

The Making of a Makerspace: A Handbook on Getting Started

Shannon Welbourn, B.A. (Hons.), B.Ed.

Department of Educational Studies

Submitted in partial fulfillment  
of the requirements for the degree of  
Master of Education

Faculty of Education, Brock University

St. Catharines, Ontario

© Shannon Welbourn 2019

## Abstract

This research project sought to develop a makerspace handbook that is useful in supporting pre-service teacher candidates to integrate makerspace and maker mindset in their classrooms. As makerspaces have become more common in our schools and classrooms, the handbook was created to provide a practical, hands-on guide for getting started with designing and implementing makerspaces in K-12 classrooms and schools. This project investigated the knowledge needed to design and facilitate makerspace learning environments, developed the handbook *The Making of a Makerspace: A Handbook on Getting Started*, and collected expert feedback from reviewers of the handbook to contribute to teachers' knowledge about makerspace technologies. Emergent themes from data analysis included how the handbook supported three areas of makerspaces: (a) stations and activities, (b) the maker culture, and (c) future ready skill development. A resource such as this can grow and evolve but was designed to provide a foundation for pre-service teacher candidates getting started with makerspace design and maker mindset in their own teaching practice.

## Acknowledgements

I would like to offer bouquets of heartfelt thanks to both my advisor, Dr. Kamini Jaipal-Jamani, and my second reader, Dr. Candace Figg, whose endless support and guidance have encouraged me along this journey to completing my MRP. Their specialized research and position within teacher education provided expertise and knowledge which was essential for the success of this project. I cannot thank them both enough for providing me with the opportunity to work closely with each of them, and keeping me on track.

Additionally, I would like to thank my partner Neil, my son Dakota, and the rest of my family and friends. Whether it was playing John K. Samson's *When I Write My Master's Thesis*, or taking over laundry responsibilities and other household chores, or meal prep and clearing the dining room table of journal articles and books—again and again for family dinners on Sunday evenings—or simply remembering to ask me how the writing was coming along, each and every one of these actions and countless others continuously motivated and energized me. Everyone's belief and admiration fueled my drive to completion, and I am so grateful for the amazing support structure I have.

## Table of Contents

	<b>Page</b>
Abstract .....	ii
Acknowledgments.....	iii
List of Tables .....	vi
List of Figures .....	vii
<b>CHAPTER ONE: INTRODUCTION TO THE PROJECT.....</b>	<b>1</b>
Background of the Problem.....	2
Statement of the Problem in Context.....	2
Purpose of the Research Project .....	3
Research Questions .....	3
Rationale and Significance .....	4
Theoretical Framework .....	6
Scope and Limitations of the Project.....	8
Outline of the Remainder of the Document .....	9
<b>CHAPTER TWO: LITERATURE REVIEW.....</b>	<b>10</b>
What Is a Makerspace?.....	11
What Is a Maker?.....	12
What Is a Maker Mindset? .....	13
Self-Directed Inquiry-Based Learning .....	15
Maker in Faculties of Education.....	17
Future Ready Skills .....	18
Critical Thinking and Problem-Solving .....	20
Collaboration and Communication.....	25
How Others Got Started .....	27
Chapter Summary .....	37
<b>CHAPTER THREE: METHODS AND PROCEDURES .....</b>	<b>39</b>
Procedures .....	39
Sample and Population, Site, and Participant Selection.....	49
Data Collection.....	49
Data Analysis.....	50
Recommendations for Improving the Handbook .....	50
Ethical Considerations.....	52
Restatement of the Area of Study.....	52
<b>CHAPTER FOUR: THE RESOURCE.....</b>	<b>53</b>
<b>CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS .....</b>	<b>124</b>
Summary.....	124
Discussion.....	125
Implications for Practice.....	128

Implications for Future Research .....	129
Concluding Remarks .....	130
References.....	131
Appendix: Questionnaire for Reviewing Makerspace Handbook .....	137

## List of Tables

<b>Table</b>	<b>Page</b>
1. Essential Components of Critical Thinking and Problem-Solving Skills ...	21
2. Essential Components of Creativity and Innovation Skills.....	22
3. Essential Components of Collaboration and Communication Skills .....	26
4. List of Fun Gadgets and Technologies Included in Nicholas Provenzano’s Makerspace .....	36
5. Stations of Choice to Explore at TCEA Makers .....	43
6. Review of Makerspace Handbook.....	51

## List of Figures

<b>Figure</b>	<b>Page</b>
1. Laura Fleming's important steps for planning a makerspace.....	30
2. Kolb's four-stage experiential learning cycle used to investigate the knowledge needed to design and facilitate makerspace learning environments.....	41
3. An example of the colourful makerspace display set up for an event.....	47

## CHAPTER ONE: INTRODUCTION TO THE PROJECT

This is a study of how makerspaces support the development of pre-service teacher candidates' knowledge of teaching with technologies for 21st century competencies. According to the *Horizon Report 2017* (Freeman, Adams Becker, Cummins, Davis, & Hall Giesinger, 2017) and *Horizon Report 2018* (Adams Becker et al., 2018), makerspaces have continued to be a newsworthy topic, appearing in every edition since it was first featured in the 2015 report. As suggested in the 2018 *Horizon Report*, makerspaces are becoming an integral part of teaching and learning, and there are increasing numbers of makerspaces found in K-12 schools, showing the importance of offering these hands-on makerspace experiences to pre-service teacher candidates in teacher education programs (Figg, Rowsell, Welbourn, & Pelchat, 2018).

Makerspaces provide learning environments in which learners explore and discover various resources and materials—an environment where learners find beads to construct bracelets, wood and construction tools to construct birdhouses or other items, sewing machines to learn how to sew, duct tape for creative building, and other resources that stimulate creativity and exploration. Learners also program robots, and code with a variety of robots and 3D printers/tools. Makerspaces offer learner-directed creativity and choice, moving beyond traditional learning approaches, while empowering learners to develop critical thinking and authentic learning (Freeman et al., 2017), and as technology continually advances, provides those resources for exploration to the curious mind. It is therefore important for pre-service teacher candidates to also experience makerspaces, so they can develop, enhance, and understand how to integrate makerspace technologies into their own classrooms.



## **Background of the Problem**

The term “makerspace” is currently a buzz word in education but most often refers to the collection of resources in one “space” that provides learners with opportunities for creating hands-on approaches and real-world problem solving, which Papavlasopoulou, Giannakos, and Jaccheri (2016) explain are valuable and robust learning experiences. Gerstein (2014) suggests that where and how learning occurs has changed the experience of what is learned; the “makerspace is more than a space itself, it is a mindset that can and should be taught” (Roffey, Sverko, & Therien, 2016, p. 9). Fleming (2015b) further explains, “To define a school makerspace by its purpose and simplest of terms, it is a place where young people have an opportunity to explore their own interests; learn to use tools and materials, both physical and virtual; and develop creative projects” (p. 5). These experiences provide the learners with choice, allowing active participation in their learning, “moving from consumption to creation and turning knowledge into action” (Fleming, 2015b, p. 7). There is a need to create spaces where the students are able to create and problem solve, whether building or designing or coding, while having the freedom to explore in their own way, but knowing the teacher will be at their side to guide or encourage when needed; these are the spaces that will prepare our students for the demands of the future (McKibben, 2014).

## **Statement of the Problem in Context**

As makerspaces have become more common in our schools and classrooms, the need for makerspace education is essential. Learners in K-12 schools are expected to gain specific 21st century skills and experiences by the time they graduate (Schrum & Levin, 2016). Kurti, Kurti, and Fleming (2014) assert that this 21st century skill learning

requires student-initiated learning opportunities; therefore, a teacher must know how to guide a student through inquiry-based learning even though they are not able to fully understand what that individual student learner needs. As such, it would make sense that pre-service teacher candidates are exposed to these types of learning experiences and makerspace opportunities so they can teach K-12 students these skills and begin to integrate these technologies and design learning environments that support the development of 21st century skills into their own teaching and classroom practice. Pre-service teacher candidates need to learn about the maker movement so they can be better teachers in the digital classroom, encourage their students' creativity and natural maker abilities, while better preparing their students for the future (Schrum & Levin, 2016).

### **Purpose of the Research Project**

The purpose of this research project was to design a handbook to assist pre-service teacher candidates in integrating makerspace and maker mindset in their own classrooms. This handbook can be used as a guide for creating similar experiences for their students. The handbook is a useful resource on its own and can be built upon further when pre-service teacher candidates have an additional opportunity to participate in a makerspace event. The latter gives them an experiential foundation and context upon which they can develop their own creative approach to integrating makerspaces in their own classrooms.

### **Research Questions**

The goal of the makerspace handbook is to provide a clear understanding of makerspaces, and what goes into setting up a makerspace. I will share my experiences with makerspace, including a step-by-step guide showing how to set-up a variety of

different stations and the materials required, while delving into how other educators have set-up their Makerspaces. Through the development of this resource, the following research questions will be addressed:

- What is makerspace, maker, and maker mindset?
- What technologies are incorporated into makerspace?
- How are the key future ready skills of critical thinking and problem solving; creativity and innovation; collaboration and communication intertwined within the makerspace and maker mindset learning environment?

