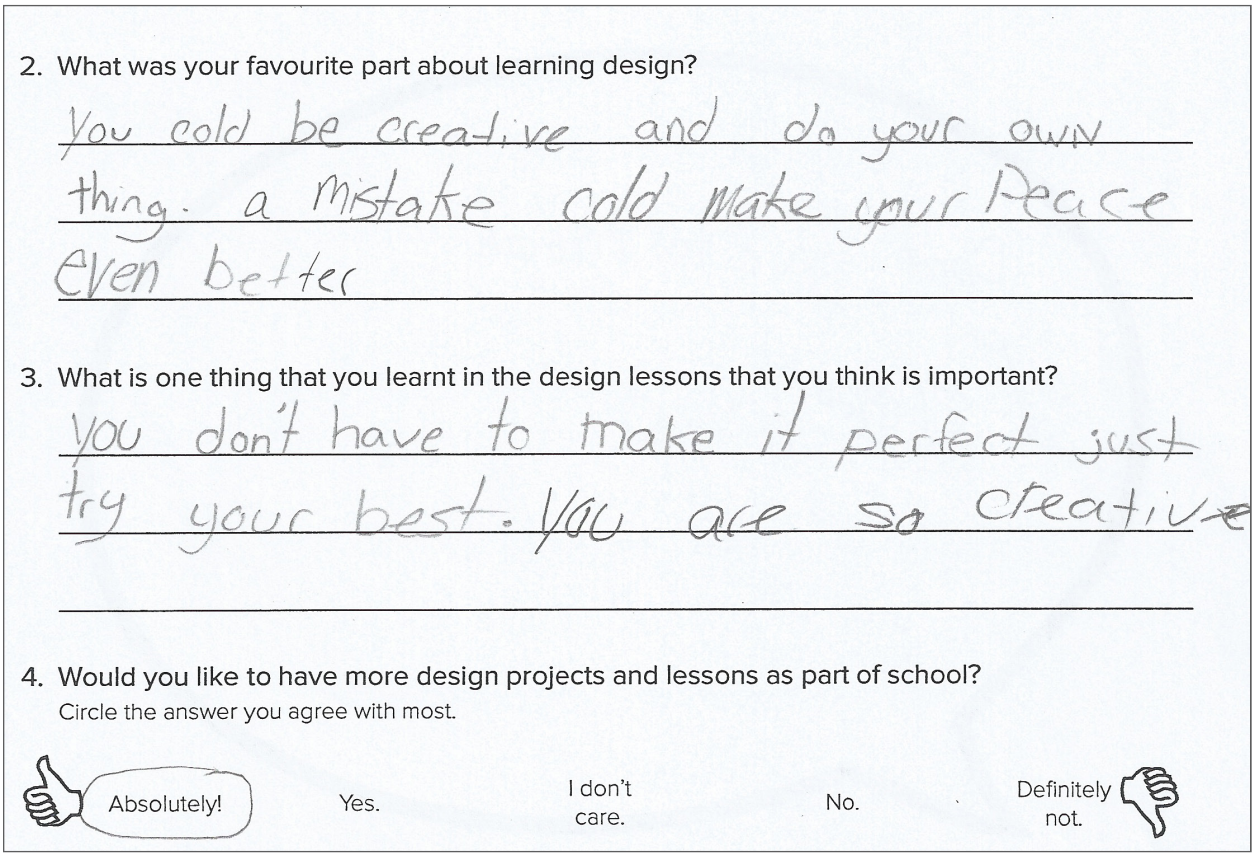
Neil Pinkerton, KGMS teacher

As the design lessons emphasized that there was no wrong answer and lots of possible solutions, we began to see the students' confidence grow. The design projects allowed students to comfortably take risks and to push themselves. "It's brought out their creativity that they've always had but have felt they can't explore in a typical classroom because they're not willing to take that risk to make a mistake. And here that ability to make a mistake is really just completely mitigated by the fact that you're supposed to; its part of the entire process" (Neil Pinkerton, personal communication, January 19, 2015). In the student's feedback forms it was clear that this emphasis was really important to them, for example one student said, "A mistake could make your piece even better!".

Another student explained, "You don't have to make it perfect, just try your best, you are so creative". Through the design activities at KGMS we observed that students felt a strong sense of pride in their work and a desire to share what they had created.

"One of the biggest growths I've seen through my students is their confidence. A lot of the time, in this school particularly, you'll see students who struggle to do the higher demand projects and in this case, because there is no 'right answer', you'll see students who would normally struggle, just completely flourishing" (Adam Lewis, personal communication, January 19, 2015).

As the teachers saw success at KGMS with design-based learning, the research focus shifted from working with students to working with teachers.



2. What was your favourite part about learning design?

You cold be creative and do your own thing. a mistake cold make your Peace even better

3. What is one thing that you learnt in the design lessons that you think is important?

you don't have to make it perfect just try your best. You are so creative

4. Would you like to have more design projects and lessons as part of school?
Circle the answer you agree with most.

Absolutely! Yes. I don't care. No. Definitely not.

Fig.33 Student questionnaire


Predict
Visualize
Question
Connect
Infer
Evaluate
Start by selecting a Unit or Theme.
Write down everything you can think of that is taught or covered in that Unit or Theme.
Live Love Teach

4.3 Working With Teachers

4.3.1 Research Activities

Through my early work in classrooms at KGMS it was identified that it would be beneficial to have classroom teachers develop and teach their own design lessons, in order to make deeper connections to curriculum and other classroom activities. Given that most teachers do not have any training in design-based learning and most lack an understanding of design in general, it was evident that design based teaching resources would be necessary.

Initial research to inform the development of teacher resources was gathered through direct classroom observations and frequent discussions with six classroom teachers about design-based learning. My first-hand experiences teaching in these classrooms also significantly informed the development of early prototypes for teacher resources. When I taught in their classrooms I had to develop tools and methods for teaching design, as I couldn't find existing resources that met my needs. Through this experience I gained a deeper understanding for their role as teachers and the challenges that they face in navigating resources. This triggered conversations with teachers about their approach to lesson planning and the types of resources that they find most useful.

In addition to classroom observations and weekly conversations with teachers, my research process included two key activities: a cultural probe and a co-creation workshop.

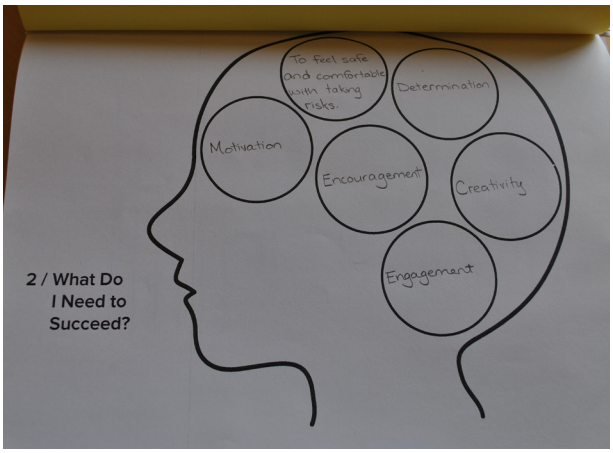
Cultural probe

I developed a cultural probe to learn more about the teaching experience and to gain a deeper understanding of the teachers' needs, desires and values. Cultural probes are "provocative instruments given to participants to inspire new forms of self-understanding and communication about their lives, environments, thoughts and interactions...As an exploratory

Fig.34 Teachers participating in a co-creation workshop

research method, cultural probes are not intended to be formally analyzed, but rather to serve as inspirational pieces identifying key patterns and themes that might emerge from a participant group or culture." (Martin & Hanington, 2012, p. 54). The cultural probe was completed by six teachers at KGMS and included the following six activities:

1. A daily diary where teachers recorded their 'highs' and 'lows'
2. A fill-in-the-blank activity where teachers were asked, "What do students need to succeed?"
3. A photo journal activity where teachers were asked to take photos of 10 things that help them teach.
4. A collage activity where teachers expressed the difference between teaching at KGMS in comparison to a general school.
5. A making activity where teachers were asked to turn a blank piece of paper into something else.
6. A mapping activity where teachers were asked to record what they know about design, and what they would like to know.



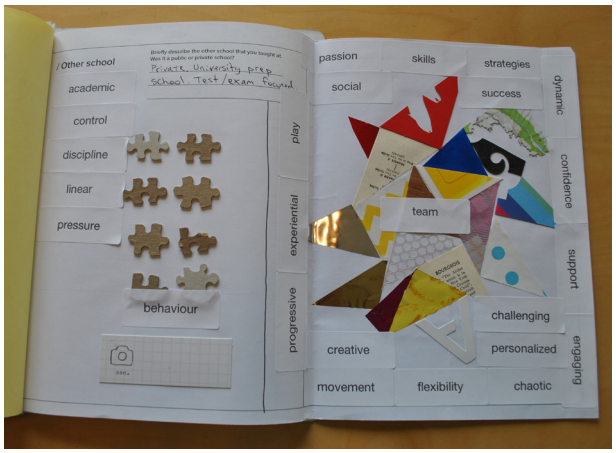


Fig.35 Fill-in-the-blank activity response

Fig.36 Collage activity response

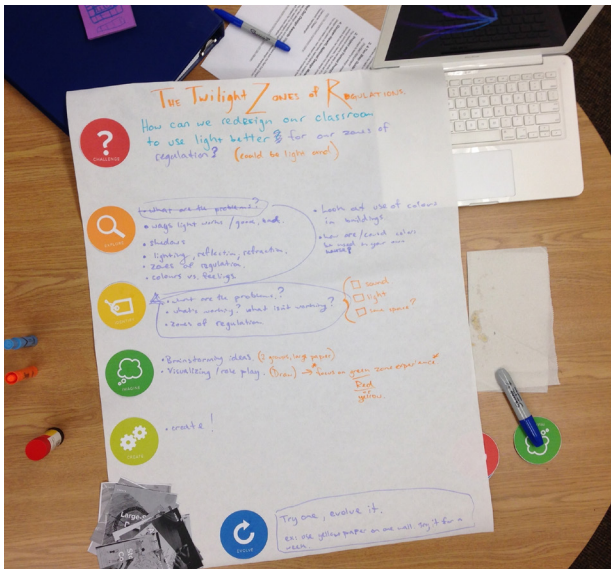
CO-CREATION WORKSHOP

In June, following the last day of school, I led a co-creation workshop with six teachers at KGMS. The goal of the workshop was to gain further insight into the type of support and amount of support that the teachers would need in order to develop and implement their own design projects. The workshop included two activities, which occurred over a three hour time period. In the first workshop activity the teachers split into two groups of three and were asked to come up with a design project that could connect with any grade 4 or grade 6 curricular topic. The objective was to see if the teachers could develop a design project on their own, without help, and to identify areas in the development of a design project where the teachers needed the most support.

The teachers were offered a variety of design resources (produced by other organizations) to use during the session, and a set of cue-cards that I developed which offered short project prompts or ideas (see figure 38).

"Ideas were coming so fast it was hard to almost reign them in!"'

Adam Lewis, KGMS Teacher



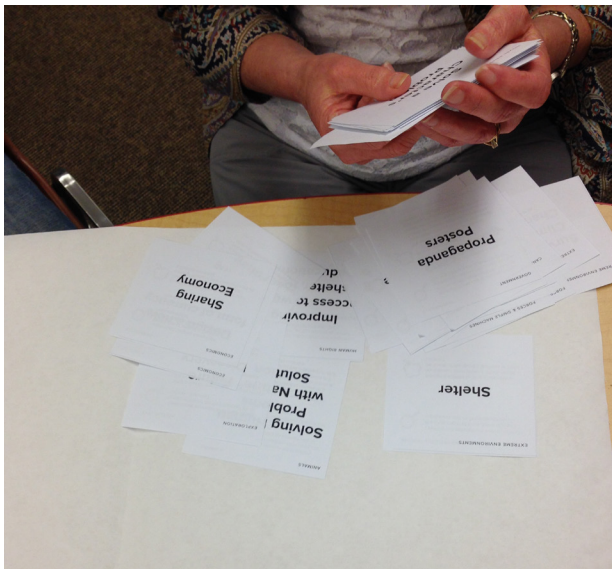


Fig.37 Group A's design lesson plan, "The Twilight Zones of Regulation"

Fig.38 Group B using the cue-cards to help them generate project ideas

"That was the best hour of professional development I've had in 14 years. I walked away with an entire unit that would've taken me days to come up with and wouldn't have been as good."

Johanna Frank, KGMS Teacher

The workshop also included a second activity, where teachers were asked to assign various tasks involved in planning and teaching design projects to either the 'teacher' or the 'designer'. The goal of the activity was to see which tasks the teachers felt most comfortable completing on their own and which tasks they felt they needed help from a designer to complete (see fig. 39). The workshop brought to the surface a lot of key insights into the type of support that teachers need, and led to the development of design criteria explained further in *Section 4.3.2: Design Criteria*.

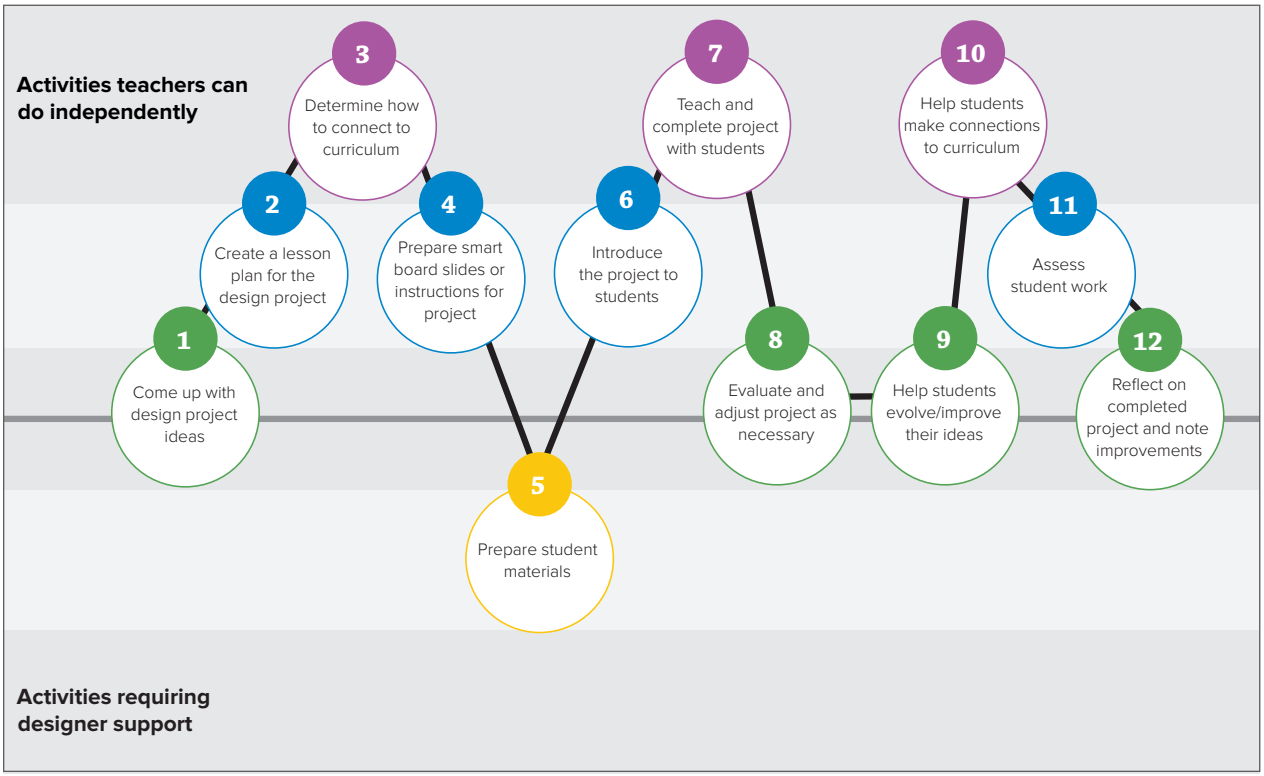


Fig.39 Synthesis of teacher responses from the task delegation activity

4.3.2 Design Criteria

Following the collection of primary research from teachers through discussions, cultural probes and a co-creation workshop, I began the process of synthesizing the data collected. Primary and secondary research from a variety of methods and sources were triangulated using affinity diagrams (see figure 40, 41). This synthesis led to the identification of key findings which informed the development of design criteria for the *Teaching With Design* resource materials, as listed below.

The *Teaching With Design* resource materials should:

1. Promote design projects that connect to curriculum
2. Encourage and support collaboration amongst teachers
3. Allow for the development of design projects that are flexible and adaptable to meet student and teacher needs
4. Provide teachers with prompts and guidance to spark the development of custom design projects
5. Promote the use of design coaches and lead to independent use of design by teachers over time

Fig.40, 41 Triangulation of research to identify key insights

The following is a summary of the key research findings as they relate to the design criteria.

1. CURRICULUM INTEGRATION

"Integration among subjects is seamless in design projects, unlike some learning activities where teachers force connections to meet curriculum mandates for interdisciplinary instruction."

Davis et al., 1997, p.26

The resource materials should promote design projects that connect to curriculum, because the research showed that:

1.1 Curriculum related design projects can enhance student learning of required content

1.2 Referencing curriculum helps teachers to develop strong interdisciplinary design projects.

1.3 Interdisciplinary design projects allow teachers to use their time more effectively by achieving multiple instructional goals.

Curriculum related design projects at KGMS allowed students to demonstrate their understanding of a subject in creative ways, and were an effective form of assessment. When asked to develop their own design projects, the curriculum provided a useful starting point for teachers. When encouraged to connect their design project idea to more than one curricular area or subject, they were easily able to make multiple connections. The planning of design projects may require additional time but teachers can achieve multiple instructional goals through a single project. "It allows me as a teacher to work on multiple domains and multiple areas simultaneously without having to worry about the time crunch, which is something we are facing all the time" (Neil Pinkerton, personal communication, January 19, 2015). For these reasons, the resource materials should encourage the use of curriculum as the starting point from which to generate design project ideas, and should encourage the development of cross-curricular design projects.

2. COLLABORATION

The resource materials should encourage and support collaboration amongst teachers, because the research showed that:

2.1 Collaborative planning increased the quantity and quality of design project ideas.

2.2 Collaboration and discussion is important for coordination of design projects across grades and subjects.

2.3 Teachers can help each other to integrate design-based learning more effectively in their classrooms.

Working collaboratively in the co-creation workshop, the teachers at KGMS were able to generate a large number of ideas in a very short period of time. Each teacher brought different ideas, different past experiences and a different perspective, which allowed for the development of extremely rich and well considered lessons. Collaborative planning requires additional time and coordination of schedules, which can be challenging, but research showed that it could also lead to more efficient and effective use of time. "The ideas that we generated using each other were amazing. It felt efficient" (Norlene Page, personal communication, June 25, 2014).

By working collaboratively the teachers were able to help each other understand how to integrate a design-based learning approach. Teachers should be encouraged to discuss design projects, ask questions of each other, clarify their understanding of design concepts and share their learning with one and other.

Discussion of design projects among colleagues is also important for identifying cross-curricular or cross-subject teaching opportunities. In this way, collaboration can also spread design-based teaching to a greater number of teachers within a school. Given the amount of overlap in content areas across grade levels, discourse around design projects is also important for the coordination of projects across grade levels, allows teachers to build on what students may done in previous design projects. Resource materials should support collaborative planning and establish a common language for design-based learning in order to support these conversations.

"We were sharing ideas and bouncing ideas off of each other and then going in directions that we never would have thought of on our own."

Johanna Frank, KGMS Teacher

"Among the resources that teachers need is a network of other teachers who are using design thinking in their classroom"

Davis et al., 1997, p.115

3. FLEXIBILITY & ADAPTABILITY

"Professional development should help teachers link their instructional goals to the specific features and affordances of curriculum materials, and should support teachers in making the necessary design modifications required to achieve this alignment "

Brown & Edelson, 2003, p.6

The resource materials should allow for the development of design projects that are flexible and adaptable to meet student and teacher needs, because the research showed that:

3.1 Teachers commonly adapt and customize lessons and activities to suit their needs and instructional goals.

3.2 Projects need to be adaptable and flexible to suit variations in curriculum, school structures and timelines.

3.3 Projects need to support differentiated instruction to meet varying student needs and abilities.

The resource materials should allow for adaptation and modification of design projects to suit teachers' instructional needs. This allows teachers to accommodate: individual student ability; class level and school structure (ex. split classes); changes in required curriculum; rate of student learning; amount of time available and other daily factors. Several teachers at KGMS expressed that they typically do not follow standardized lesson plans. They prefer to (and need to) adapt and combine a variety of resources to suit their needs and to accommodate unexpected changes. When the teachers at KGMS developed design projects during the co-creation workshop they intuitively considered how a single project could be flexible in terms of scale and duration to suit a given time line. The resource materials should allow for this flexibility and embrace teachers' natural ability and tendency to adapt and modify resources to suit their needs.

"Working through a child's strengths puts a positive spin on learning, especially for a student who has had continued difficulty in school. Instruction, when it is differentiated, better matches an individual's abilities, styles and needs."

Weinfeld et al., 2013, p.83

Flexible and adaptable design projects are also preferable to allow for differentiated instruction, a recommended teaching strategy, especially for children with gifted characteristics and learning differences. A single design project should have the ability to be modified and adapted to suit variations in student needs and abilities. During the co-creation workshop teachers considered how to adapt their project ideas to suit different student abilities and they included ideas for extension and differentiation in their lesson plan. One teacher observed that many of the design projects even allowed students to differentiate their own learning by providing student's with opportunities for choice within a project.

4. PROMPTS & SUPPORT

The resource materials should provide teachers with prompts and guidance to spark the development of custom design projects, because research showed that:

4.1 Teachers often look to the Internet, books and past experiences for ideas.

4.2 Teachers found prompts helpful for generating design project ideas.

4.3 Teacher benefit from structure and guidance when planning design lessons.

In discussions with teachers about commonly used resources they often referenced Google, Pinterest and Teachers Pay Teachers. In the Photo Journal activity, in response to the question, "What helps you teach?", the teachers took photographs of digital and print resources including books for teachers and books for children. The teachers expressed comfort in seeking resources to support their instructional goals and many expressed that they use the Internet to spark ideas.

"I'm not really an outline kind of person. Sometimes I'll look on Pinterest and I'll look for an idea or spark, but rarely will I follow a lesson plan."

Johanna Frank, KGMS Teacher

In the co-creation workshop at KGMS I asked teachers to develop a design project and supplied them with a variety of resources that they could use to support them in their planning. Teachers did not gravitate towards the detailed lesson plans but rather to the short project idea cards that were provided. With simple prompts they were able to develop their own projects based on initial ideas from the cards. One teacher said that she would like it if the cards were like a daily flip calendar so she could scan through them easily. Another teacher said that rather than reading the full lesson plans provided in the book Why Design? (Slafer & Cahill, 1995), he found it helpful to simply scan the project titles. This illustrated that simple project prompts were sufficient in helping teachers to successfully develop design projects. Brown and Edelson (2003) suggest, "we must find a middle ground between expecting teachers to adopt materials "as-is" and expecting them to develop materials from scratch" (p. 2).

The resource materials should provide teachers with prompts or starting points, from which they can develop custom design projects.

5. PROFESSIONAL DEVELOPMENT & COACHING

The resource materials should promote the use of design coaches and lead to independent use of design by teachers over time, because the research showed that:

5.1 Teachers benefit from ongoing opportunities for conversation and professional critique as they apply design strategies.

5.2 A gradual transition from support to independence over time is effective for sustained change and adoption of design.

5.3 Design knowledge should be released over time as needed.

"I thought [the design process] was a really good framework for teachers. And it's simple. It's six things and you just go through them step by step and plan it out."

Adam Lewis, KGMS Teacher

At the conclusion of the co-creation workshop the teachers and administration at KGMS expressed that facilitation was critical for the successful development of their design projects. The direction and guidance that I was able to provide helped them in the planning process and allowed for redirection as necessary. In the beginning when teachers were asked to generate design project ideas they were very solution focused, such as "design new sunglasses", "design toys". At this point I prompted the teachers to generate project ideas based on questions rather than end-results. After this redirection the teachers immediately began generating stronger project ideas such as, "How can you protect yourself from the light?", "How you can you redesign the classroom to use light more effectively?". Several times throughout the workshop I provided small cues that were necessary for guiding the teachers.

When asked to identify areas in which they needed the most support, teachers identified a need for up front support when generating project ideas and opportunities to 'touch base' with a designer during the delivery of a project. Teachers expressed a desire for support with evaluating and adjusting the lessons; helping students evolve their ideas; and reflecting on projects and noting improvements for next time (see figure 39). These needs support the notion of designer as coach, providing on-going critique and support to adjust and improve lessons in 'real-time'.

The group unanimously agreed that a gradual shift to independence would be a successful model for professional development. As teachers gain familiarity and confidence with using design as a pedagogical approach they will require less

Fig.42 Teachers at KGMS participating in a Design Workshop

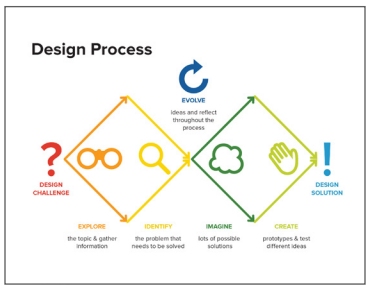
support from a design coach. At KGMS, we saw that over the course of a year teachers were able to successfully transition from observing to co-teaching to independent teaching of design projects with the guidance and feedback from a design coach.

In the book, *Design as a Catalyst for Learning*, McCoy describes design as "deceptively simple" (as cited in Davis et al., 1997, p.95). I observed this in my teaching at KGMS as well, in that teachers were able to quickly pick up on the basics of design after only a few short lessons, yet there was still much complexity and richness to the design process and design methods that they were lacking. A coaching model would allow for teachers to gain more advanced knowledge as they are ready and would also allow them to gain subject or curriculum specific design knowledge as relevant to their teaching practice.

5. DESIGN OUTCOME

Fig.43 Introducing the design process to students and teachers

5.1 Imagine, Create & Evolve



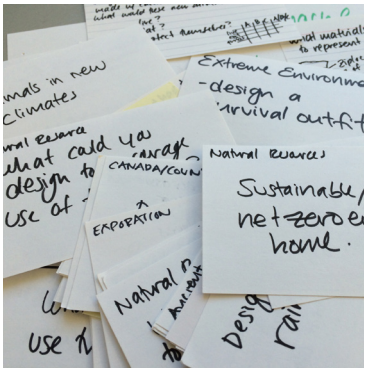


Fig.44 Initial design process diagram

Fig.45 Cue cards containing design project ideas

Initial ideation and creation of resources began in September 2013 as I began teaching in classrooms at KGMS. In my role as *Designer in Residence* I developed my own teaching materials in order to introduce design to students. Materials and tools that I developed to support my teaching practice became the first exploratory prototypes for teacher resources. The first set of materials that I developed included a series of slides for a smart board and a diagram to explain the design process to both students and teachers (see figure 44). The design process provided the structure from which I developed and taught design lessons. I also began collecting my own design project ideas on cue cards (see figure 45), which became the starting point for the Design Challenge Cards and Process Activity Cards that are part of the final *Teaching With Design* resource package.

My first-hand teaching in the classroom, weekly in-class observations and conversations with teachers were critical research activities that informed the development of early prototypes for the resource materials. From the Summer of 2014 through to March 2015, ideation, prototyping and user testing occurred in an iterative process as I considered what teachers would need in order to develop and teach their own design lesson. In September 2014, as the new school year began, I provided teachers with early drafts of the resources. Teachers used these early prototypes to aid in their planning of design projects in conjunction with bi-weekly design coaching meetings. Through this process I was able to see how the prototypes were being used by the teachers and make adjustments accordingly. As I developed and evolved the prototypes new versions were passed on to teachers for use in their classrooms.

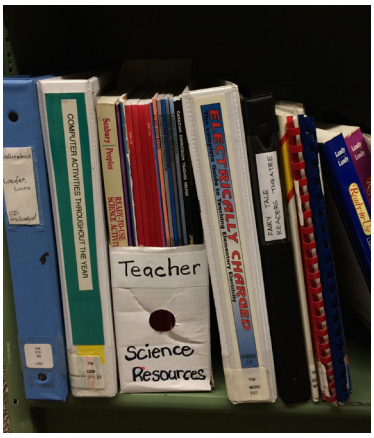
KEY PRECEDENTS

As I began to create the resource materials I looked to other teaching resources and training models as precedents. Teaching resources are commonly contained within binders or coil-bound books and are often accompanied by worksheets designed for photocopying, called black-line masters (see figure 46, 47). These resources also typically include detailed and lengthy descriptions for teachers about how to use the resource materials provided. Through discussions with teachers I noticed that blackline masters are typically contained within bound books which make it more challenging for teachers to feed them through photocopiers (see figure 47). I noticed that worksheets are convenient and helpful tools for teachers which are frequently used. However, I also noticed a heavy reliance on worksheets as a teaching tool when alternative methods may have been more engaging or effective.

Through my observations at KGMS I also became aware of the frequent use of the Smart Board as a key teaching tool and I identified that it would be important to design for this functionality. The Smart Board is an important tool for multi-modal communication, as it allows teachers to display visual instructions to support the auditory instructions they frequently deliver. Insights such as these, informed the format of the resources I developed.

Delivery models for teacher training and resource dissemination were also reviewed, including: Teachers Pay Teachers (http://teacherspaysteachers.com), Learn Zillion, (http://learnzillion.com) and NoTosh (http://notosh.com) (see figure 50).

Of particular relevance to my thesis as a precedent is *The Critical Thinking Consortium (TC²)* (2011-2015), a Canadian based non-profit association that promotes critical thinking in primary and secondary schools and is currently working with the BC Principals' and Vice-Principals' Association. They offer a variety of services to support teachers including in-person mentoring and professional development, online coaching and webinars, as well as print and digital resources. TC² refers to their approach as *The 'Comet' Model*. Workshops and presentations, as the head of the comet, introduce key ideas and approaches



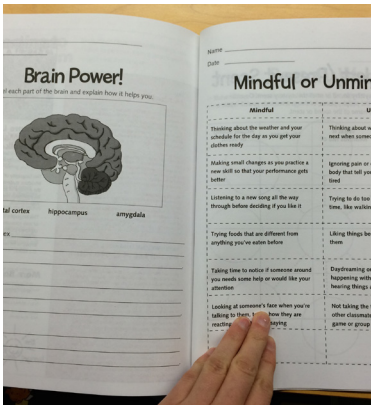


Fig.46 Teaching resources at KGMS

Fig.47 Blackline masters provided for photocopying

to teachers. The tail of the comet is a prolonged period of sustained professional development that slowly works towards transforming teachers' practice. This may include growth through conversations with colleagues, access to professional resources and assisted implementation within classrooms.