### **Rationale and Significance**

My makerspace journey began long before the popularity of Do-It-Yourself (DIY), Hackerspaces, Makerspaces, and FabLabs ever came about. My space was my craft room and it was my most favourite space in which to spend time. It was filled with construction paper, glue, crayons, pencil crayons, markers, popsicle sticks, scissors, paint, paint brushes, glitter, beads, stickers, cardboard, tissue paper, shoe boxes, yarn, buttons, sewing supplies, my grandma's old knee press sewing machine, and all sorts of other bits and bobs. It was the ultimate imagination and creativity room, where no one told me what I had to do (other than the weekly reminder to keep things tidy), and every day was filled with endless possibilities. I was fortunate to have this space which allowed me the opportunity to be creative and make things, and to have so many positive experiences as a young child.

Looking back on these experiences, I realize they have had a huge impact on who I am today and have especially influenced my beliefs as an educator. I did not realize at the time, but I was already developing critical thinking skills and problem solving at a

very early age. I set challenges for myself and designed and created things to “fix” or solve the challenges. When I couldn’t figure something out or needed help, I would ask my parents or brother for their ideas to help me work through things from another perspective. I was learning and growing from my mistakes, often using trial and error to solve the various challenges I had set for myself. I was developing a maker mindset—long before it would become a common term of today. My personal experiences in my “craft space–makerspace” demonstrated many of the 21st century skills we are working to infuse in today’s classrooms.

When I became the Library and Media Services Supervisor in the Instructional Resource Centre (IRC) of Brock University’s Hamilton Campus, I pursued makerspaces and maker mindset within a library-like setting. In collaboration with the IRC Manager and support of the Faculty of Education, we created makerspaces in each of our IRCs, and we hosted several makerspace events for our pre-service teacher candidates and teachers in the community. A strong focus of our makerspace was built on our belief of what was needed to prepare students with future ready skills, which aligns with the P21 Partnership for 21st Century Learning (P21) framework that states, “A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future” (P21, 2019, p. 4).

The handbook, presented in Chapter 4, is a practical resource to assist pre-service teacher candidates with integrating makerspace technologies into their classrooms. Although useful as a stand-alone guide, the pre-service teacher candidates who are first able to experience our makerspace events will have a stronger understanding of the context of the handbook. The ability to prepare our students for unknown futures starts

with the teachers being comfortable with ever-changing technologies and embracing a maker mindset. Modelling makerspace for our pre-service teacher candidates prepares them to teach the students of tomorrow (Figg et al., 2018).

The handbook will be a beneficial resource for teachers to use for setting up makerspaces in their own classrooms, libraries, or schools and will highlight why makerspaces are important for preparing students with future ready skills such as critical thinking and problem solving; creativity and innovation; collaboration; and communication. It will provide suggested purchases and a guide to materials and consumable supplies, as well as identifying specific stations and accompanying supplies for each. Despite some uncertainty of how to get started, creating a makerspace does not need to be overwhelming. The handbook will ultimately take readers step-by-step through set-up and provide a foundational introduction to makerspace knowledge.

### **Theoretical Framework**

When investigating makerspaces, it is difficult to anchor the research to a single theoretical framework. With early roots in Dewey's (1938) constructivist theory and experiential learning to Piaget's (1973) constructivism and Vygotsky's (1978) social constructivist theory, making is considered an active experience where the maker is at the centre of their learning (Ackermann, 2001; Hsu, Baldwin, & Ching, 2017; Shively, 2017). Enter Papert (1980) with the infusion of technology and constructionism, where learners are viewed as being self-directed in exploring their current environment which leads to stronger comprehension (Ackermann, 2001). Stager (2013) in collaboration with Dr. Seymour Papert, developed the Constructionist Learning Laboratory, "an environment in which knowledge was constructed inside the head of the learner through

the act of making something shareable outside of their head” (p. 487). Makerspaces and the maker movement has its roots in all of these learning theories.

However, this study examines how makerspaces can support the development of pre-service teacher candidates’ knowledge of teaching with technologies for 21st century competencies. Therefore, the act of teaching using these learning environments and the technologies often available through makerspaces is more closely related to the theoretical construct of Technological Pedagogical and Content Knowledge (TPACK)—the learning theory that explains how teachers develop knowledge about how to teach with and promote learning with technologies—than those that focus just on experiential learning and maker mindset. The TPACK framework describes the intersections of technological knowledge (TK), pedagogical content knowledge (PCK), content knowledge (CK), and pedagogical knowledge (PK; Mishra & Koehler, 2006). Figg and Jaipal (2009) further identified the types of learning activities that promote the building of these different types of professional knowledge. For example, research has shown that new teachers are more likely to integrate technologies into their practice when they feel they have appropriate technical knowledge and truly believe in their ability to successfully integrate technologies (Cohen, 2017). However, Mishra and Koehler (2006) explain that this technical knowledge (TK) is just one part of the knowledge that teachers must have in order to be successful with integrating technologies; teachers must also have experiences related to the pedagogy of using those tools and the usefulness of tools for teaching specific content. Figg et al. (2018) suggest that makerspaces support the development of TPACK by

providing teachers with opportunities to gain familiarity with multiple types of

technologies (which builds Technical Knowledge), see modeling of how technologies enhance structured and informal learning environments (which enhances Technological Pedagogical Knowledge), discuss how different types of makerspace activities map to the curriculum (enhancing Technological Content Knowledge), and engage in the process of critical thinking and problem solving as participants in makerspaces (which engages teachers in using Technological Pedagogical Content Knowledge). (p. 2038)

Therefore, it is relevant to explore how makerspace experiences and maker mindset infused in a teacher education program can assist pre-service teacher candidates in developing their TPACK (Cohen, 2017; Figg et al., 2018).

### **Scope and Limitations of the Project**

For the purpose of this project, the focus will be on introducing makerspaces to pre-service teacher candidates in order to assist them with developing stronger abilities for meaningful integration of technologies.

There also are some limitations to acknowledge. Although the development of the handbook will be influenced by my participation in the design and implementation of makerspace events for the pre-service teacher candidates at Brock University during 2017-2019, the handbook does not describe how to create a makerspace for all possible situations and cannot take into consideration the situation that might exist for every reader of the handbook.

### **Outline of the Remainder of the Document**

Chapter 2 is a review of the literature surrounding makerspaces including what is makerspace, who is a maker, and what is the maker mindset. Also, self-directed inquiry

learning, making in Faculties of Education, and the type of 21st Century learning skills referred to as “future ready skills,” will be discussed. Lastly, a spotlight on how two other well-known makers got started will be included.

Chapter 3 outlines the research methods and procedures used in the development of the makerspace handbook. It explains the personal experiences of attending makerspaces in Texas and England, and how these experiences informed the practical set-up of the IRC makerspace events which formed the foundation for the makerspace resource which provides a step-by-step guide. Chapter 3 also describes the methods used to acquire feedback as to the effectiveness and quality of the handbook to promote the ability of pre-service teacher candidates to use makerspaces within their own teaching practices.

Chapter 4 is the tangible product, the makerspace handbook, *The Making of a Makerspace: A Handbook on Getting Started*, created to assist pre-service teacher candidates or practising teachers in implementing and integrating maker into their spaces.

Lastly, Chapter 5 summarizes the discussion and key findings. It also looks at implications and guides future research surrounding makerspaces and their classroom or school use.



## CHAPTER TWO: A REVIEW OF THE LITERATURE

As this research project's focus is on supporting the growth of pre-service teacher candidates' knowledge about how makerspaces promote teaching with technologies for 21st century competencies, it is important to establish how the current literature about makerspaces and teaching with technologies informs the study. Exploring the literature has shown that makerspace technologies are abundant in K-12 education (Cohen, 2017). As such, supporting pre-service teacher candidates' growth and understanding of makerspaces and how they can enhance their students' 21st century competencies and learning experiences, is essential for their own TPACK development.

This review of the literature begins by defining the term "makerspace," followed by what is a maker and an explanation of the maker mindset. These three terms help to set the stage for an understanding of the makerspace and technologies that can be found in such a space. Next, the chapter looks at the intersection of self-directed and inquiry learning that are the two types of learning experiences most often enabled through makerspaces, followed by an exploration of how makerspaces have been employed in a faculty of education to prepare pre-service teacher candidates to design and teach with these learning environments. Then, the chapter examines future ready skills—otherwise referred to as 21st century competencies—that are often developed through the makerspace experiences. Lastly, the chapter highlights two prominent people who have both written a book about their experiences with makerspaces, how they define makerspaces, their early beginnings, and influences, and how they planned and set-up their makerspaces.

## What Is a Makerspace?

According to Educause (2013),

Makerspaces are zones of self-directed learning. Their hands-on character, coupled with the tools and raw materials that support invention, provide the ultimate workshop for the tinkerer and the perfect educational space for individuals who learn best by doing. ... They promote multidisciplinary thinking and learning, enriching the projects that are built there and the value of the makerspace as an educational venue. (p. 2)

A little closer to home, Canada Research Chair in Technology and Pedagogy (2015-2020) and UOIT Professor Janette Hughes states “Makerspaces are creative spaces where people gather to tinker, create, invent, and learn” (p. 1).

Although we do not have one unified definition for makerspaces, several people and a variety of groups have provided versions of how to define what makerspace means to them. Some speak to the literal “space” such as Blackley, Sheffield, Maynard, Koul, and Walker (2017) who state, “*Makerspaces* are physical spaces that have been designed or set aside to support the maker in the creation, design, and building of new projects and technologies” (p. 23). Likewise, even within a physical space, no two makerspaces are identical. Commonality is the shared space or “gathering point” (Maker Media, 2013, p. 1) where people can come together and work on projects, work alone, or with help from another who may be knowledgeable in the area of exploration, and have use of various tools that may not otherwise be accessible—all in a variety of spaces that have no defined space limit, but are understood by the making they empower (Maker Media, 2013). The unique nature of makerspaces derives from addressing what the community needs

(Hughes, 2017) and therefore building or creating a space that suits the interest of the community of makers using the makerspace is necessary.

Makerspaces provide a space, and also an opportunity, to design and create, where students can work collaboratively with others, and use trial and error to solve problems through several iterations. These opportunities allow for students to experience learning in new or different ways. Makerspaces provide engaging experiences, promoting STEAM (science, technology, engineering, art, and math) and innovative curriculum alignment, nurturing risk-taking and equity of resources for all learners (Bonagura, 2017). Makerspaces promote access to all learners, offering “multiple pathways to learning” (Martinez & Stager, 2013, p. 3) and a “range of learning styles” (Blackley et al., 2017, p. 23).

When the term makerspace launched out of the introduction of Dale Dougherty’s *Make Magazine* in 2005, some believed makerspaces were something new. However, Bonagura (2017) suggests that it is clear that makerspaces emerged from fundamental educational theories such as “Piaget’s Constructivist Learning, Renzulli’s Enrichment for All, and project-based learning (PBL)” (p. 14). Makerspaces are for everyone, and provide for engaging experiences that promote shared or individual creativity and growth.

### **What Is Maker?**

*“We, as individuals, define Maker for ourselves. We determine what a Maker is for us”* (Provenzano, 2016, p. 10). The definition of a maker is dependent upon how we define ourselves as a maker. Making things aligns with DIY and favourite pastimes. Whether knitting or crocheting, or building with Lego, coding a robot, or 3D printing and design, these are all examples of things a maker makes, and is a personal choice of the

individual. “Having the title of Maker defined by someone else is ridiculous, and it seems to be the antithesis of what being a Maker is all about” (Provenzano, 2016, p. 10).

Individuality is foundational as a maker and defies standardized educational practices that attempt to remove what is unique in each of us (Kurti et al., 2014). According to *The Maker Manifesto*, “Making is fundamental to what it means to be human. We must make, create and express ourselves to feel whole. There is something unique about making physical things. These things are like little pieces of us and seem to embody portions of our souls” (Hatch, 2014, p. 11). This personal form of expression allows each of us, as makers, to share what is unique about us in a variety of ways.

### **What Is Maker Mindset?**

The maker mindset goes beyond the physical space or the various tools and materials that are available within a makerspace. The maker mindset stems from previous research by Carol Dweck (2006) about fixed versus growth mindset. Having a fixed mindset causes one to believe that what they are capable of is out of their control and stifles their potential. With a growth mindset, one has the ability to adapt and change to the ongoing surroundings as they occur.

The maker mindset fosters creativity and innovation, risk-taking and problem-solving (Dougherty, 2013) by providing a safe environment to explore ideas and inviting the learner to think in different ways with a “can-do attitude” (Dougherty, 2013, p. 9) and to build upon what they may already know. Makers adopt a mindset that they can develop and grow, and that their willingness to explore and try new approaches can make a difference to the world around them (Dougherty, 2016).

People can get caught up in the word “space”, but it is far more than the room or the physical space, or the tools and supplies within it (Provenzano, 2016). It is a mindset. It is the way we think about things and how we approach learning. Blackley et al. (2017) state how the “maker approach” (p. 23) provides makers with an opportunity to learn in a wide variety of ways. Each learner has a different learning style, and we have an opportunity to build on our own experiences and those of others as well. “The Maker Movement encourages a growth mindset” which promotes trial and error, learning from mistakes, and growing out of failures while preparing for the future (Fleming, 2015b, p. 9). When learners take risks, resulting in failures or mistakes, their skills are developed as they reflect and build upon their strategies, which all promote growth and advancement (Sharples et al., 2013).

The growth mindset creates a maker culture, shared by learners who are motivated to create with their peers, or meet new people through shared interests (Sharples et al., 2013). This learning lends itself to collaborative possibilities that support taking risks. The learning opportunities provided by failed attempts help to develop the maker mindset, which can help students to persevere across all areas. These opportunities can fall outside of their traditional day to day classroom experiences and extend their learning beyond and into real life scenarios (Fleming, 2015b), while also cultivating opportunities for hands-on investigation and creation (Rix, 2014). These hands-on experiences allow students a sense of pride and accomplishment as they are able to problem solve and stick with it while working to completion of whatever task they are creating.

A risk-taking culture where failure is applauded, and with more failure an increased comfort can be developed through a maker culture, and failures turn into

opportunities for success (Fleming, 2015b). Schools that are able to promote this type of learning community engage students and teachers in learning how to look at each learning experience and embrace the moment in which they look at the problem in a different way (Fleming, 2015b). As shared by Hughes (2017), “A maker culture promotes risk-taking, learning from mistakes, problem-solving, and developing an ability to persevere when tasks are difficult” (p. 2). In providing opportunities to fail, embracing a mindset which allows for thinking about things in different ways, and encouraging how one can grow through making mistakes, schools provide a culture of learning where students can feel safe and empowered in their pathways to success.

### **Self-Directed Inquiry-Based Learning**

Creating an environment for learning that suits the needs of individual learners is an important fundamental quality for makerspace success. “GREAT makerspaces give students a choice and allow them to take control of their own learning” (Fleming, 2018, p. 8). Spaces where learners want to spend time is important since “students must be attracted to the space and be inspired to use it” (Kurti et al., 2014, p. 9). Hughes (2017) suggests that in order to ensure that students will want to use the space, we must “take time to find out what students want to do in the makerspace and tailor the space accordingly” (p. 2). The space, after all, is for learners—to enrich their learning process and allow them opportunities to learn and grow. The ideal “educational makerspaces are based on student ownership of their learning” (Kurti et al., 2014, p. 11). Krishnamurthi and Rennie (2013) share that student-centred learning designed in a way that allows for choice gives learners an opportunity to discover different interests during enriched experiences. We do not direct the students to specific tasks they must complete, but rather

allow students to select and choose which stations they wish to explore, and in which order they wish to explore. Although we do offer some guidance, the students are not told specifically what they need to create or complete, leaving much room for self-directed learning, setting their own pace, where they can explore the materials found at the specific stations and use in creative ways. Dewey believed, as shared by Fleming (2015b) “children had to participate actively in their own learning, with the teacher taking the role of a partner, a guiding influence, in that process” (p. 3), speaking to the importance of inquiry and not structuring or prescribing pre-determined and specific methods to outcomes. “The benefit of increased student agency over learning, the authentic connections we make to the world around us, and the twenty-first-century skills Inquiry-Based Learning (IBL) nurtures provide great reason to explore how inquiry can enhance what you are doing in your own classroom” (MacKenzie, 2016, p. 9).

Acknowledging the benefits to the classroom as a whole when students are given choice and an opportunity to be a valued partner in their own education, being given a voice to break out of traditional learning of desks in rows, and a teacher at the front of the room telling everyone what to do, allowing students to try things on their own, to figure things out and persevere, with the teacher on the side, encouraging and supporting the process in whatever capacity is needed—that’s the student directed learning through inquiry, and the moments of learning that will be impactful. As Fleming (2015b) reminds us,

Talk to your students. They are your stakeholders. Invite students to discuss their interests and share their opinions. This model of integrated decision making,

focused on the goal of maximizing the impact of your makerspace, will help ensure a student-centered learning environment. (p. 13)

However, “Inquiry-based learning is more than asking a student what he or she wants to know. It’s about triggering curiosity. And activating a student’s curiosity is, I would argue, a far more important and complex goal than mere information delivery” (Wolpert-Gowron, 2016, para. 1). The more we allow the freedom to explore and create, the more we “Empower students to become the Makers they want to be” (Provenzano, 2016, p. 13). We give the tools—put the tools in place—so they can be creative, but also knowing the potential limits while working beside them, so you can offer encouragement when needed to help inspire them to continue and persevere. Provenzano (2016) elaborates further that when we give students opportunities to make and showcase their creations, we enhance the chances of students continuing to create rather than be users of the creations.