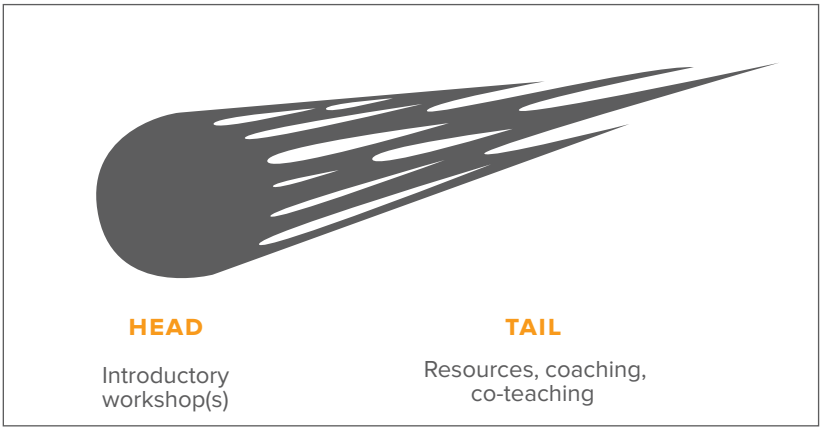


Fig.48 The 'Comet' Model described by TC[2]

Figure 49 has been removed due to copyright restrictions. The information removed is a diagram from IDEO, & W.K.Kellogg Foundation. (2008). Tangible Steps Toward Tomorrow. Retrieved from http://www.wkkf.org/resource-directory/resource/2008/02/tangible-steps-toward-tomorrow-printer-friendly

Fig.49 Teacher empowerment diagram (W.K.Kellogg Foundation & IDEO, 2008)

Feedback loops are also another important aspect of an effective training model. In a publication about early childhood education produced by W. K. Kellogg Foundation and IDEO (2008), they identify that teacher empowerment requires collaboration, scaffolding and feedback (see figure 49). Specifically the publication highlights the importance of regular feedback and reinforcement from mentors as an effective strategy for supporting and training new teachers. They suggest several large-scale changes that would help to better align the education system with contemporary society. They recommend a shift

	Coaching - Face to Face	Coaching - Online	Workshop - Face to Face	Workshop - Online	Pay for Service/Product	Freemium	Open Source	Subscription	1 Time Free	
Learn Zillion	●			●			●	●		Website containing free Math and English resources with videos explanations. Strong design precedent. District level embedded Pro-D
Teachers Pay Teachers					●		●			Website that sells resources developed by individual teachers. Similar to Etsy for teachers. Some available for free.
Critical Thinking Consortium	●	●	●	●		●		●		Consultancy that offers a variety of services. Membership & Parternship Fees for Individuals and School Districts. Some free resources online.
NoTosh	●	●						●	●	Consultancy - Paid consulting, including "NoTosh On Tap"
DIY							●			Website with Free downloadable PDF templates with "How to Use" info. Strong design precedent.
Common Curriculum						●		●		Online curriculum planning tool. Free for individual teachers, $90/teacher/group. Design precedent for website functionality.
Method Kit					●					Printed cards for sale through website.
Design Thinking for Educators	●		●		●		●			Free PDF. Charge for workshops and consulting through Standford d.school
IDEO Method Cards					●				●	App $5, Cards $50
Service Design Toolkit	●			●			●			Website with free downloadable templates. Recommend hiring external consultant, and offer face to face training.
Cards Against Humanity					●		●		●	Card game. Purchase professional set, or print at home for free from their website.
Teach BC							●			Open source website for teachers to share resources and research.
Environmental Learning Resource							●			Downloadable PDF Resource Guide from BC Ministry of Education website.
Cooper-Hewitt Design Resources							●			Website with free lesson plans. Sign-up to add your own.

Fig.50 Review of key precedents and approaches for dissemination of resources and training

from 'prescription to permission', explaining that top-down prescription prevents teacher from using their creative skills. In contrast, they seek "solutions that create structure and support teachers but leave room for freedom and interpretation" (p.106). They also suggest a shift from 'one-size-fits-all to mass customization'. They explain that rather than providing a standard experience for all students, teachers need tools and systems that allow them to meet individual student needs.

In addition to reviewing existing resources and models for dissemination within the education context, resources for teaching design and disseminating design knowledge were also reviewed. These included design toolkits produced by various organizations including: IDEO method cards (http://www.ideo.com/work/method-cards), Development Impact and You Toolkit (http://diytoolkit.org), and Method Kit (http://methodkit.com).

5.2 Coaching Model

"To truly use design problem solving, these teachers need ongoing professional critique of their assignments and teaching practices as well as assistance in developing new facilitation skills."

Davis et al., 1997, p.108

The final outcome for supporting teachers with design-based learning is a set of print and digital resources for teachers and a proposed model for professional development. The resources would be distributed through a professional development service that includes training and support from a design coach.

The *Teaching With Design* coaching model proposed through this thesis project, includes four phases: learning about design; planning a design project; teaching design in the classroom; and continuing the use of design.

The 'learning' phase begins with an introduction to design workshop led by a design coach, and may be followed by direct teaching in the classroom by the design coach. This offers teachers an opportunity to observe design being taught with their own students. Following an introductory workshop, a design coach would work with teachers in groups or individually to support them with the planning and teaching of design projects.

The diagram on the following pages (figure 52) illustrates that within each of these phases there can be various levels of engagement between a teacher and a design coach. For example, within the 'planning' phase the most intensive level would be co-planning. However, alternatively planning might occur through a collaborative workshop, through check-in meetings, or independently. Planning might also occur at more than one level, for example through a collaborative workshop and independently with resources. The options shown indicate varying levels of support from a design coach; within each of these levels the frequency of support could also be increased or decreased. For example check-in meetings could occur monthly or weekly depending on the level of guidance needed and the funding available.

The 'continue' phase indicates that after a teacher plans and teaches his/her first design project, he/she may repeat the process of planning and teaching with varying levels of support.

As teachers become more comfortable with the integration of design in their classroom, there may be a reduction of frequency or intensity of the coaching support provided. A design coach can provide ongoing opportunities for conversation, critique and feedback; and can enrich teachers' design content knowledge, and suggest additional design resources. A detailed description of each phase and the various coaching levels is provided on page 74-77 (figure 52).

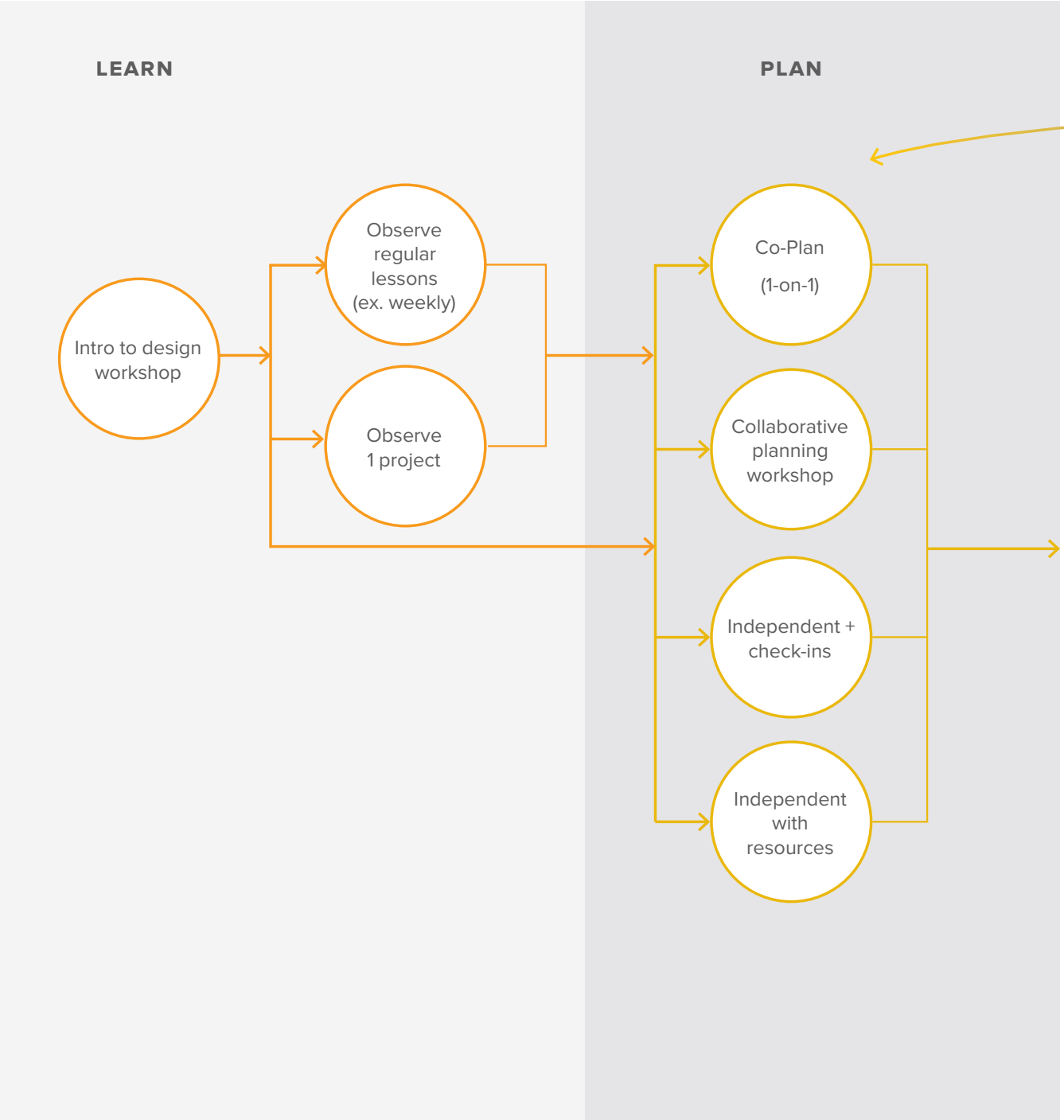
This proposed model is flexible and can be adjusted to meet varying teacher needs and school budgets. A design coach may also provide different amounts of support to various teachers within the same school. This model supports the gradual release of teachers towards more independence over time, which is an important factor for creating sustained change in their teaching practice.

This model of on-going and embedded professional development has been proposed to support long-term and successful integration of design-based learning. In the "Teachers Development Research Review" and *Design as a Catalyst for Learning*, both authors recommend sustained learning over multiple days and weeks (Davis et al., 1997; Vega, 2013). Their research shows that teachers are likely to resort back to familiar methods without longer-term training. Their research also indicates that long-term professional development has a greater impact on student learning than short-term workshops.

At KGMS various approaches to design coaching were explored, including in-classroom teaching on a weekly basis, coaching through individual meetings on a bi-weekly basis and collaborative meetings on a monthly basis. This model was effective at KGMS with teachers of varying experience.
I also worked with three teachers in a second private school, Southridge School, where the involvement as a design coach was less intensive. In this case, as a design coach I helped to develop a design project, introduced the project to the students and then supported the teachers through email and phone conversations. The interactions at KGMS and Southridge School showed that the type of approach needed varied, depending on teachers' experience and needs, school culture, funding and timelines.

Fig.51 Design coach and teacher co-teaching in the classroom

Teaching With Design Coaching Model



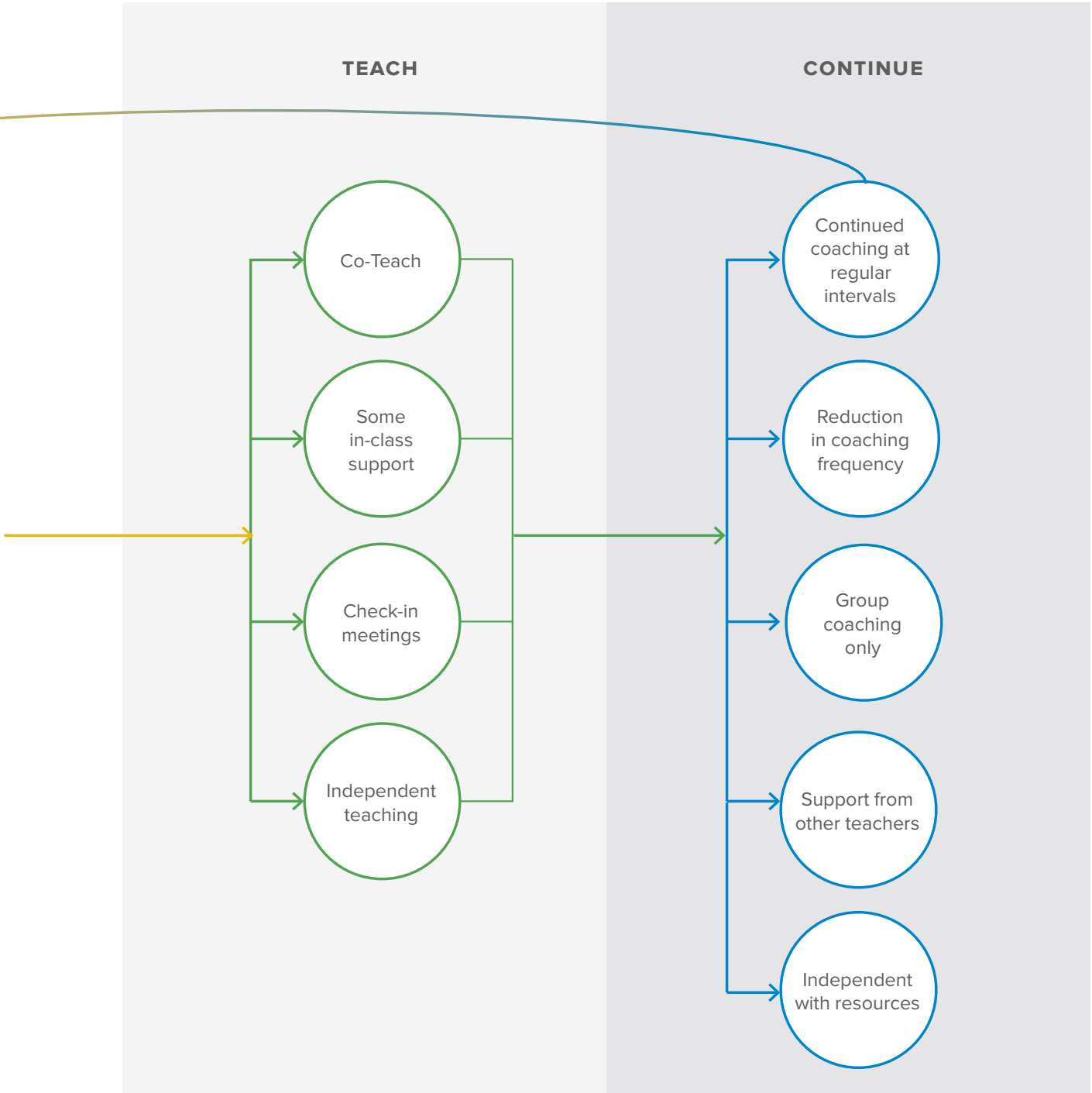


Fig.52 *Teaching With Design* coaching model including options for various levels of support

Teaching With Design Coaching Model

(Descriptions to accompany figure 52, on previous page.)

LEARN

In this phase teachers are introduced to the design-based learning approach and the design process.

Intro to design workshop
The design coach leads a group workshop that introduces teachers to the basics of design, design-based learning and the design process. The workshop includes a discussion about the integration of design into that specific school and classrooms

Observe regular lessons (ex. weekly)
The design coach leads design lessons in the classroom(s) on a regular basis. For example, weekly lessons for one term. This allows the coach to model the strategies for the teacher(s). It also allows the teachers to observe what their own students are capable of and how they respond to design activities.

Observe 1 project
The design coaches leads one design project within each classroom. This allows the coach to model the strategies for the teacher, but is less intensive than regular lessons, and may only include 1-5 lessons.

PLAN

In this phase teachers develop and plan custom design projects that relate to their curricular and instructional goals. The teachers and coaches use the resource materials to support the planning process.

Co-plan (1-on-1)
The teacher and coach co-plan a design project together. This usually occurs during a teacher's prep block.

Collaborative planning session
The coach facilitates a planning session with multiple teachers. In this case the teachers work together in small groups to help each other plan lessons for each of their classrooms. The design coach moves between the groups providing support as needed.

Independent + check-ins
The teacher plans a design project independently with a couple of opportunities to check-in with a design coach. These check-in opportunities are shorter than co-planning meetings and may occur at varying levels of frequency.

Independent with resources
A teacher plans a design project independently with support from the *Teaching With Design* resources.

TEACH

In this phase teachers lead a design project with their own students.

Co-teach

The teacher and the design coach co-teach a design project. In this case the coach may take the lead with support from the teacher, or the teacher may take the lead with support from the coach.

Some in-class support

The teacher leads a design project with his/her students, but the design coach may support a few of the lessons. For example, the design coach might introduce the project to students, and then come back half-way through the project to further support the teacher and students.

Check-in meetings

The teacher leads a design project with his/her students. The teacher meets with a design coach, outside of class time, to discuss how the project is going and to receive suggestions and feedback

Independent teaching

The teacher leads the design project independently with his/her students.

CONTINUE

Once teachers have planned and led their first project, they may continue teaching design with varying levels of support. The level of support they receive may continue to change or decrease as they gain experience.

Continued coaching at regular intervals

The teacher continues to receive support in planning and teaching design from a coach at regular intervals (for example, weekly or monthly).

Reduction in coaching frequency

The teacher continues to receive support from a coach but the frequency of meetings is reduced. For example, coaching may shift from weekly to bi-weekly to monthly meetings as the year progresses.

Group coaching only

Teachers within the same school receive coaching through collaborative meetings. No 1-on-1 coaching is provided. Frequency of these meetings is flexible, for example once per term or once per month.

Support from other teachers

The teacher receives support from other teachers within the school instead of through a design coach. This may be through scheduled meetings or informal conversations.

Independent with resources

The teacher continues to plan and teach design projects independently with support from the resources provided.

5.3 Teacher Resources

The final outcome of my thesis project is the *Teaching With Design* resource package for teachers. Seven print and digital resources have been created to support teachers with the development of their own custom design projects.

Rather than providing teachers with detailed lesson plans, the resources provide a framework and various tools that can be used to develop projects that are customized to suit instructional goals and classroom needs. These flexible resources may be used in a variety of ways by different teachers. The resources may be used when co-planning with a design coach, when planning collaboratively with other teachers, or when planning independently.

PRINT RESOURCES:

1. **Design Challenges** (cards)
2. **Process Activities** (cards)
3. **Planning Guide** (resource binder)
4. **Activity Worksheets** (resource binder)

DIGITAL RESOURCES:

5. **Planning Template** (Power Point template)
6. **Assessment Guide** (Word document)
7. **Design Slides** (PDFs for projection)

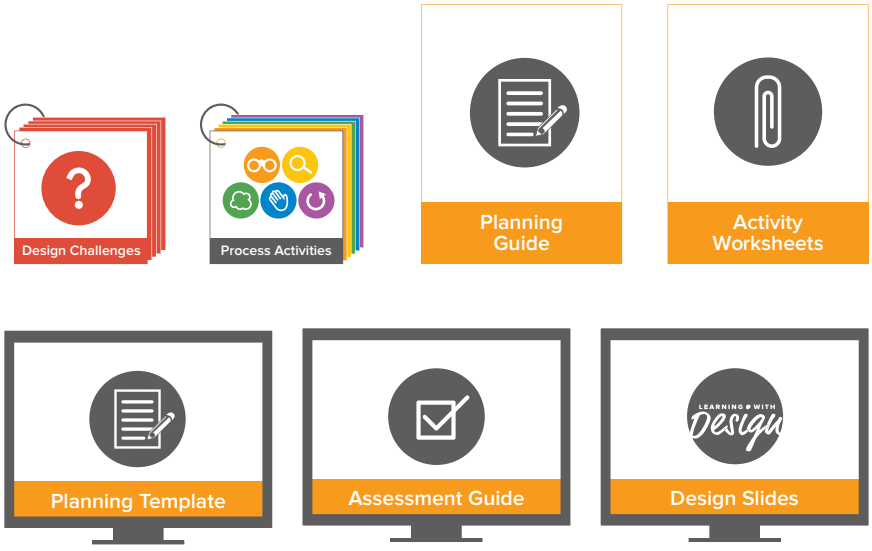


Fig.53 *Teaching With Design* resources provided

Fig.54 Teaching With Design resource package containing the print resources

DESIGN PROCESS DIAGRAM

The *Teaching With Design* resource materials use the design process as a basic framework to support teachers in lesson planning and guide students through design projects. The design process diagram used within the resources was developed after reviewing existing diagrams and through user testing with students and teachers. This design process diagram, and the six steps featured in it, are used within all of the resource materials, providing a clear and consistent reference for teachers and students. Below is an explanation of the six phases of the design process and the icons which represent them.

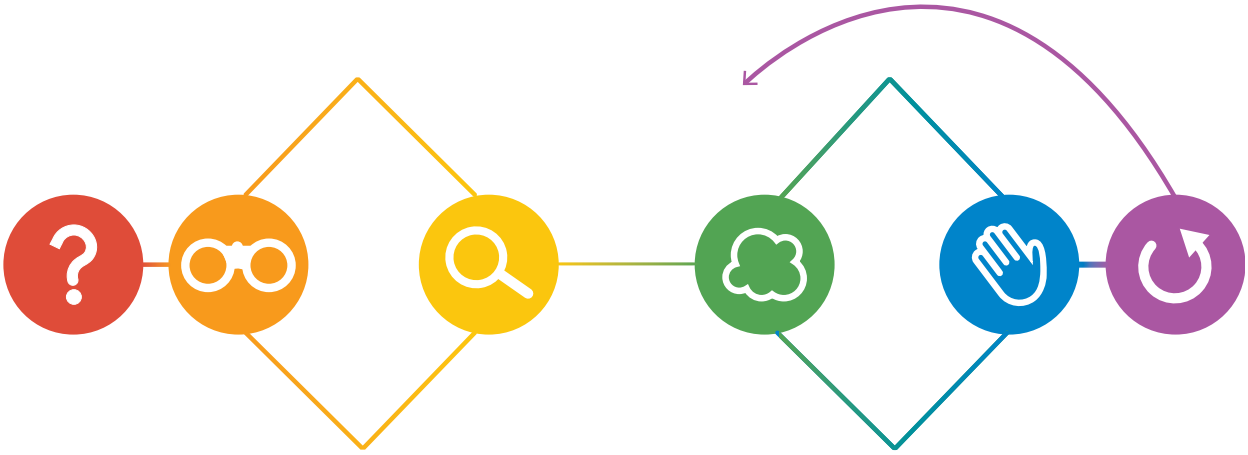


Fig.55 Design process

1. DESIGN CHALLENGE

The design process begins with the identification of a design challenge. This is often posed in the form of a question and therefore, this phase is represented by the question mark icon.

2. EXPLORE

Following the identification of a design challenge, students begin by exploring the topic and gathering information. This phase is represented by a binocular icon because students are encouraged to look wide, think divergently and gather lots of information through various research methods.

3. IDENTIFY

Following the research phase, students begin to synthesize the information they have collected and they identify the information that is most important. Sometimes this involves refining the design challenge to focus on a specific problem that was identified in the explore phase. The magnifying glass icon symbolizes that in this phase students are narrowing in, or focusing on a more specific details of the challenge.

4. IMAGINE

In the imagine phase students begin to brainstorm lots of possible ideas using divergent thinking. The cloud or thought bubble icon represents this ideation and imagination phase.

5. CREATE

Following the imagine phases, students select their best ideas and illustrate and refine these in more depth. This often occurs through the creation of prototypes or detailed drawings. The hand icon symbolizes that in this phase students use their hands through drawing, or making to communicate their design solution.

6. EVOLVE

Finally, in the evolve phase, students are asked to consider how they might improve their design solution. The arrow icon symbolizes that in this phase students may need to go back and repeat some of the previous steps in order to refine and improve their solution further.

The diamonds illustrated in the design process diagram indicate the divergent and convergent thinking this is required throughout the design process. The purple arrow, after the final step indicates the iterative nature of design.

Contains 55 Design Challenge Cards, organized into 27 curricular themes.

DESIGN CHALLENGE CARDS

Rather than providing teachers with detailed lesson plans, the *Teaching With Design* resource package provides teachers with 55 Design Challenge Cards. These cards provide short suggestions for possible design projects and support teachers in generating project ideas. A teacher may select one Design Challenge Card and expand upon it, or a teacher may combine several of the cards to generate his/her own variation of a project.

The cards have been organized by key themes listed on the bottom of each card. These themes are based on key topics outlined in the BC curriculum for grade 4-7, with an emphasis on connections to science and social studies. Teachers can flip through the cards and scan the themes to identify design challenge ideas that relate to their instructional goals, or they may look up a specific theme in the index provided.

Fig.56 Design Challenge Cards

Fig.57 Design Challenge Cards

Contains 50 Process Activity Cards, divided into the five design process phases: explore, identify, imagine, create and evolve

PROCESS ACTIVITY CARDS

In addition to the Design Challenge Cards, the resource package includes 55 Process Activity Cards. These cards provide teachers with ideas for design activities or methods that can be incorporated into design projects. The Process Activity Cards are organized into five sections, based on the five remaining phases of the design process (Explore, Identify, Imagine, Create and Evolve). Once teachers have decided on the overall design challenge or project they wish to teach, they can begin to develop a more detailed project plan by selecting activities to guide students through for each phase of the design process. Teachers can flip through the cards to spark ideas, and can pull out the ones that they think are appropriate for their project.

Fig.58 Process Activity Cards

Front of the Process Activity card displays a large title

Photo provides a visual cue for the activity

Icon and colour band indicate that in this case, this is an activity for the explore phase of the design process

Research Brainstorm

Questions: Before beginning to research it is helpful to start by identifying the questions that you want to answer. Have students work in groups or individually to brainstorm a list of possible questions. Then have them select the questions that they think are most important to research.

Problems: Before students begin to research a topic, ask them to brainstorm what they think the problems might be. This is a good way to do a pre-assessment to gage what students already know, or what their assumptions might be.

Back of the card includes a brief description of the Process Activity

Fig.59 Process Activity Cards

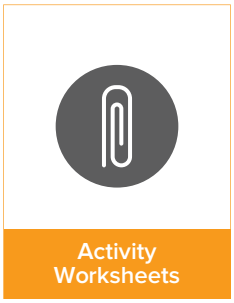
The Design Challenge and Process Activity Cards allow teachers to mix and match the cards provided, with their own ideas to develop a custom projects that suit their instructional goals. For example, in figure 60, a teacher has chosen to lead a design challenge titled, "Surviving Climate Change". The teacher has also chosen a variety of process activities including brainstorming, storyboarding and personas that she will lead as part of the project.

Fig.60 A selection of Process Activity Cards to support the chosen Design Challenge

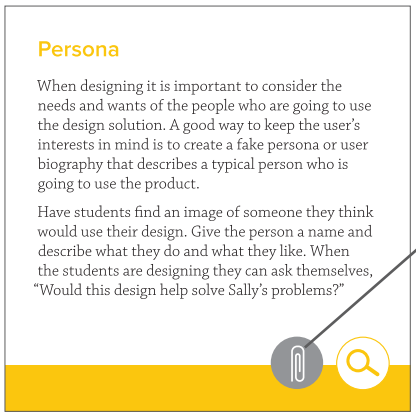
ACTIVITY WORKSHEETS

Some of the activities suggested in the Process Activity Cards are accompanied by printable Activity Worksheets. These worksheets, commonly referred to as blackline masters, are available in the resource binder for teachers to photocopy.

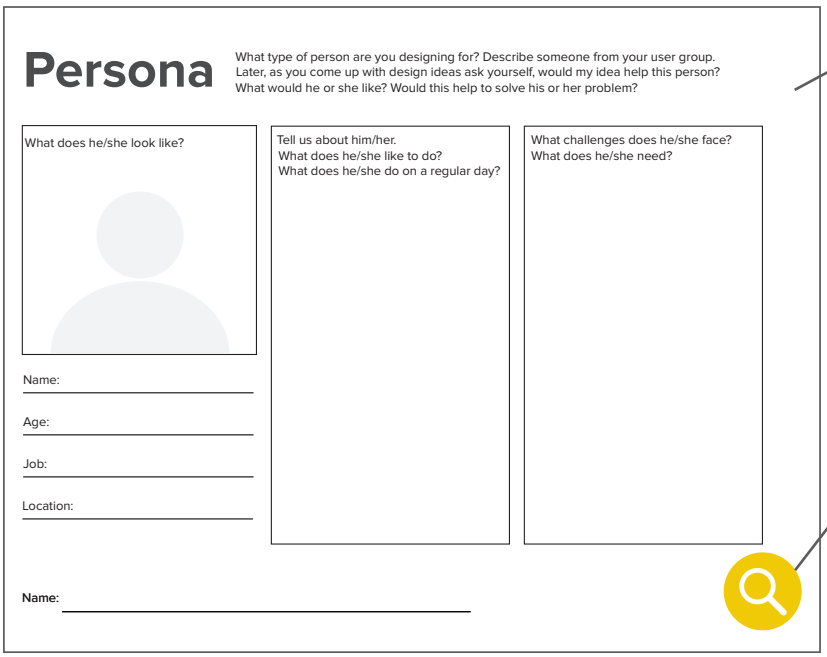
A grey icon on the bottom of a Process Activity Cards indicates that there is a corresponding worksheet that can be photocopied for student use. Below is an example of a Process Activity Card and its corresponding worksheet.



Contains 10 Activity Worksheets that correspond with 10 of the Process Activity Cards.



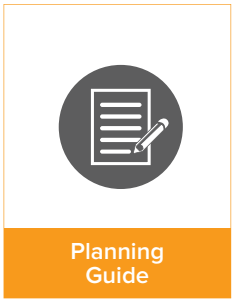
Paperclip icon on the Process Activity Card indicates that there is a corresponding worksheet provided for this activity (see below)



Activity Worksheet that corresponds to a matching Process Activity Card (see above)

Icon indicates this is an activity for the identify phase of the design process

Fig.61 Activity Worksheets



Planning Guide is located within the Resource Binder.