### **Maker in Faculties of Education**

Wolpert-Gawron (2016) states that encouraging students to want to learn new things can be difficult and it is necessary to find ways to spark their interest or help them to be intrigued by constantly leading by example and showing enthusiasm and excitement for what you are accomplishing. Modelling makerspace for pre-service teacher candidates prepares them for getting their students interested in maker ideas, where they can use their own ideas to create. Exposing learners to new ways to learn and possibilities for creative, hands-on activities that they may not otherwise have had a chance to explore or learn about in their day to day lives. Allowing opportunities to try new things in a makerspace, students are given the opportunity to direct their own learning, in the order



and pace they wish to learn and complete tasks in (Provenzano, 2016). Activities that involve “tinkering and making support collaborative, iterative design methodology, where student-centered projects prepare students for real-world challenges in careers and college” (Martinez & Stager, 2014, para. 45).

Makerspace events where pre-service teacher candidates participate as the learners, or makers, in the event are able to think about how they could bring these maker ideas into their own classroom through their own self-directed exploration and discovery, and also recognize the importance of student voice. There is plenty of room for curiosity and the maker mindset to develop. “What students want to learn and make always comes first, and they find the tools that support their interests” (Provenzano, 2016, p. 59). When you give students a voice in their learning, they believe they can have a positive impact and effect change (Dougherty, 2016).

To prepare students for the future, educators need to think about how we teach and deliver information. “We want students to extend beyond reporting and to seek answers to authentic questions. Collaboration between teachers and media specialists can result in authentic inquiry and can develop life-long learning dispositions” (Smay & Walker, 2015, p. 43). Exposure to a variety of materials and tools, with a combination of low and high technologies, allow learners to have choice as they investigate and creatively explore while developing future ready skills.

### **Future Ready Skills**

Provenzano (2016) explains that innovation and critical thinking happens when students are provided with the freedom and space to explore a learning need. As well, spaces that also promote inquiry, confidence to try new things, and perseverance through

multiple attempts and trials result in developing better questions for deeper understanding (Kurti et al., 2014).

Bannan (2016) interviewed several educators and education technology coordinators from across the United States who have been working with makerspaces as a way to encourage students to innovate and build critical thinking skills. Among these interviews, teachers shared that makerspaces have been beneficial to their schools as they were helping students to develop new skills of innovation. One claimed that giving students the opportunity to develop their learning in makerspaces was the best way to enrich their learning and ensure future success. One of the interviewees stated, “Makerspaces are changing the way students learn today and potentially how they live and work in the future” (as cited in Bannan, 2016, para. 33).

The Framework for 21st Century Learning focuses on “21st century student outcomes [which] are the knowledge, skills, and expertise students should master to succeed in work and life in the 21st century” (P21, 2019, p. 3). The learning outcomes for “Learning and Innovation Skills” are the primary focus from this framework that is explored and related to the Makerspace and maker mindset. P21 (2019) states that

Learning and innovation skills increasingly are being recognized as the skills that separate students who are prepared for increasingly complex life and work environments in the 21st century, and those who are not. A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future. (p. 4)

Blackley et al. (2017) in their research with pre-service teachers surrounding makerspace and reflective practice, set out to “highlight and develop the 21st century learning skills of: collaboration, communication, creativity, and problem solving” (p. 24).

“Innovation isn’t something you can force on people, especially students. Innovation tends to come from a need and the space and freedom to explore. Their innovations will happen organically, and students will learn amazing new things on their own” (Provenzano, 2016, p. 23). Makerspaces provide these “spaces” and allow the freedom to explore. Makerspaces promote inquiry, confidence to try new things and perseverance through multiple attempts and trials, which result in developing better questions for deeper understanding (Fleming, 2015b; Kurti et al., 2014).

### **Critical Thinking and Problem Solving**

According to the Framework for 21st Century Learning (P21, 2019), critical thinking and problem-solving skills include: reason effectively, use systems thinking, make judgments and decisions, and solve problems. Table 1 outlines the essential components of critical thinking and problem solving, including situational reasoning, being able to analyze and determine outcomes, evaluate evidence, and alternate viewpoints, interpretation of information, critical reflection, and innovative solutions.

Makerspaces provide opportunities for these types of critical thinking and problem solving while “engaging learners in creative, higher-order problem solving through hands-on design, construction, and iteration” (Blackley et al., 2017, p. 23). In maker learning opportunities, there is much room to grow and mistakes are not mistakes, but rather opportunities for growth and innovative solutions. “It’s OK to fail. In fact, we encourage what most of society calls ‘failure,’ because in reality, it is simply the first or second or third step toward success” (Kurti et al., 2014, p. 10). “In order for a child to understand something, he must construct it himself, he must re-invent it. Every time we teach a child something, we keep him from inventing it himself” (Piaget, 1972, p. 27).

Table 1

*Essential Components of Critical Thinking and Problem-Solving Skills*

Component	Approach
Reason effectively	<ul style="list-style-type: none"> <li>– Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation</li> </ul>
Use systems thinking	<ul style="list-style-type: none"> <li>– Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems</li> </ul>
Make judgments and decisions	<ul style="list-style-type: none"> <li>– Effectively analyze and evaluate evidence, arguments, claims and beliefs</li> <li>– Analyze and evaluate major alternative points of view</li> <li>– Synthesize and make connections between information and arguments</li> <li>– Interpret information and draw conclusions based on the best analysis</li> <li>– Reflect critically on learning experiences and processes</li> </ul>
Solve problems	<ul style="list-style-type: none"> <li>– Solve different kinds of non-familiar problems in both conventional and innovative ways</li> <li>– Identify and ask significant questions that clarify various points of view and lead to better solutions</li> </ul>

*Note.* Adapted from P21 Partnership for 21st Century Learning (2019, p. 4).

An important part of the learning process is through mistakes and stems from the teachers encouraging the learning potential that can come from mistakes and also allows students to be more willing to try unfamiliar things because they know it is ok to try something, make mistakes, ask questions, make adjustments, and try again (Fleming, 2015b). Provenzano (2016) explains that teaching answers alone is not what prepares our students; instead, teaching how to question, how to look critically at things around us, and how to analyze and interpret various situations prepares our students for the future. Teachers need to model this daily. “The teacher as a maker is important if we want our students to become problem solvers. If the teacher is a maker and there is a space for students to grow as makers, then we will have a generation of students ready to tackle the tough problems the world will face in the coming years” (Provenzano, 2016, pp. 15-16). This again speaks to the importance of preparing our pre-service teacher candidates to be makers.

### **Creativity and Innovation**

Using the Framework for 21st Century Learning (P21, 2019), creativity and innovation skills include: think creatively, work creatively with others, and implement innovations. Table 2 outlines the essential components to creativity and innovation, including brainstorming different ideas and techniques, effective communication with others while respecting diverse perspectives, success out of failures, and contributing creative ideas. Makerspaces promote creativity and innovation by giving people a place to come together and share a variety of ideas, and trial and error (Hughes, 2017).

Provenzano (2016) states “Makerspaces are a great way to bring back creativity and support deeper learning” (p. 21). Ten years prior to this statement, Sir Ken Robinson (2006) shared a TED Talk titled “Do Schools Kill Creativity?” At the beginning of his talk, Robinson profoundly states, “My contention is that creativity now is as important in education as literacy, and we should treat it with the same status” (2:57).

Table 2

*Essential Components of Creativity and Innovation Skills*

Component	Approach
Think creatively	<ul style="list-style-type: none"> <li>– Use a wide range of idea creation techniques (such as brainstorming)</li> <li>– Create new and worthwhile ideas (both incremental and radical concepts)</li> <li>– Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts</li> </ul>
Work creatively with others	<ul style="list-style-type: none"> <li>– Develop, implement and communicate new ideas to others effectively</li> <li>– Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work</li> <li>– Demonstrate originality and inventiveness in work and understand the real-world limits to adopting new ideas</li> <li>– View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes</li> </ul>
Implement innovations	<ul style="list-style-type: none"> <li>– Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur</li> </ul>

*Note.* Adapted from P21 Partnership for 21st Century Learning (2019, p. 4).

Robinson (2006) goes on to describe the overarching similarities across all education systems he had encountered around the world and shared common findings. “We stigmatize mistakes” and are therefore educating creativity out of people (Robinson, 2006, 5:22). Children are born with creativity and imagination. “Picasso once said this, he said that all children are born artists. The problem is to remain an artist as we grow up. I believe this passionately, that we don't grow into creativity, we grow out of it” (Robinson, 2006, 6:06). As education shifts to increased allotments to math, science and language, other subject areas are pushed aside and squeezed out. “Our education system has mined our minds. ... And for the future, it won't serve us. We have to rethink the fundamental principles on which we're educating our children” (Robinson, 2006, 17:40).

Sir Ken Robinson (2006) spoke true to his beliefs and shared, with over 54 million views to date, his view that: “Our task is to educate their whole being, so they can face this future. By the way—we may not see this future, but they will. And our job is to help them make something of it” (18:34). Over 12 years later, the conversation is still going. The recognition and value of creativity continues to be loudly voiced and compliments the opportunities we can offer our students through makerspaces. Fleming (2015b) shares of her makerspace that it “is about creating a genuine and committed culture of innovation, as well as about providing the foundation that the students need to be able to thrive and flourish in that kind of culture, one that is increasingly important in the economic life of our country” (p. 27). As educators today, we need to provide opportunities for our students to continue creativity and innovation. When individuals have an idea, and they are given an opportunity to share their idea and then make it into something tangible, it inspires continued creativity and imagination, and we become makers (Dougherty, 2016). Educators have a chance to encourage a desire and passion to

learn in their students by creating creative and collaborative environments. Supporting our students through failure and success, and acceptance to learn different things in varying ways, is what will continue to drive them to explore other passions and innovations while preparing to be future ready.

### **Collaboration and Communication**

Using the Framework for 21st Century Learning (P21, 2019), collaboration and communication skills include: collaborate with others, and communicate clearly, as shown in Table 3. “The Maker Movement embraces the power of collaboration. The collaborative environment of a makerspace allows an individual to embrace and even seek out challenges beyond his or her comfort zone. Together, students can collectively engage in shared learning experiences” (Fleming, 2015b, p. 10). Makerspaces level the playing ground where no one person is the keeper of knowledge. “Students are encouraged to share knowledge, help each other, and work in teams. ... Great educational makerspaces embrace the power of collaboration” (Kurti et al., 2014, p. 11). Students and teacher alike can learn a great deal from each other if they learn the value of listening to each other, communicating effectively, and collaborating. Being able to work effectively with others means that a variety of ideas and skill sets can be brought together to make something greater, and in bringing people together, with shared outcomes, mutual respect, and meaningful relationships form (Provenzano, 2016). Collaborating with others develops important skills valuable outside of makerspaces as well, and will help students to collaborate more effectively whether in a class setting or elsewhere (Fleming, 2015b). Any future job or career students consider will surely benefit from the necessary skills provided in the makerspace environment and transfer to future readiness in any job.



Table 3

*Essential Components of Collaboration and Communication Skills*

Component	Approach
Collaborate with others	<ul style="list-style-type: none"> <li data-bbox="656 428 1435 491">– Demonstrate ability to work effectively and respectfully with diverse teams</li> <li data-bbox="656 501 1435 606">– Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal</li> <li data-bbox="656 617 1435 722">– Assume shared responsibility for collaborative work, and value the individual contributions made by each team member</li> </ul>
Communicate clearly	<ul style="list-style-type: none"> <li data-bbox="656 758 1435 863">– Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts</li> <li data-bbox="656 873 1435 936">– Listen effectively to decipher meaning, including knowledge, values, attitudes and intentions</li> <li data-bbox="656 947 1435 1010">– Use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade)</li> <li data-bbox="656 1020 1435 1125">– Utilize multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact</li> <li data-bbox="656 1136 1435 1199">– Communicate effectively in diverse environments (including multi-lingual)</li> </ul>

*Note.* Adapted from P21 Partnership for 21st Century Learning (2019, p. 5).

## How Others Got Started

Lastly, as this project is providing a handbook on how to set-up and successfully run makerspaces, it is important to review how others are already doing this within their own communities. Both individuals highlighted in this next section have written a book about their experiences with makerspaces, and the next section explains how they define makerspaces, their early beginnings and influences, and how they planned and set-up their makerspaces

### Laura Fleming and Defining Makerspaces

For the first exploration, I read Laura Fleming's *Worlds of Making: Best Practices for Establishing a Makerspace for Your School*. Laura Fleming is a teacher-librarian, well-known maker, and now also a best-selling author. The book *Worlds of Making* outlines the basics of getting started, specifically looking at “the nuts and bolts of imagining, planning, creating, and managing your own makerspace” (Fleming, 2015b, p. 1). Fleming (2015b) defines makerspace as the following:

To define a school makerspace by its purpose in the simplest of terms, it is a place where young people have an opportunity to explore their own interests; learn to use tools and materials, both physical and virtual; and develop creative projects. It should be envisaged and implemented as a concept that can adapt to a wide variety of uses, shaped not only by educational purposes defined by teachers or the school or the wider curriculum but also by students' own creative goals and interests. With a real potential to revolutionize education, we have begun to see makerspaces popping up all across the country. (p. 5)

Further to her definition, Fleming (2015b) explains that makerspaces within educational

settings of today have the opportunity to renew the value of hands-on technology and home economics classes of the past, along with a new informal component which allows students greater choice and the effective ownership of their learning.

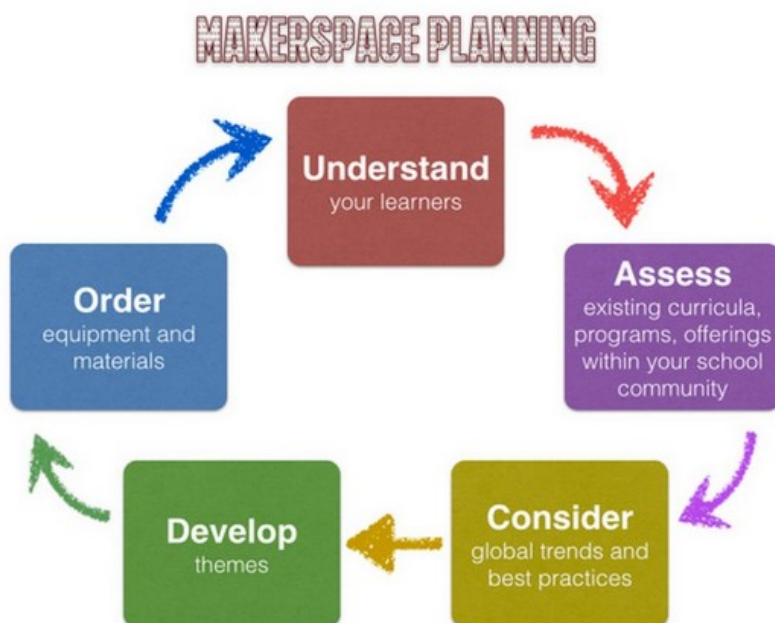
**How Laura got started: Early beginnings of makerspace.** Laura Fleming was a school librarian and the maker movement came to her through literacy. As Fleming (2015b) explains in *Worlds of Making*, “For years, in my library, I had often allowed opportunities for my students to play and tinker with their reading and writing” (p. 8). By giving the students an opportunity to explore and co-create with digital stories and various medias, her students moved from consumers to creators. “Those early experiences were my first attempts at ‘making’ in my library even though they were seemingly far removed from the usual conception of making with tools in the physical realm” (p. 9). Later she held an event that offered further “makerspace learning experience(s)” such as “the opportunity to create online comics, design video games, make stop-motion animation, and many other activities designed to unlock their creative potential” (p. 9). Laura’s makerspace was born after this event by designating an area of her library. “A string of highly imaginative literary experiences had led up to this and had therefore set the stage for creativity and making” (p. 9).

**Planning makerspaces.** Fleming (2015b) shares the importance of developing a space and a mindset before anything else: “It is crucial to first consider creating the culture and environment necessary for success” (p. 12), a space that is conducive to growth and a mindset which allows mistakes, creativity, and imagination. “For innovation to flourish, a carefully crafted environment built on trust, empowerment, and risk taking must be established” (Fleming, 2015b, p. 13). It is easy to get excited about

creating a makerspace and jump into ordering supplies and tools, and a variety of new technologies, but time must first be spent on planning the space as illustrated in several important steps in Figure 1. Taking the time to understand the specific culture and needs of the environment you are creating are primary focus. Every makerspace will be different, and each space should reflect the specific needs and interests of your community of learners.

Next, Fleming worked on developing themes for her high school library makerspace. Fleming (2015b) states “The themes for my makerspace included the following: Robotics, 3-D Printing/Design, Hacking/Remixing the Web/Coding/Computer Programming, Molecular Gastronomy, Wearable Tech, Electricity/Papertronics, Polymers, Engineering Inventions” (p. 14). Once Fleming had spent the necessary time to determine what was important for her school’s specific makerspace, and the thematic use of the space it was then appropriate for her to be ordering technologies and items that would support the chosen themes (Fleming, 2015b).

Spiralling between planning and preparing and figuring out how to make everything just right can delay the naturally evolving magic of makerspace. Much time can be spent worrying about having the perfect resources or about spending on the wrong resources due to budget restrictions, or being nervous to include items in the space that you do not feel confident using (Fleming, 2015b). At a certain point, the planning and preparing does need to shift, and “while this planning phase is incredibly important, driving real change means spending less time planning and more time doing” (Fleming, 2015b, p. 15).