PLANNING GUIDE

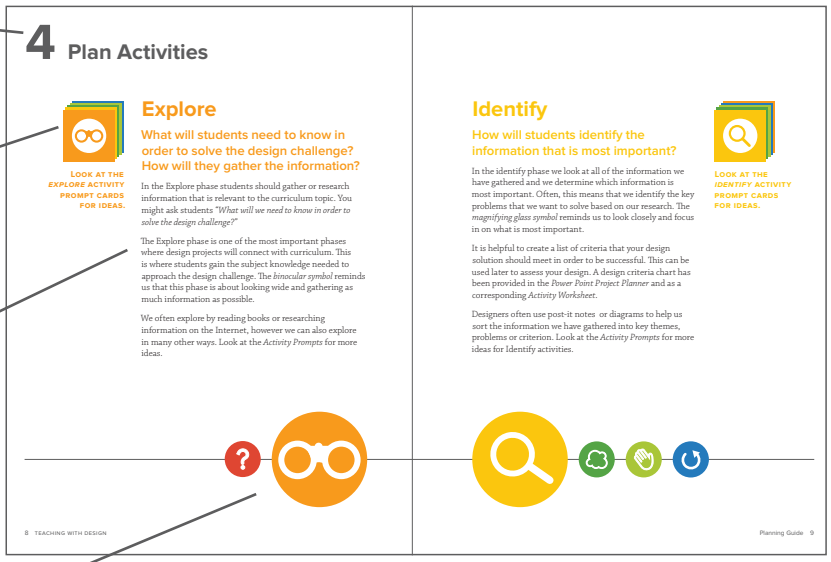
In order to support teachers in developing custom design projects, a Planning Guide has been provided which takes teachers through a step-by-step process to plan design projects that relate to curricular topics or units. Each page guides teachers through a step in the planning process and provides teachers with reminders and guiding questions. For example, in the pages shown below, teachers are asked to plan activities that will support students in the explore and identify phases of the design process.

Each step within the planning process is numbered and titled

Icon indicates the resource that can be used to support the planning step

Description of what to consider for this phase of the planning process

In step 4, "Plan Activities" icons on the bottom of the page provided a reference to the design process



4 Plan Activities

Explore

What will students need to know in order to solve the design challenge? How will they gather the information?

LOOK AT THE *EXPLORE* ACTIVITY PROMPT CARDS FOR IDEAS.

In the Explore phase students should gather or research information that is relevant to the curriculum topic. You might ask students *"What will we need to know in order to solve the design challenge?"*

The Explore phase is one of the most important phases where design projects will connect with curriculum. This is where students gain the subject knowledge needed to approach the design challenge. The *binocular symbol* reminds us that this phase is about looking wide and gathering as much information as possible.

We often explore by reading books or researching information on the Internet, however we can also explore in many other ways. Look at the *Activity Prompts* for more ideas.

Identify

How will students identify the information that is most important?

LOOK AT THE *IDENTIFY* ACTIVITY PROMPT CARDS FOR IDEAS.

In the identify phase we look at all of the information we have gathered and we determine which information is most important. Often, this means that we identify the key problems that we want to solve based on our research. The *magnifying glass symbol* reminds us to look closely and focus in on what is most important.

It is helpful to create a list of criteria that your design solution should meet in order to be successful. This can be used later to assess your design. A design criteria chart has been provided in the *Power Point Project Planner* and as a corresponding *Activity Worksheet*.

Designers often use post-it notes or diagrams to help us sort the information we have gathered into key themes, problems or criterion. Look at the *Activity Prompts* for more ideas for Identify activities.

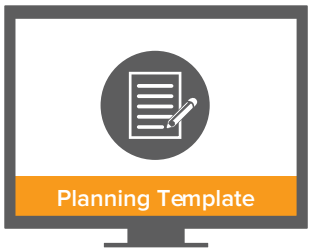
8 TEACHING WITH DESIGN

Planning Guide 9

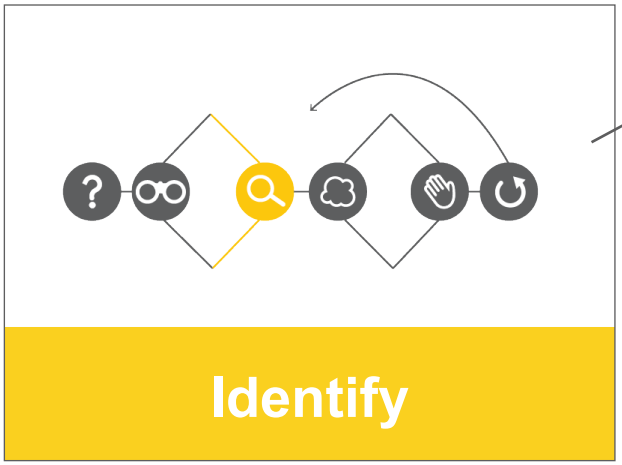
Fig.62 Planning Guide

PLANNING TEMPLATE

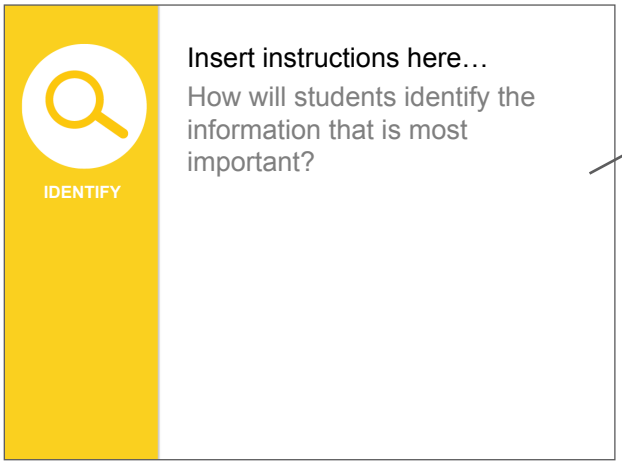
As teachers follow the Planning Guide and develop a detailed lesson plan, they can record their plan in the Planning Template provided. This is a digital Power Point template. Teachers can insert instructions into the template for each phase of the design process and they can make adjustments as necessary, including adding, moving or removing pages. They can also add images or examples to support the explanation of the project to students. The lesson plan that teachers create using the template, can be shared with students using a projector, such as a Smart Board.



The Planning Template is a digital Power Point document.



The design process diagram is repeated as a cover slide for each phase of the design process, as a reminder for teachers and students



For each phase of the design process there is a 'blank' template page for teachers to insert instructions for students.

Fig.63 Planning Template

The Assessment Guide is a digital Microsoft Word document.

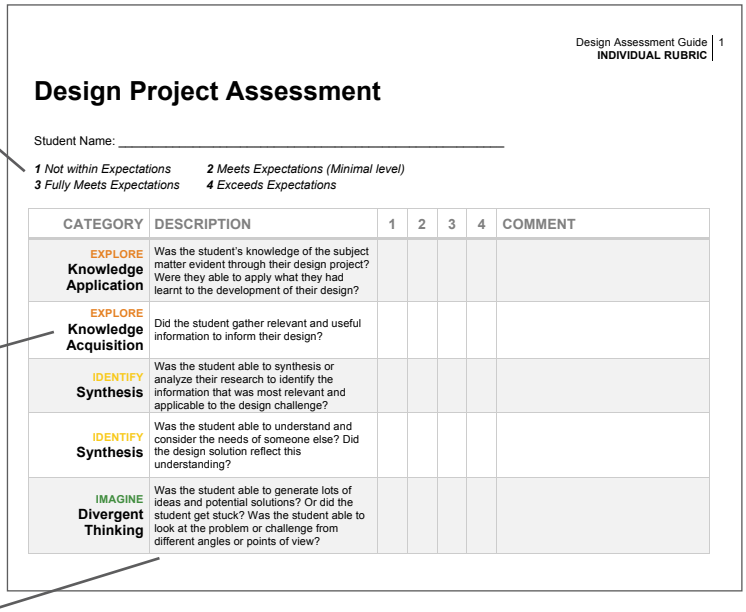
ASSESSMENT GUIDE

Teachers can use typical social studies and science grading rubrics to assess students' understanding and application of curricular knowledge within a design project. However, an Assessment Guide has been provided to support teachers with the evaluation of design specific skills. Fifteen different assessment categories are included, and are organized based on phases of the design process. This assessment tool can be used with all design projects and will allow teachers to track student growth over the course of multiple projects throughout the school year. The assessment guide provided as a digital Word document, is intended as a framework or template that can, and should be, modified to suit each project. Teachers may modify or eliminate assessment categories based on their objectives.

The assessment guide uses a four-scale system similar to rubrics produced by the BC Ministry of Education

15 different assessment categories are included, and are organized based on phases of the design process

A brief description in the form of questions, is included for each category.



Design Assessment Guide | 1
INDIVIDUAL RUBRIC

Design Project Assessment

Student Name: _____

1 *Not within Expectations* ***2*** *Meets Expectations (Minimal level)*
3 *Fully Meets Expectations* ***4*** *Exceeds Expectations*

CATEGORY	DESCRIPTION	1	2	3	4	COMMENT
EXPLORE **Knowledge Application**	Was the student's knowledge of the subject matter evident through their design project? Were they able to apply what they had learnt to the development of their design?					
EXPLORE **Knowledge Acquisition**	Did the student gather relevant and useful information to inform their design?					
IDENTIFY **Synthesis**	Was the student able to synthesis or analyze their research to identify the information that was most relevant and applicable to the design challenge?					
IDENTIFY **Synthesis**	Was the student able to understand and consider the needs of someone else? Did the design solution reflect this understanding?					
IMAGINE **Divergent Thinking**	Was the student able to generate lots of ideas and potential solutions? Or did the student get stuck? Was the student able to look at the problem or challenge from different angles or points of view?					

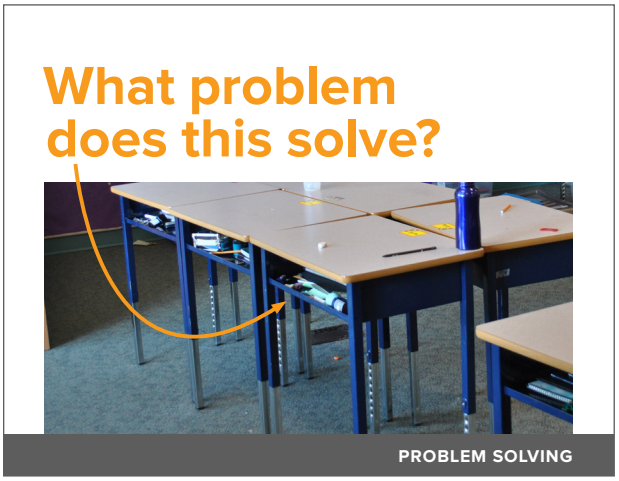
Fig.64 Assessment Guide

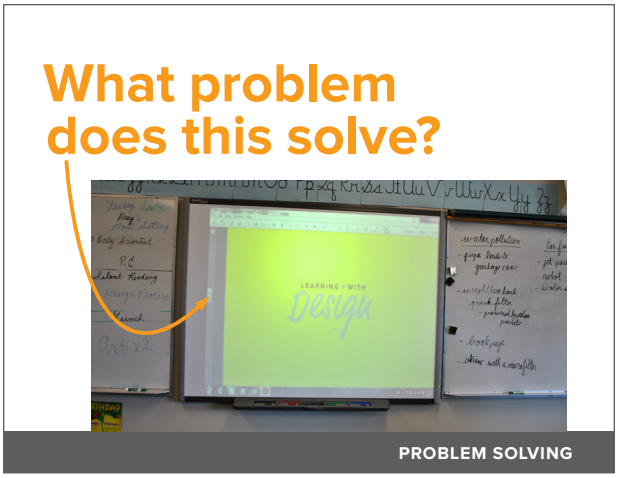
DESIGN SLIDES

To help teachers with the introduction of key design concepts to students, a variety of general Design Slides have been provided as a digital resource. These slides are intended to be shared in a classroom setting using a projector such as a Smart Board.

The Design Slides have been grouped into sub-sections such as “Intro to Design”, “Types of Design”, and “Brainstorming”. Depending on the project, teachers may find a selection of these slides helpful to share with students. Below is a selection of slides found within the sub-section, “Problem Solving”.

Includes 66 Design Slides, organized into 7 sub-sections, in a PDF format for digital viewing.





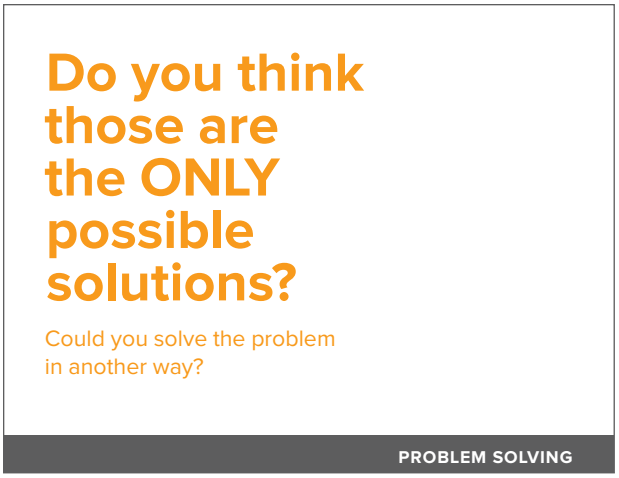


Fig.65 A sample of the Design Slides

RESOURCE PACKAGE

The *Teaching With Design* resource binder includes the Planning Guide, Activity Worksheets and a Digital Resource Appendix, which contains information about the Planning Template, Assessment Guide and Design Slides. An introductory guide at the front of the binder provides a summary of design-based learning, the design process and the *Teaching With Design* resource materials. This introductory guide is intended to supplement an Introduction to Design Workshop, as illustrated in the coaching model. The final section of the binder is titled, "My Design Ideas" and is a space for teachers to store their own notes, lesson plans and design teaching materials. A pocket at the front of the binder contains the Design Challenge Cards and Process Activity Cards.

Teachers, or the administration, could purchase the resources directly through a design coach or through a *Teaching With Design* website. The digital resources could be stored on a school server or downloaded through a *Teaching With Design* website.

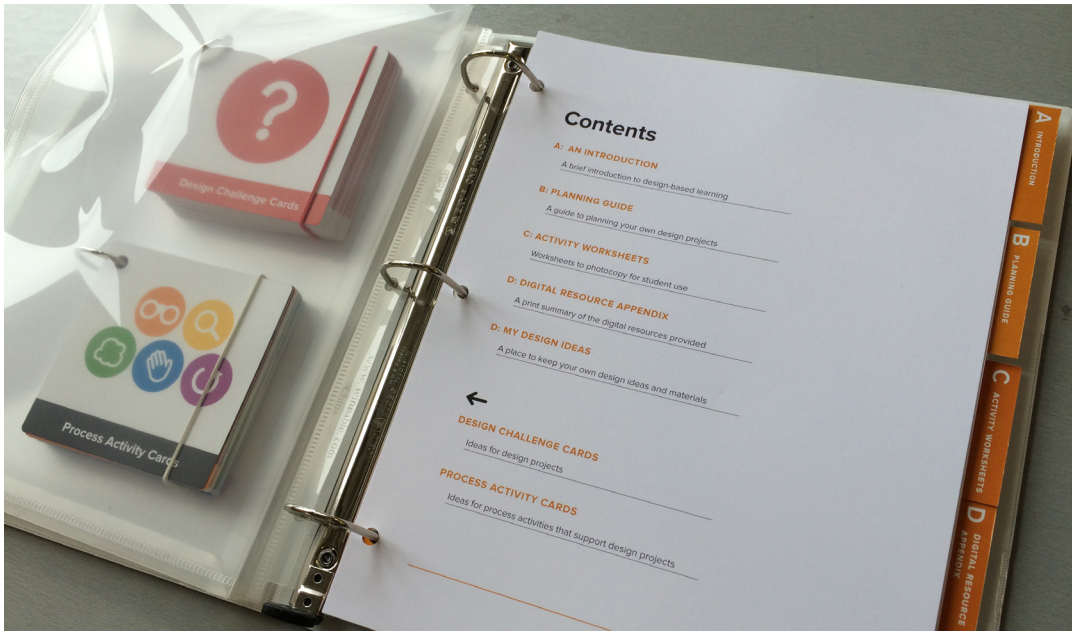


Fig.66 Process Activity Card and corresponding Activity Worksheet

Fig.67 *Teaching With Design* resources used in a collaborative planning session

5.4 User Testing & Feedback

User testing occurred through an iterative process ; as teachers tested the resources and provided feedback, the resources were revised and updated versions were distributed for further testing. In total, user testing and feedback was provided by approximately nine teachers at KGMS.