*Figure 1.* Laura Fleming's important steps for planning a makerspace. Reprinted with permission from *School Library Journal* (Fleming, 2015a). Copyright 2015 by Laura Fleming.

**Setting up a makerspace.** Now that the culture, environment, themes, and ordering have been considered, the next step for Fleming (2015b) was to give attention “to designing the physical aspects of the makerspace” (p. 17). For setting up her physical space she used as many “existing resources” from her library space as possible, repurposing “some library tables and bookshelves” (p. 18).

Fleming (2015b) shares “Practical considerations for setting up your makerspace” (p. 18) should include open access to the internet, electrical connectivity—keeping in mind safety and tripping hazards with extension cords, work areas and surfaces that are easy to maintain and keep clean, and above all a space that promotes creativity and feels inspiring.

Fleming (2015b) chose to set up her makerspace with a combination of fixed and flexible stations: “The fixed stations are areas that are out in the makerspace all the time for students to just walk in, sit down at, and engage with” (p. 19). Fixed stations, as shared by Fleming (2015b), include things such as littleBits, breaker space, Lego, makey-makey and a 3D printing and design area: “In choosing these to be our fixed stations, I aimed to include activities that students would be able to start and complete during their time-limited visits to the space as well as to enable them to do so independently with little or no instruction needed” (p. 19). Flexible stations were ones that allowed for movability into other classrooms or to be cycled throughout the space in the library. Fleming (2015b) explains that flexible stations were ones including activities that allowed for movability and collaboration with teachers in their classrooms, or to be cycled throughout the space in the library; these included “molecular gastronomy” (p. 19), robots, and electric circuits.

Fleming (2015b) acknowledges that it can be difficult at times when trying to fit within a particular space, or budget, or when school policies get in the way of the makerspace planning and design: “Inspiration need not be expensive. Overcoming such challenges offers opportunities to be creative” (p. 22). It is possible to create a makerspace regardless of how much money you are allowed to spend, and although these obstacles may be present, Fleming speaks volumes to the power of creativity, repurposing, and asking for help. Having spent the time planning and creating an environment and culture that was appropriate for her specific makerspace, she could inspire others to want to be involved.

Fleming (2015b) continued to promote her makerspace and do her part to keep the students’ interest in the space as well; by leaving a “digital breadcrumb” (p. 22) displayed on a Smart TV each day, she was able to keep her students excited and entice students into the makerspace. Additionally, she created an atmosphere and culture for learning where you could work in collaboration with others, or on your own, and be proud of yourself for the things you create.

### **Nicholas Provenzano and Defining Makerspaces**

For the second exploration, I read Nicholas Provenzano’s (2016) *The Nerdy Teacher Presents: Your Starter Guide to Maker Spaces*. Nicholas Provenzano is a self-proclaimed “nerdy teacher”—a middle school technology coordinator, makerspace director, and well-known education blogger and author. *The Nerdy Teacher* includes stories about making and makerspaces that have been personally experienced by Provenzano, and ideas for setting up makerspaces in your own schools. Provenzano (2016) acknowledges that everyone has their own way of defining makerspaces, however

he simply states: “Making is the creation of something new that was not there before” (p. 9). The author further defines makerspace and making as something that we all can do, and are capable of making “something awesome” (p. 9) with anything that is available to us to make and create with.

**How Nicholas got started: Early beginnings of maker.** Provenzano (2016) looks back to his childhood to address how he got started in making: “When I was growing up ... my parents didn’t have much, but they made something for their kids that mattered. That’s the beauty of Making. It’s creating something you want and sharing it with others” (p. 11). He grew up in an environment that offered him opportunities to make. Provenzano shares memories that he can remember from when he was younger and recognizes family experiences that impacted and encouraged his creativity. He was influenced by watching things his parents did. “These experiences forged who I am today, and I think it’s important to help students have these experiences at school. Especially if they’re not getting them at home” (p. 12). As Provenzano grew up, he took these childhood experiences with him, citing that they have made him who he is today as a teacher. Provenzano addresses Teacher as Maker, saying “You might not think of yourself as a Maker, but you are. You make things every single day. You craft lesson plans, build bulletin board displays, create new curriculum, make awards for students, and make so many different things, but you have never really thought about it that way” (p. 13). Finally, Provenzano believes “We are all Makers” and similar to Sir Ken Robinson, students are naturally creative, making them “natural-born Makers” (p. 16).

**Planning a makerspace.** In setting up the physical space, Provenzano (2016) speaks to a variety of areas and benefits of each. Most importantly, Provenzano feels



makerspaces should be openly accessible in spaces where students can feel free to access at any point throughout the day, avoiding any space that could be used or scheduled for classes throughout the day. Provenzano expresses “We tend to want to plan and organize every aspect of our spaces, but this is the space where we want students to freely come and go as ideas come to them. Too many procedures will limit the number of students who will use the space” (p.32).

Alternative planning may place the space directly within a classroom as suggested by Provenzano (2016) such as housing a mini-makerspace directly in an classroom. The same ideas of having designated space and free use should still apply to the in-class model. Provenzano shares that the space within a classroom should have some guidelines so students understand when it is or is not appropriate to be used for particular tasks or during “free-time.” Additionally, the space should have areas where students can safely store projects they are working on, and it is essential for the space to be comfortable and inviting (Provenzano, 2016). A space that is inviting to all students is a continued theme throughout Provenzano’s guide and an important part of the plan for a successful makerspace. For increased success, Provenzano feels the best space for the makerspace is to have it within the Media Centre/School Library as he feels “The media center, or library, has always been the hub for learning in a school” (p. 34). Provenzano further explains, “We want students to have access and be in a comfortable and safe place to try new things, and the media center is a great place to start” (p. 34). The media centre is a space that is open and accessible throughout the day and continues to offer a safe and rewarding learning space.

Next, Provenzano (2016) explored how these spaces would be furnished, and how they would be used, supervised, and accessed. Provenzano believed that the

“library/media centre” (p. 35) was the most advantageous spot for the makerspace as it was an open and inclusive space where everyone was welcome, and allowed for collaboration between various combinations of groups, while also offering support or guidance if needed from the teacher or librarian supervising the media space. As promoted by Provenzano (2016), the more that teachers can make use of the space with their classes, the more students are exposed to the open environment available to them which they can access the makerspace outside of class time as well. He also acknowledged that “Building a Makerspace is a task that requires the skills of many different people” (p. 46). Bringing people together and building collaboratively on everyone’s ideas helps to ensure that the space continues to be for everyone.

**Setting up a makerspace.** Provenzano (2016) wanted to make sure his space was fun and engaging and knew that depended on the relevance of the contents of the space. Provenzano shared “We all learn through play. It’s the most basic learning strategy that we have been engaging in since birth. Give humans something fun and we will learn everything we can about it” (p. 55). He knew that the success of his makerspace would depend on the items he put into the makerspace, ensuring they would promote learning through play and inquiry. The various “fun gadgets” that Provenzano included in his makerspace are illustrated in Table 4.

With these gadgets, Provenzano (2016) is confident that you could use the makerspace across the entire curriculum. Provenzano states, “I can talk about the big ideas that will fit into any curriculum to help teachers get the most out of Makerspaces” (p. 63), which he has used himself and is continuously making content connections across the curriculum.

Table 4

*List of Fun Gadgets and Technologies Included in Nicholas Provenzano's Makerspace*

Gadget	Use
Chromebooks	3D design, easy portability throughout Makerspace allowing collaboration (p. 52), also wanted to keep programs web-based so students could continue to work on these at home (p. 51)
3D Printer	“The real power of 3D printing isn’t in the printer; it’s in the design process” (p. 53)
Lego	Construction (i.e., buildings)
Green Screen	Video creation
Raspberry Pi, Arduino	For learning how to code
SAM Labs	Connect SAM pieces to their computer, phone or iPad and code them to do what you want (p. 56)
3Doodler Pen	Draw in 3D on the spot (p. 56)
littleBits	Connecting parts of circuits together to build something (p.56)
Makey Makey	Jumper wires and one board interact with objects and your computer (p. 57)
Kano	A computer that students can build on their own (p. 57)
EZ-Robot	Assemble and program your own robot (p. 58)

*Note.* Adapted from Provenzano (2016, pp. 51-58).

Provenzano (2016) expresses the importance of giving his students the freedom to create as it allows his students to learn in ways that they want rather than him telling them how they have to learn. This freedom has produced projects he would not have imagined such as a rap battle the students created to showcase what they had learned and understood about a book they were reading in class. “Not only did they show their understanding,” shares Provenzano (2016), but “their passion was clear, and they had fun—learning can be fun!” (p. 68).