TEACHING RESOURCES

"The framework that Caylee has provided, essentially allows teachers to create a customizable project to meet the requirements of the classroom"

Adam Lewis, KGMS Teacher

One of the challenges that the teachers faced when planning their first design projects was understanding how much structure or freedom to provide their students. Teachers also often saw the 'making' as the main component of design and felt they had to provide students with content knowledge before they could tackle a design project. The development of a clear and concise design process diagram was therefore necessary to help teachers to understand that there are many steps involved before making or creating can happen, and that students can gain content knowledge through the design process. Through observations and discussions with teachers, it was evident that the design process introduced in the *Teaching With Design* resources provided a framework that guided them in planning lessons and was a useful scaffold for students.

"I've [also] appreciated having a process that you can put in place to help with going from the essential questions through the process of design, to a product, and still it is not difficult for the kids to actually execute" (Norlene Page, personal communication, January 19, 2015).

Based on this feedback, the design process diagram and steps became the central language within the resources. The icons and terms used to describe the process were refined through a series of iterations. Several of the teachers expressed that the resources and framework provided made the introduction of a new pedagogic approach surprisingly simple and easy and to follow.

"When I had first heard about the design project at our school I was really excited about it, but there was also a big part of me

that was really hesitant because I was thinking how am I as a teacher going to be able to implement this in the classroom? When Caylee came in and she offered all of these great resources...it was great for me to see how structured it can be." (Colleen Blackwell, personal communication, January 19, 2015)

To compliment the structured design process diagram that I used with the teachers, I also showed them the design process drawn as a messy squiggly line. This was an important addition to reiterate to the teachers; I explained that although the design process can be described as 5 key phases (explore, identify, imagine, create and evolve), in reality it is much messier and less linear. As the teachers became comfortable with the structure that the design process provided, I then encouraged them to break away from it in a more flexible and intuitive way.

The teachers found that the design process aligned well with other teaching models that they were already using within their practice. One teacher explained, "[Caylee's] way of designing projects goes hand in hand with the Universal Design for Learning that we are already practicing in our Pro-Ds" (Adam Lewis, personal communication, January 19, 2015). At Southridge School, they found that design-based learning aligned well with inquiry-based learning encouraged through the International Bacclaureate Programme.

The Power Point Planning Template provided to teachers was one of the most frequently used resources; "It helps me to kind of streamline my ideas and streamline my lesson plans so that they are more focused. When I'm more focused the kids get more focused on the projects as well" (Colleen Blackwell, personal communication, January 19, 2015). As teachers used the Power Point Planning Template (figure 68), I reviewed the changes that they made and this informed the design. Originally, I had a more complex template that restricted teachers from making changes to the format but this proved to be more frustrating for them than helpful.

Fig.68 Excerpt from a Power Point Template completed by a teacher to support her design project

The Design Challenge Cards and Process Activity Cards were also well used by the teachers, especially during collaborative planning sessions. They found that the cards helped by providing them with initial ideas that they could build off of. One teacher

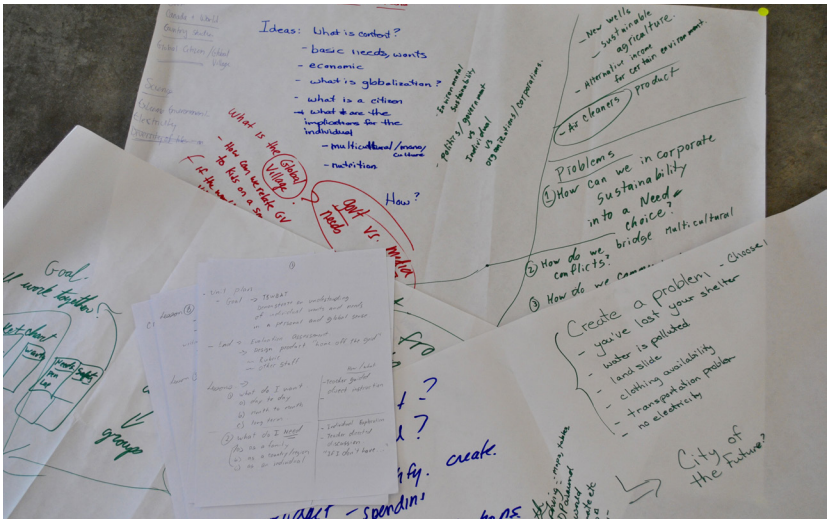


Fig.69 Teacher ideation from a collaborative planning session

explained that the cards increased his excitement towards lesson planning and encouraged collaboration amongst teachers. When the teachers were asked to generate their own project ideas using the cards, one teacher explained, "normally it would've been an arduous task, however immediately ideas started getting thrown down to the paper and by the end of it we had several projects which essentially encompassed all of the topics that needed to be taught during the year" (Adam Lewis, January 19, 2015).

One of the challenges that I faced when designing the Design Challenge Cards was determining an appropriate system for organizing and categorizing the cards. Since there is a large number of cards (55), I wanted to make it easier for teachers to search for a specific card or theme. However, I did not want to create such a restrictive system that teachers would only look at a few cards that were labeled as directly relevant to their curricular topic. Many design challenge ideas could relate to multiple themes or subjects so it did not make sense to group the cards by subject area. The final solution of listing keywords and providing an index for reference seemed to be an effective approach that allowed teachers to flip through the cards for spontaneous ideas or search through the index for a more direct approach. The cards are intentionally not organized or labeled by grade level as there is a lot of overlap in the curricular content and one of the advantages of design projects is that they can easily be made more or less challenging to suit a grade level, or to varying abilities within a grade.

Through email correspondence with teachers, I was able to get a sense of whether or not they were making use of the resources I had provided. Through an email update, one teacher informed me, "I'm going to start *Early Settlers* next week with my grade 5s and I'm going to go use the [design challenge] idea about exploration on Mars as an assessment" (Colleen Blackwell, personal communication, October 14, 2014).

The Process Activity Cards were developed after I observed that teachers tended to resort to familiar methods when leading design projects, such as asking students to draw on letter size paper or research through books and websites. There are many alternative methods used in design for 'creating' and 'exploring' that I wanted to introduce to teachers. The teachers found these cards helpful when planning design projects as the cards exposed teachers to new ideas and alternative formats. In a discussion with one teacher about the Process Activity Cards, he expressed that they would be useful for giving him ideas for classroom activities, even beyond design projects. For example, thinking about math, he pulled out the sidewalk chalk card and explained that this card could prompt him to mix up his math lesson by taking the kids outside. Used in this way, he described the cards as a valuable 'idea bank'(Adam Lewis, personal communication, October 27, 2014).

As a design coach, the Design Challenge Cards and Process Activity Cards also became a useful tool during coaching sessions. Often in a coaching session teachers will ask questions, that require me to generate a response on the spot. The cards act as a helpful reminder for me, and help me to express ideas more clearly to teachers.

A web-based interactive version of the cards was also considered, however the printed version is more effective for actively engaging teachers in conversation with a design coach, and with other teachers. The cards also allow for a teacher to physically sort and separate cards that are relevant to their specific project. A digital version could be considered as a secondary platform that would allow teachers to view the cards remotely, and search by key word automatically.

Through the iterative process of user testing and prototype development the resources evolved over time. The Planning Guide evolved most dramatically as the needs of the teachers became clear. For example, it became evident that the digital resources, although useful for teachers, were often forgotten when they were not accessible at hand or included with the print resources. For this reason, the Planning Guide, clearly outlines the digital resources and prompts teachers to access these within their planning process.

COACHING MODEL

Throughout the two-year collaboration at KGMS, teachers received regular coaching through in-classroom guidance, one-on-one planning sessions and collaborative group sessions. It was evident, that the coaching provided a valuable support structure for the teachers that could not be offered through the resources alone.

"With her knowledge of design and my knowledge of the classroom we can find a middle ground as to what will work best for the students"

Adam Lewis, KGMS Teacher

"The resource she's producing is great, but at the same time, having someone there who coached us through all of the different journeys and all of the different aspects of design was really important...It became very simple, very straightforward and something very doable by myself without even needing a coach in the future" (Neil Pinkerton, personal communication, January 19, 2015).

Initially I thought that coaching may be effective and more timely through email or online correspondence however it became clear that this was not a useful method for teachers as they do not spend much time sitting at their computers during the course of the day. In general, teachers are also very self-sufficient and are not used to reaching out for support; the teachers would rarely email me to ask questions even though they knew I was available. In-person coaching became an important way for me to check-in with teachers, respond to questions and provide suggestions.

"Having a designer actually working at the school has been absolutely critical. Caylee comes to work with us on a regular basis and brings an expertise that I don't have and that I don't know that I could have based on the training I've received" (Neil Pinkerton, January 19, 2015).

Case-based instruction, problem-based learning, critique and experimentation are signature pedagogies in art and design that are not common within education programs (Sims & Shreeve, 2012). In undergraduate design pedagogy, " teachers do not hold the answers before they begin to teach" (Sims & Shreeve, 2012, p.57), rather they support students in creating original outcomes through dialogue, critique and suggestions. These conversations often deal with open or unknown outcomes, hence art and design pedagogies are sometimes described as "pedagogies of ambiguity" (Sims & Shreeve, 2012, p.57-58). Elementary school teachers are less familiar with these pedagogic approaches and therefore benefit from support and coaching in this regard.

Through coaching, teachers were able to successfully transition from co-teaching to independent teaching. At KGMS we also saw teachers transition, in some respect, into the role of design coaches. As I introduced design to new teachers, they were able to seek support from the more experienced teachers. These new teachers didn't have the opportunity to watch me teach design within their classrooms, however, by talking to other teachers in the school and observing the design projects in progress in other classrooms they were able to gain a stronger understanding of the approach. After reviewing the introductory guide to design, one teacher explained, "I could understand it, because I'm seeing it in action here" (Tanya Hill, personal communication, December 11, 2014).

We saw that as more teachers began teaching design in their classrooms, more teachers got pulled into the project. In September of 2013 I started by coaching two teachers; in January of 2014 I started working with four more teachers; and now to date, thirteen teachers have been introduced to the design-based learning approach at KGMS. By starting small and building as we saw success the design coaching program naturally expanded. The flexible coaching model that we developed allowed for support to easily shift and accommodate changing and growing needs within the school.

"It's not about having someone come in and do this stuff for us, its about building capacity."

Dr. Jim Christopher,
Head of School at KGMS

5.5 Future Directions

RESOURCES

The resources created through this thesis project are directed at grade 4-7 teachers with an emphasis on the integration of design into social studies and science curriculum. Additional resources and Design Challenge Cards could be created for other grade levels and for design activities that connect with other subjects such as Math and Social Emotional Learning. These materials are intended as introductory resources; additional materials for more advanced applications of design would be useful.

These materials have been developed for use with the proposed design coaching model. Additional resources would be required to support alternative modes of dissemination and expansion, as outlined below. Further, resource materials would also be required to support the training of additional design coaches.

FURTHER EXPANSION

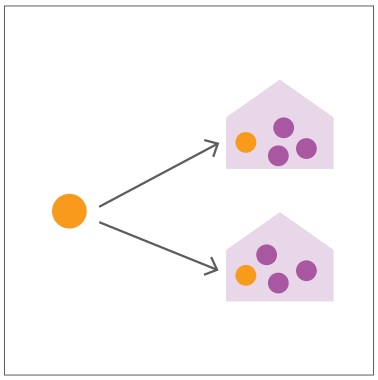


Fig.70 Current Model: As a design coach I offer support within a small number of schools.

There are several possibilities for the expanded dissemination of design-based learning, as illustrated in figures 71-78.

The current *Teaching With Design* model requires the use of design coaches to introduce teachers to design and for on-going professional development to create a sustained change in teaching practice. In order to support an expansion of *Teaching With Design* to additional schools across BC and beyond, additional design coaches would need to be hired and trained. This would require the development of a business model for an education consultancy or franchise that would offer professional development services and resources to schools (figure 71, 72). The resources that have been created would be one key touch-point within this larger service. Another key touch-point would be a robust website that could provide information about design-based learning, and highlight previous design projects as case study examples for teachers. This website would need to provide teachers and administrators with information about the *Teaching*

Models of Dissemination for Expansion

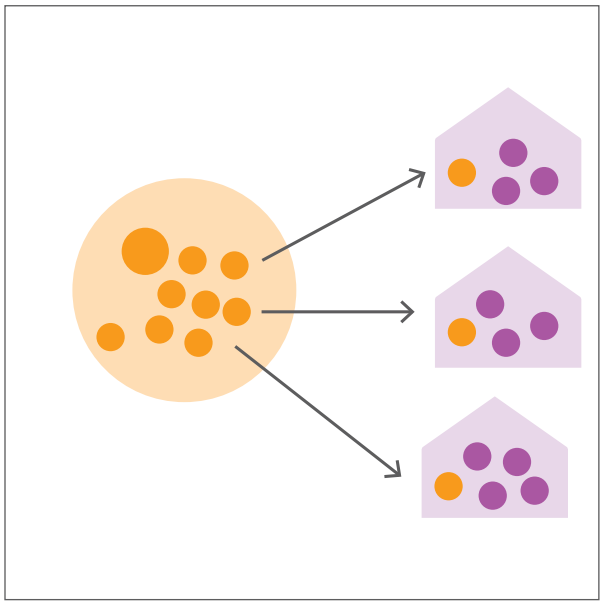


Fig.71 Design education consultancy offers embedded, sustained coaching within schools.

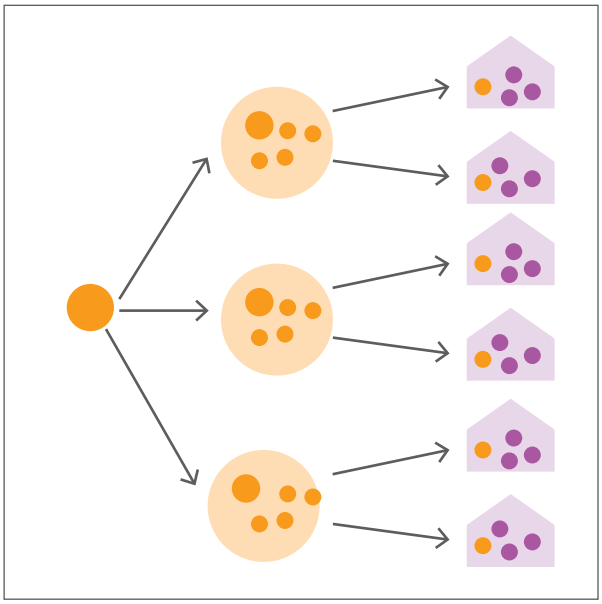


Fig.72 Franchise model. Lead design coach provides materials to design education franchises, who then offer embedded, sustained coaching.

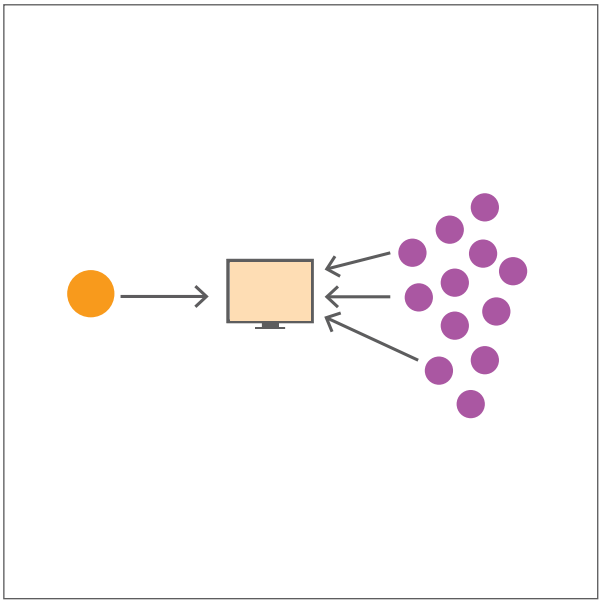


Fig.73 Traditional model where teachers learn design independently through a book or website.

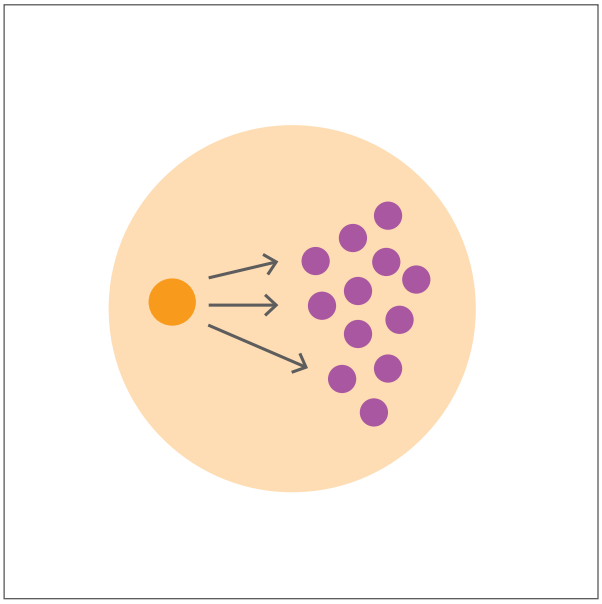


Fig.74 Training is provided by a design coach to individual teachers through a workshop.

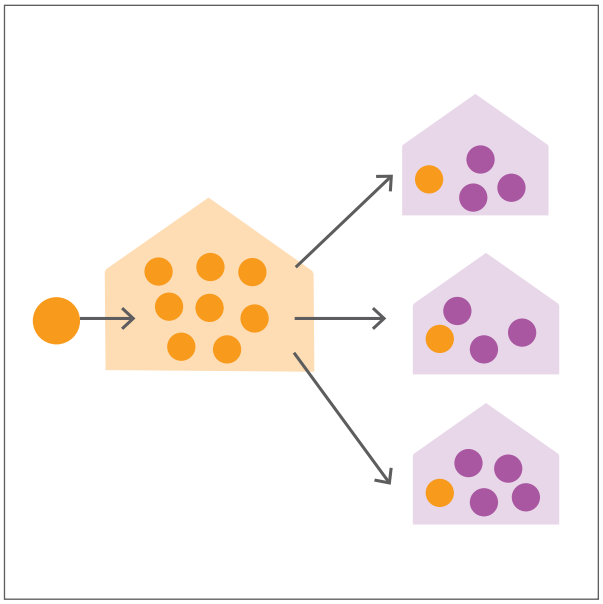


Fig.75 Post-secondary design students are trained as design coaches and then provide embedded training to teachers within K12 schools.

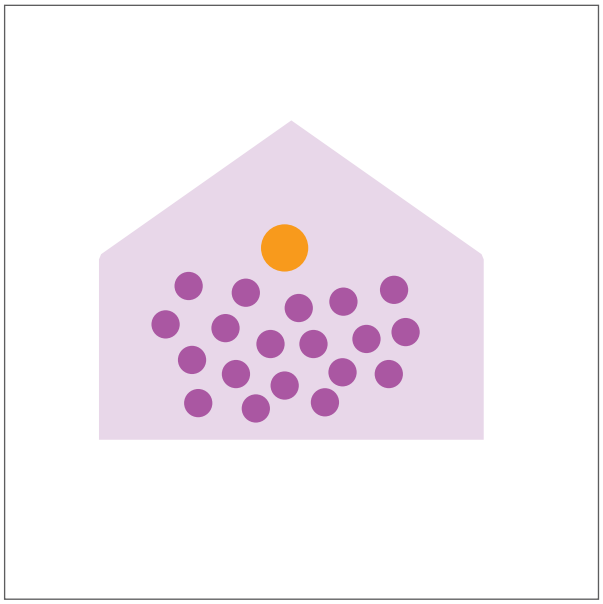


Fig.76 Teachers learn about design as part of their University education.

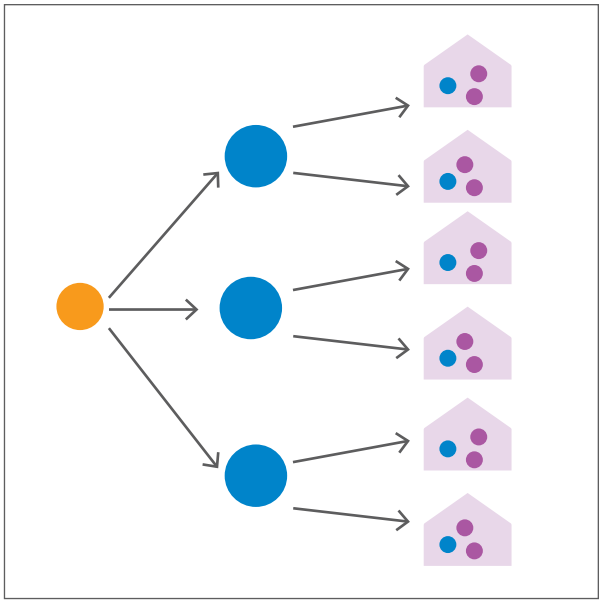


Fig.77 Partner with a third party organization such as the International Bacclaureate Programme (IB). Teach design to current IB Trainers, who can then support schools with design-based learning.

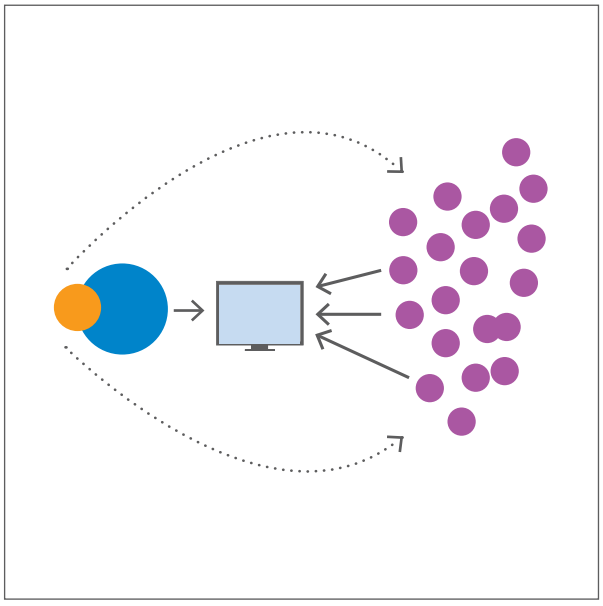


Fig.78 Partner with BC Ministry of Education to provide resources for teachers. May also include direct coaching.

With Design coaching model, including workshops and training opportunities. Such a website would also be used to provide secure access to the digital resources for schools who have purchased a license to the materials. A website could also host a forum for teachers to allow them to connect and share design project ideas. This would allow for teachers to support each other and provide a place for collaboration.

This proposed service model requires the development of a larger system for training coaches and disseminating resources. It also requires the support of administration and funding for professional development and coaching. This approach is more intensive and could limit the adoption of design-based learning to a broad audience. There is an opportunity to develop an additional set of resources for general distribution that would not require the use of design coaches. For example, resources could be created and sold through a third party website such as *Teachers Pay Teachers*, or developed into a book for dissemination through a publishing company (figure 73). Short 2-3 day workshops could also be offered as a way to engage teachers in design-based learning independently from their schools and administration (figure 74).

Additional models for expansion could also be considered, such as the alignment of *Teaching With Design* within a post-secondary design institution (figure 75). Coaching for K12 teachers could be offered through the institution and design students could be trained to provide coaching and support for the development of design projects. This would foster relationships between elementary and post-secondary institutions and would take advantage of a large body of design 'experts' found within design institutions.

Teaching With Design could also be introduced to teachers through an alignment with post-secondary education programs, such as the Faculty of Education at UBC (figure 76). This would embed design-based learning into existing educational programs and would introduce the approach to teachers at the beginning of their careers.

The International Baccalaureate Programme (IB) would be another key place for alignment (figure 77). The IB Programme

already has a series of certified trainers that provide professional development support within their schools. By introducing design-based learning to these trainers, dissemination could occur through the existing infrastructure established for support and mentorship within these schools. Design has recently been introduced into the IB Middle Years Programme (MYP) as its own course. This creates a clear opportunity for the integration of design coaches to support MYP teachers currently responsible for the delivery of this new course content. There is also an opportunity to introduce design-based learning into the Primary Years Programme (PYP) as a pre-cursor to MYP.

"All students should have equitable access to learning, opportunities for achievement, and the pursuit of excellence in all aspects of their educational programs."

BC Ministry of Education, Special Education Policy, 2014

Finally, there is an opportunity to further expand and disseminate the design-based learning approach through an alignment with the BC Ministry of Education and their current initiative to improve and revise curriculum (figure 78). This initiative includes efforts to establish more flexible curriculum "to better enable teachers to innovate and personalize learning", and places an emphasis on cross-curricular competencies including critical, creative and reflective thinking (BC Ministry of Education, 2013c, p.3). Given the alignment of these goals with the design-based learning approach, a partnership could be formed to offer design-based learning training and resources through the BC Ministry of Education website or through the BC Teachers Federation (BCTF). The support and promotion of the BC Ministry of Education would help to disseminate this approach and create opportunities for direct coaching within schools. A partnership would be beneficial within a public school setting where funding for professional development is limited.

Further inquiry into these options is necessary for larger-scale dissemination and widespread adoption of design-based learning.

RESEARCH

The *Teaching With Design* resources and coaching model have shown to be successful tools at KGMS and Southridge School. KGMS, as a school for children with learning differences, has a unique school structure and approach to teaching that aligns well with the design-based learning approach. Through testing with this student population we were able to see the benefits of this approach for a wide range of learners, with varying skills and abilities. Additional research at Southridge School, an International Baccalaureate private school, allowed for the testing of this approach within a different context and student population. Further testing of resources and the design coaching model at additional schools, with varying grade levels and student populations would be recommended.

In particular, it would be important to consider how this approach could be applied in a public school setting. At KGMS we have seen many benefits of the design-based learning approach for students with learning differences, and we have identified that this approach is effective for differentiated learning and for meeting a variety of student needs within a single classroom. Given the large class sizes and diverse population found within public school classrooms, this approach may help teachers to better meet the various needs of their students and may create a more supported, flexible and personalized learning environment. The public school system presents a significant opportunity.

"You'll see students who would normally struggle, just completely flourishing."

Adam Lewis, KGMS Teacher


DOMAINE
DE LA
DAMASE

6 APPENDIX

Fig.79 Tin can robot

6.1 Pre- and Post-Design Assessment

The following is a detailed description of the design assessment described in Section 4.2.2 on page 38.

OBJECTIVE

The purpose of this assessment was to see if students' spatial visual skills improved after several months of design lessons.

Spatial visual skills, including spatial orientation and spatial reasoning are important skills in design, as well as in many other disciplines and subjects. As described by Betty Garner (2007), spatial visualization is the ability to mentally represent and manipulate information, ideas, feelings and sensory experiences. Spatial orientation is the ability to identify and compare where objects and places are in relationship to each other and to oneself. She explains that these are essential skills for comprehension, planning, behaviour control, computations, motivation etc.

The assessment tool was co-development by Doris Wells-Papanek, MEd, the Director and Founder of the Design Learning Network, and Dr. Robert K. Greenleaf, the President of Greenleaf learning. Virginia Tze, a school psychologist with a PhD in School and Clinical Child Psychology, provided consultative support for the development of the measurement tool and scoring of the assessment. She also conducted the statistical analyses of the pre- and post-assessment results.

ASSESSMENT TOOL & METHOD

Divisions 6 & 7

In November 2013, 30 students in grades 5, 6 and 7 at Kenneth Gordon Maplewood School completed the pre-assessment. These students were in classes referred to as Divisions 6 and 7. Tutors at KGMS administered the pre-assessment in private tutoring

rooms with each student individually. The pre-assessment include two activities.

Activity #1: Floor Plan

In this activity students were asked to draw a floor plan of their home. If a student was not familiar with the term 'floor plan' the tutor provided the following description: "If you pulled the roof off of your home (house, apartment etc.) and looked at it from above, like a bird, what would you see? Draw a picture of what it would look like".

Students could receive a maximum of four points for their floor plan: 1 point for correct perspective; one point for sense of scale; 1 point for connected rooms (accuracy); 1 point for details added.

Activity #2: Image Comparison

In this activity students were asked to look at a series of four images (shown in figure 80). On the first sheet (see figure 81), Students were asked to identify at least three things that they noticed about Image 1. Students could record their own answer or the tutor could record the response for them. Students were then asked to identify at least three things that they noticed in

Figure 80a has been removed due to copyright restrictions. The information removed is a photo of a tree. Source: Leslie. (2009). Snips and Snails and Puppy Dog Tails: Autumn's Arboreally Cool Falling Leaves. Retrieved from http://www.snipsandsnailsandpuppydogtails.com/2009/11/autumns-arboreal-leaves.html

Figure 80b has been removed due to copyright restrictions. The information removed is a photo of Otty Lake. Source: Norm Hull. (n.d.). Otty Lake Management Plan. Retrieved from http://www.dnetownship.ca/content/otty-lake-management-plan

Figure 80c has been removed due to copyright restrictions. The information removed is a photo of boxes. Source: Pile of boxes. (n.d.). Retrieved from http://pixgood.com/pile-of-boxes.html

Figure 80d has been removed due to copyright restrictions. The information removed is a photo of a highway. Source: Ramanathan Kathiresan. (2008). Airborne View of US Highway System in Seattle City. Retrieved from https://www.flickr.com/photos/rampix/2983350797/

Fig.80 The image comparison activity involved these four images.

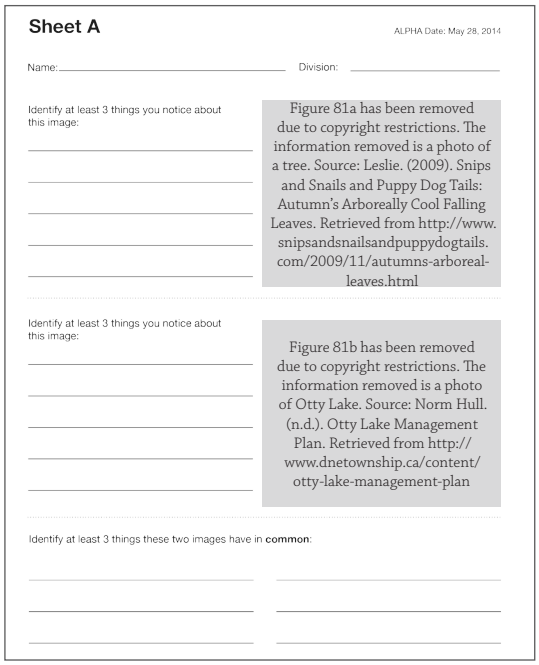


Fig.81 Image Comparison Activity, page 1

Image 2. Finally, students were asked to identify at least three things that the two images had in common.