### **Chapter Summary**

In reviewing the literature, it is clear that there are tremendous benefits to be gained by students who have access to makerspaces and afforded the opportunity to develop a maker mindset. In doing so, students are much better prepared for their unknown future and careers. Despite there not being a universal definition for makerspaces, most agree that a makerspace is a space to freely explore and collaborate with others while developing skills for 21st century learning. The purpose of makerspaces and openly accessible spaces where anyone can come together to work through activities and new ways of learning on their own or with the help of someone else, along with access to a variety a technologies and tools that may otherwise not be available to them, while feeling empowered to try new things, tend to be a common thread throughout all makerspaces, which leads to developing a maker mindset.

The review of the Framework of Partnership for 21st Century Learning framework outlined specific competencies that are essential for future ready skills and preparedness and how each of the skills aligns with makerspace outcomes. Through students’ access to makerspaces and the ability to develop maker mindset, they are given

opportunities to problem solve, and to think critically about the world around them. Makerspaces naturally promote creativity and value the potential of learning and growth that results from mistakes. These spaces where people gather to learn and grow also allow for people to share their knowledge with each other or to work through new ideas together. The opportunity to collaborate and improve communication with others is also a positive outcome from makerspaces.

Hearing how some others have approached making and makerspaces within their own school setting, also helps us to see how the makerspace technologies have been integrated in real world scenarios. Other teachers, or librarians who have successfully used makerspaces to help their students learn and grow in meaningful ways, speak volumes to how we can ensure that learning is fun, and that students will want to learn. This also supports the importance of providing pre-service teacher candidates with the makerspace experience in order to develop their knowledge of teaching with technologies for 21st century competencies, while also preparing them to create these makerspace experiences for their students as well.

### CHAPTER THREE: METHODS AND PROCEDURES

This research project sought to develop a makerspace handbook that is useful in supporting pre-service teacher candidates to integrate makerspace and maker mindset in their classrooms and lesson planning. The intent in the creation of this handbook was to provide a practical, hands-on guide for getting started with designing and implementing makerspaces in classrooms and schools. This chapter discusses the methods used to study how a makerspace handbook was developed and then examined by reviewers with expertise in makerspace design and implementation, and the reflections and recommendations learned from the study for improving the handbook.

The study was guided by the following questions:

- What is makerspace, maker and maker mindset?
- What technologies are incorporated into makerspace?
- How are the key future ready skills of critical thinking and problem solving; creativity and innovation; collaboration and communication intertwined within the makerspace and maker mindset learning environment?

#### Procedures

This project was conducted in three stages: (a) investigating the knowledge needed to design and facilitate makerspace learning environments, (b) the development of the handbook *The Making of a Makerspace: A Handbook on Getting Started*, and (c) expert Review and feedback of the handbook for contributing to teacher knowledge about how to design and implement makerspace events and learning environments.

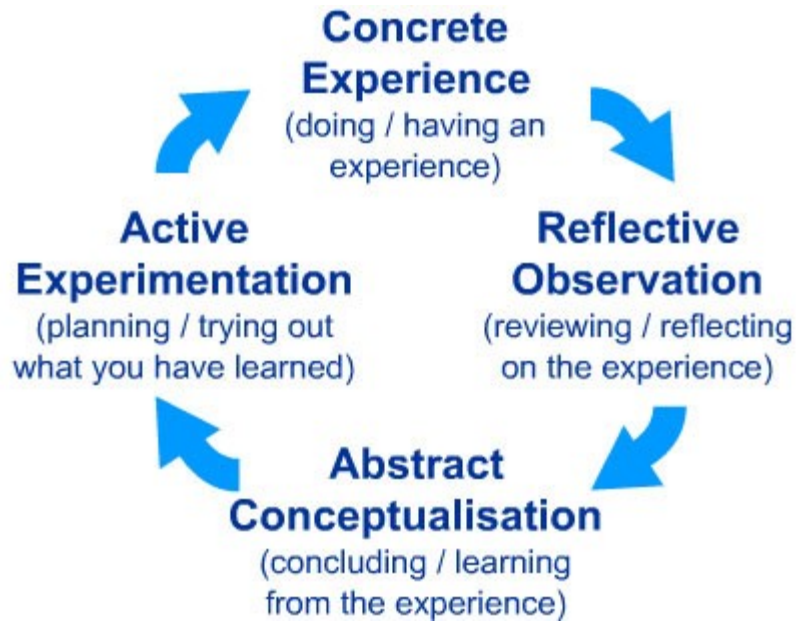
#### Stage 1

Stage 1 involved investigating the knowledge needed to design and facilitate makerspace learning environments. Kolb's (1984) four stage learning cycle was used to

investigate the knowledge needed to design and the facilitation of makerspace learning environments. The four stages of the cycle in which I engaged included: Concrete Experience, Reflective Observation, Abstract Conceptualisation, and Active Experimentation (see Figure 2).

**Concrete experience.** As Figure 2 shows, the first stage of such an investigation requires “doing / having an experience.” For my own hands-on experiences, I attended a workshop in Texas designed to teach educators how to design and implement makerspace learning environments, and then visited a Hackerspace in Nottingham, U.K., where I was able to have my own hands-on experiences. The following narrative tells this story.

***Making my way in Texas.*** I remember being super excited about going to Texas to attend the workshop on how to hold a makerspace event, but really had no idea what I had signed up for—other than heat! As we arrived at the event, we were directed into a large room that had lots of tables set up. At a quick glance around the room, I saw around the exterior walls of the room there were twelve groupings of tables set up with various materials and themes. In the centre of the room were several tables to make a nametag, and in between the centre tables and exterior tables, were tables and chairs for the attendees to sit at. We were immediately thrust into the making by creating our own name tag. There were so many different supplies and materials to use. I walked around the tables and saw what caught my eye. A chipboard circle for the base, scrabble letters for my name, and other blingy stickers to embellish my name tag. Hot glue guns and other adhesives were available to affix items to the tags, and lots of different types of ribbons, strings, yarns and materials that could be used for the necktie/lanyard part of the name tag. After we were done making our name tag, we were to walk around the room to explore the various stations they had set-up for the day.



*Figure 2.* Kolb's four stage experiential learning cycle used to investigate the knowledge needed to design and facilitate makerspace learning environments. Source: McLeod (2017, p. 1). Copyright 2017 by S. A. McLeod.



There were 12 stations, but we would only have time to go to half of them throughout the day. We had to choose and sign-up for 45-minute time slots at the stations we wanted to explore further. As I walked around the room and tried to quickly take in the variety of different experiences being offered at each station, I found myself becoming intrigued to learn more. Some of the stations had tools and materials which were familiar to me, but I found myself seeing an opportunity to explore more. Other stations included items I knew very little about and again, found myself excited to engage in a bit of the unknown. (The stations are listed in Table 5.)

The stations I chose to explore were: Station 1 (Green Screen and DoInk App), Station 4 (Robots), Station 6 (Bead It), Station 7 (Textiles), Station 9 (Circuits), Station 11(3D Printing), and I snuck a little bit of time into Station 3 (Coding) and Station 5 (Repurpose).

*Hacking it in Nottingham, UK style.* Within a day and a half of landing from Texas, I was boarding a plane again—this time heading to England for a big surprise birthday party. I hoped that I might be able to find makerspaces in England to continue my learning journey. I found that “makerspaces” were more commonly called “hackerspaces” in England and was able to find a hackerspace in Nottingham that was only about a half hour away from where we were staying! Even luckier, there was an “open-hack night” that we could attend. When we arrived at the hackerspace, we were welcomed to a tour of the space—a 4,300 square foot space, organized in general areas of making/crafting/building/creating and offering a large variety of tools needed for all sorts of different projects. They had basic tools such as screwdrivers, paint brushes, glue guns, and soldering irons and also had larger, high-end tools such as a precision mill, metal lathe, and laser cutter, which were purchased through pledge drives.

Table 5

*Stations of Choice to Explore at TCEA Makers*

Station no.	Station name	Station contents
1	Green Screen and DoInk App	The DoInk app, the green screen with lights and umbrellas, and props to build a set and costumes
2	Build It	Kevo Planks, Structures and Contraptions sets
3	Coding	Scratch and Scratch Jr., Makey Makey
4	Robots	Sphero, Bee-bot, Dot & Dash, Ozobots, Tcl (pronounced “tickle” simple programming language), Wonder app
5	Repurpose	Cardboard, makedo toolkit containing cardboard knife and plastic screws, Klever Cutters
6	Bead It	Large assortment of beads in various colours, sizes, types, along with stretchy cord, fishing line, leather strands, and jewellery making tools such as pliers, crimpers, wire cutters
7	Textiles	Crocheting, knitting, weaving, weaving looms, variety of yarns and weaving loops
8	Osmo	Tangram, Newton, Masterpiece, Coding Awbie
9	Circuits	Chibi Lights, copper foil strips, conductive dough - squishy circuits, draw circuits circuit scribe maker kit with conductive ink, snap circuits
10	More Making	Suspend balance game
11	3D Printing	Makerbot, 3Doodler, 3Doodler Start (kid-friendly, safer than a glue gun)
12	Drones	Parrot Drone, Tcl (programming language)

*Note.* Author attended Texas Computer Education Association (TCEA) Makers workshop in July 2016.