This process was then repeated with images #3 and #4, and then again with images #1 and #4.

Students received one point for each response. When comparing two images, students were given a second point for each response that identified a similarity beyond a physical attribute. There was no maximum possible score for this activity.

Following the pre-assessment the students participated in weekly design lessons for seven months. In May, the students completed the post-assessment, which was identical to the pre-assessment.

Divisions 3, 4, 5, 9

In January 2014, an additional 56 students in grades 4 through 7 at Kenneth Gordon Maplewood School completed the pre-assessment. These students were in classes referred to as Division 3, 4, 5, 9. Tutors at KGMS administered the pre-assessment in private tutoring rooms with each student individually.

Division 3 - grade 4
Division 4 - grade 4/5
Division 5 - grade 5/6
Division 9 - grade 7

The pre-assessment included two activities. The activities in the pre-assessment for Divisions 3, 4, 5, 9 were similar to the assessment activities completed by Divisions 6 and 7, however the instructions differed slightly. The changes to the assessment tool were made after the first round of testing with Divisions 6 and 7, based on recommendations from Tze.

Activity #1: Floor Plan

In this activity students were asked to draw a floor plan of their classroom, instead of their home. This made it easier to score the assessments as we could compare the student drawings to the actual classroom layout. With Divisions 6 and 7 students could receive a maximum of four points for their floor plan. Tze recommended that we increase the point system to allow for more precision in the scoring. Students in Divisions 3, 4, 5 and 9 were scored on a 12 point system: 1 point for correct perspective,

1 point for sense of scale, up to 5 points for accuracy; and up to 5 points for level of detail.

Activity #2: Image Comparison
This activity used the same images and method as the activity completed by Divisions 6 and 7, however this time the images were in colour. Divisions 6 and 7 used black and white images, which had less clarity and seemed to distract the students. In this activity we also rephrased the instructions to say, "identify as many things as you can", instead of, "identify at least 3 things".

Students received one point for each response. When comparing two images, students were given a second point for each response that identified a similarity beyond a physical attribute. There was no maximum possible score for this activity.

For example, when comparing the box image (#3) to the highway image (#4), students were given one point if they said they both had square shapes. However, if students identified that items in both images were man-made, two points were given because this response showed that the students could connect the images to their personal experiences and knowledge.

Following the pre-assessment in Divisions 3, 4, 5, and 9 the students participated in weekly design lessons for four months. In May, the students completed the post-assessment, which was identical to the pre-assessment.

Data Analysis

After each pre- and post-assessment was scored, Tze performed paired t-test analysis to assess whether there was a statistically significant improvement in mean test scores ($p<0.05$) for each division. The paired t-test is used to identify whether a significant difference exists between pre- and post-measurement.

Analysis of Variance (ANOVA) was also conducted to exam whether there was difference between Divisions 6 and 7 on both pre-assessment and post-assessment. A second Analysis of Variance (ANOVA) was conducted to exam whether there was difference between Divisions 3, 4, 5 and 9 on both pre-assessment and post-assessment.

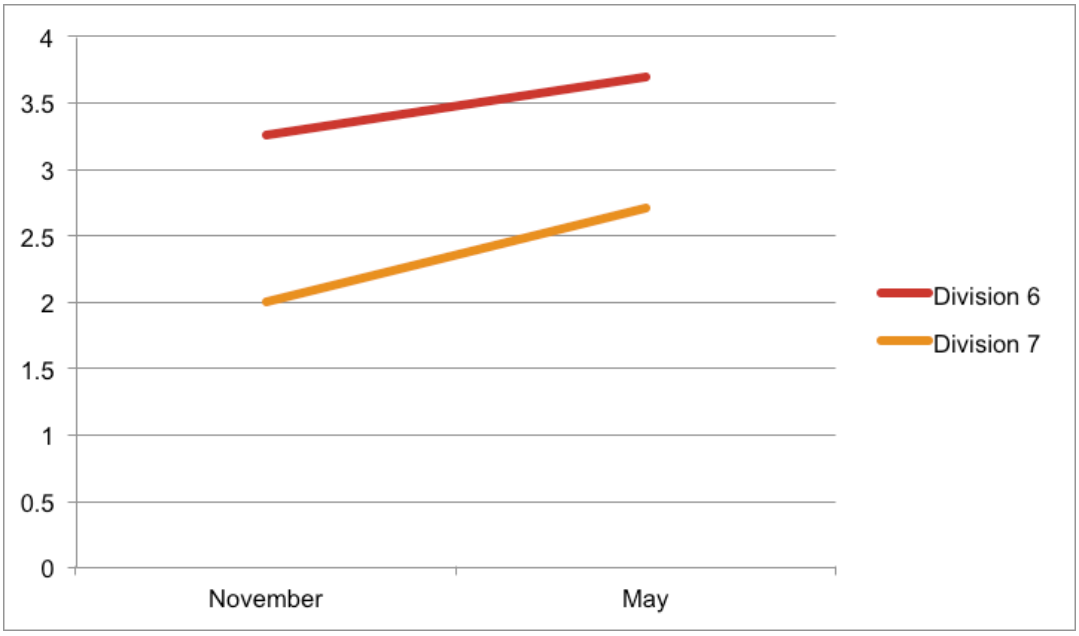


Fig.82 Floor Plan Activity: Comparison of pre- & post-assessment results from Divison 6 and 7 (7 months).

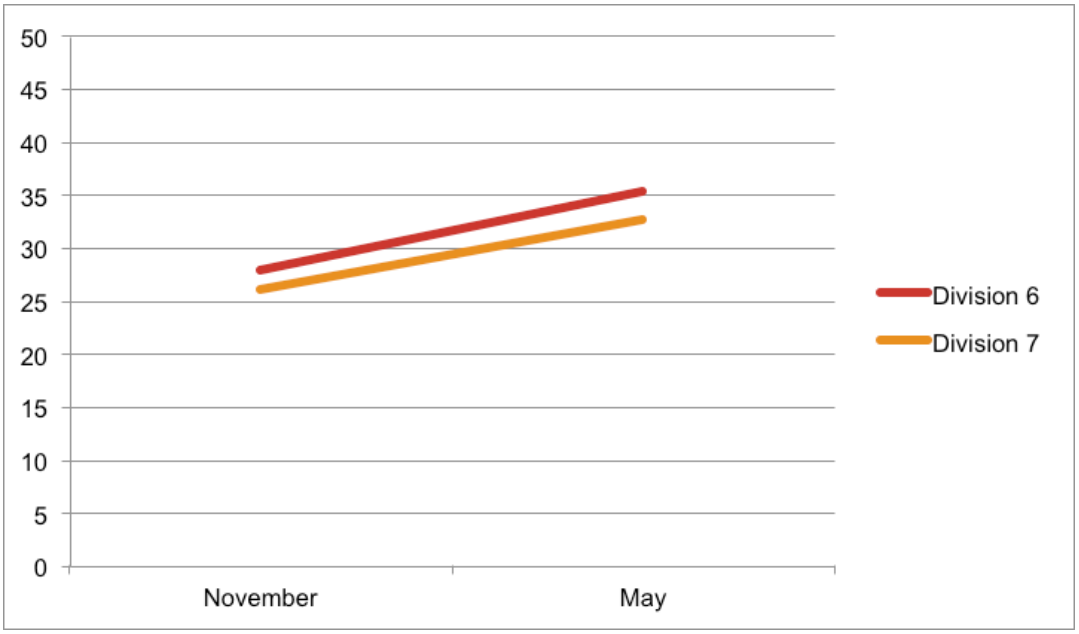


Fig.83 Image Comparison Activity: Comparison of pre- & post-assessment results from Division 6 and 7 (7 months).

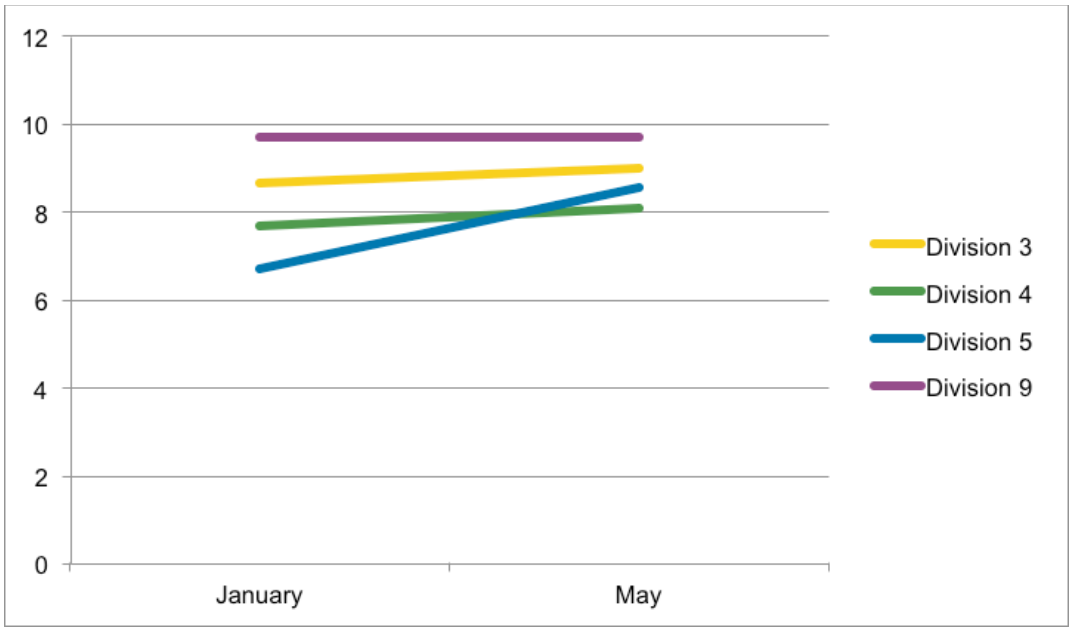


Fig.84 Floor Plan Activity: Comparison of pre- & post-assessment results from Division 3,4,5,9 (4 months).

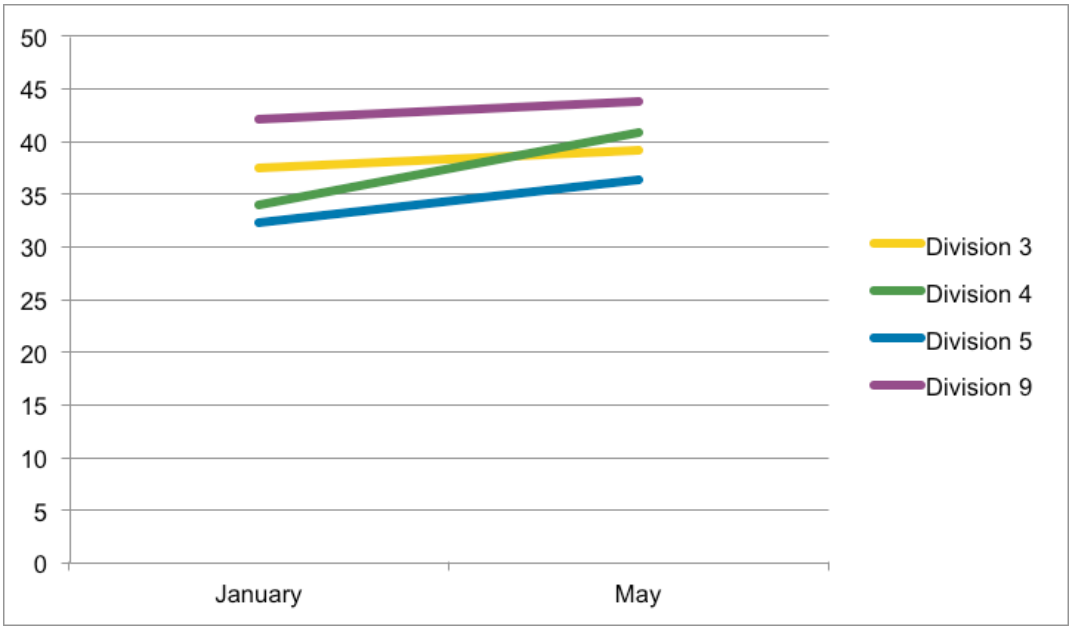


Fig.85 Image Comparison Activity: Comparison of pre- & post-assessment results from Division 3,4,5,9 (4 months).

RESULTS

In the floor plan activity, the paired t-test analysis showed significant improvement in Division 6 and 7 after seven months of design lessons and growth at a similar rate. After four months of design lessons, Division 5 also showed significant improvement. Division 6 showed mean improvement of 0.44 with p=0.048; Division 7 showed mean improvement of 0.71 with p=0.035; Division 5 showed mean improvement of 1.85 with p=0.038. The improvements for Divisions 3, 4, and 9 were not statistically significant.

In the image comparison activity, the paired t-test analysis showed significant improvement in Divisions 6 and 7 over a seven month period and growth at a similar rate. After four months of design, Divisions 4 and 5 also showed significant improvement. Division 6 showed mean improvement of 7.5 with p=0.018; Division 7 showed mean improvement of 6.57 with p=0.016; Division 4 showed mean improvement of 6.9286 with p=0.002; Division 5 showed mean improvement of 4 with p=0.020. The improvements for Division 3 and 9 were not statistically significant.

In the floor plan activity, Analysis of Variance showed a significant difference in the pre-test scores between Divisions 6 and 7 (F=9.333, p=0.005), and in the post-test scores for Divisions 6 and 7 (F=5.774, p=0.023).

In the image comparison activity, Analysis of Variance did not show a significant difference in the pre-test and post-test scores for Divisions 6 and 7.

In the floor plan activity, Analysis of Variance showed a significant difference in the pre-test scores among Divisions 3, 4, 5 and 9 (F=3.882, p=0.014). No significant difference was shown between Divisions 3, 4, 5 and 9 in the floor plan post-test and the image comparison pre- and post-test.

CONCLUSION

Results from these pre- and post-assessments showed that design-based learning had a significant impact on students' visual spatial skills. In the floor plan activity many students showed improvement in their level of detail and accuracy when drawing their classrooms. In the image comparison we saw an improvement in the quantity of responses that students provided as well as in the quality of the responses provided.

When comparing scores between classes, research findings showed a wide variance of scores in the floor plan activity between the class scores. However, in the image comparison activity there was no significant difference between the average score in each class. Wells-Papanek (Personal Communication, 2013) explained that the ability for students to score similarly in the image comparison activity, despite the significance difference in floor plan scores, demonstrates that students with weak functional mapping skills were still able to show flexibility with their imagination.

Students in Division 7 at KGMS are cognitively weaker than the students in division 6 based on their Psycho-Educational Assessments (a psychological test to analyze a child's mental processes that underlie his or her educational performance (CounsellingBC, 2000)). In the floor plan activity it was therefore not surprising to see that Division 6 was much stronger overall than Division 7, however it was surprising that in the image comparison activity both divisions scored within the same range. This was of particular interest to the administration at KGMS, who hope these visual spatial assessments may help to indicate that even though students may be academically or cognitively weak, they can still be successful in other skills and ways of thinking. These finding were also true for Division 3, 4, 5 and 9 in the pre-assessment, where the research showed a significant difference in the scores for the floor plan activity, but no significant difference in scores for the image comparison activity. In the post-assessment there was no significant difference between the scores in Division 3, 4, 5 and 9 in either activity. These initial findings present an opportunity for further research.

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