The hackerspace offered access to these bigger tools to the community members who might lack the space or money to justify having these items in their own homes. The textiles and craft area included sewing machines, plus a couple industrial sewing machines, and a knitting machine. There was a very large worktable that could be used for cutting out patterns and working with bigger pieces of material. In a smaller room off to the one side of the area, there was a room similar to the size of an oversize walk-in closet, filled with beautiful fabrics and a dressmaker's dummy. The main crafting area also had tables to spend time designing and looking through the various items such as yarn, cloth material, beads, paper and other crafting supplies while coordinating a variety of projects. The woodworking area was vast, and it was explained to us that the hackerspace had started as a carpentry workshop - so naturally they had been building on this area the longest. This space had the smell of sawdust and fresh cut wood. It had a table saw, a wood lathe, a bandsaw, and floor standing and benchtop drill and sanders. As well, there were lots of power tools and hand tools, such as saws and hammers. They also had bins of scrap wood that people could use to learn on or try out tools for the first time.

The electronics area was well organized and had a lot of information shared on posters around the area to help people learn about electronics and circuits, as well as to keep everyone safe. There were hundreds of bins with various items, such as LEDs, resistors, wires, connectors, capacitors, heat shrink, motors, bread boards, and even an area where you could make your own PCB etching area where you could design and create your own printed circuit board. The facility of the hackerspace had a variety of areas where one could work individually or as a larger group, and a kitchen and snack space, a studio space, and a comfy space where people could just relax and socialize or

share ideas. Users could come to the hackerspace without any prior knowledge and find people there who were willing to help out and offer guidance—or where users could figure out what was needed by themselves if desired. There was even a bike maintenance area where people could fix their bikes or do necessary maintenance. This hackerspace was run on a non-profit basis and was completely member funded with a “pay-what-you-can” monthly model, with all workshops and offerings being completely volunteer driven. We found that the Nottingham Hackerspace had a wonderfully collaborative environment where the members took pride in the space and everyone worked together to maintain the benefits of the space. We also learned that “Nottinghack” was the second largest in England, with over 600 members!

**Reflective observation.** Now that I had participated in hands-on experiences with makerspaces, I entered the second phase of what Kolb (1984) would describe as reviewing/reflecting on the experience. I reviewed what I had learned about what a makerspace was, how to promote making, and realized that, through my role as the supervisor of the IRC on the Hamilton campus, I already had a start on the resources that would be required to host a makerspace. I had also observed in the Nottingham hackerspace that each centre had documentation about the tools in the centre and possible activities that could be done there.

**Abstract conceptualisation.** Kolb (1984) would explain that my reflection on these experiences led to the design and the development of the plan for the makerspace events we held for our pre-service teacher candidates through the IRC. I took the basic structure of the stations in Texas, along with some of the specific breakdown of materials and tools to aid in the organization and clustering of various technologies. This allowed for a starting point of station specific topic areas. I created documentation for each centre,

and organized the centres based on what I had observed in Nottingham about the layout of tools and materials. My experiences also helped me make the decision that the number of seats at each station was to be limited to four to six people to allow for better collaboration and discussion between pre-service teacher candidates. This helped also with the calculation of the required number of stations, based on the expected number of pre-service teacher candidates attending. Through supplementary research and consultation with colleagues in the IRC, I developed additional stations to include at our makerspace events that went beyond any of the stations I had personally experienced. A great deal of planning, and shopping was required to ensure we would have enough supplies for everyone in attendance. We mapped out the gym, set-up several tables and chairs, and after a full day with five or six IRC staff, the gym was magically transformed into a makerspace filled with several colourful makerspace signs (see Figure 3).

**Active experimentation.** Kolb (1984) explained that the last stage in the learning cycle is to try out what one has learned, and we held our first makerspace event in the IRC on January 14, 2017. Overall feedback about the event was informally collected through a workshop survey that participants completed as they left the event. In addition, anonymous feedback was collected in journals during each of the makerspace events with our pre-service teacher candidates. Each station had a feedback journal on the table along with the other supplies and pre-service teacher candidates were invited to share any thoughts they had regarding the specific station, whether it was regarding the physical space, suggestions, curriculum connections or ideas for use within their own classrooms. These informal, anonymous feedback books have also been helpful in providing continued improvements to the physical stations and began my desire to pursue developing a handbook.



*Figure 3.* An example of the colourful makerspace display set up for an event Hosted by the Instructional Resource Centre, Faculty of Education, Brock University, Hamilton Campus.

## Stage 2

Stage 2 encompassed the development of *The Making of a Makerspace: A Handbook on Getting Started*. While reflecting on the design and implementation of the centres for a makerspace event, it became clear that many of the pre-service teacher candidates wanted to know how to set up makerspaces in their own classrooms or schools. The information requested included:

- the breakdown of stations, including a brief description of the station and all materials, supplies and technologies found at each station;
- the rotation schedule used for the day of the events;
- how to calculate the number of stations needed for number of attendees; and
- example projects/templates that could be used as a guide at stations.

Although pre-service teacher candidates were also interested in learning how to make curriculum connections, it is beyond the scope of this handbook to include specific curriculum alignments.

## Stage 3

To evaluate the effectiveness of the handbook to contribute to pre-service teacher candidate knowledge about how to design and implement makerspace events and learning environments in classrooms, makerspace experts were selected to act as reviewers of *The Making of a Makerspace* handbook resource and answered a series of questions through email. The resource outlines what is makerspace and maker mindset, my first experience with makerspace, and planning your makerspace event in the first section. In the second section of the resource there are over 20 station examples including suggested supplies, tools, and consumables, as well as some sample activities. Each station has been identified with key future ready skills that can be developed through exploration of each station.

### **Sample and Population, Site, and Participant Selection**

For the purposes of making this evaluation feasible, a convenience sample was used, and true random sampling was not performed (McMillan & Wergin, 2006). However, this sample could be identified as a purposive sample (Creswell & Creswell, 2018), a group of participants chosen because they met the criteria needed to provide quality feedback on the effectiveness of the handbook. Two experts who possessed expertise in designing makerspace environments had participated as facilitators of makerspace events and been part of a team of dedicated media specialists who promoted the use of makerspace activities with higher education faculty and students served as reviewers.

### **Data Collection**

Experts were provided with a copy of *The Making of a Makerspace: A Handbook on Getting Started* resource to read and review. Once participants had an opportunity to thoroughly review the resource, they were asked to complete a set of questions via email. The questions asked regarding the resource are as follows (and can also be found in the Appendix):

Perceptions of teacher use in classroom:

- What aspects of the makerspace handbook do you feel would appeal to a classroom teacher?
- How could this resource be implemented in a classroom?

Projected effectiveness of the makerspace handbook:

- How can pre-service teacher candidates use the makerspace handbook to engage students and extend their learning?



- How does this resource promote growth of the key future ready skills (critical thinking and problem solving; creativity and innovation; collaboration and communication)?
- What elements of the makerspace handbook support the ability of a pre-service teacher candidate to use makerspaces in their teaching practice?
- What additional conceptual knowledge about makerspaces or the maker mindset do you feel needs to be included in this resource?

Considerations for future improvements:

- What are some suggestions for improvements of this resource?

### **Data Analysis**

Qualitative responses from the questionnaires completed by the reviewers were transcribed and coded using an emergent coding process as described by Creswell and Creswell (2018). Each unit of data was coded. As the coding labels emerged, the units of data were chunked into categories. This was completed by chunking the categories into an open number of initial trends patterns, and areas of commonality. The resulting feedback was condensed, organized, and is presented in Table 6.

### **Recommendations for Improving the Handbook**

From the feedback that was received, a few recommendations were provided to improve the handbook. Some of the recommendations have already been added to the handbook, such as providing safety guidelines for specific stations, explaining in greater detail what some of the specific materials are, and outlining some approximate costs for a variety of items which can be found at the stations.

Table 6

*Review of Makerspace Handbook (MH)*

Category/questions	Expert 1	Expert 2	Memoing	Code
Perceptions of teacher use in classroom:				
What aspects of the MH do you feel would appeal to a classroom teacher?	The entire handbook will appeal to teachers! Why? Types of stations and very important lists of the materials.	The level of detail and the step by step description of activities and events make it easy for an interested instructor to jump in with little or no knowledge of Makerspace. The handbook demystifies and removes the intimidation factor for anyone interested in MS, but hesitant to begin	Types of stations, lists of materials, detailed activities, “demystifies”	1
How could this resource be implemented in a classroom?	In my view, very simply! Makerspace is adaptable to all subject areas by including a variety of materials on a small or large scale. The Makerspace roll out is about ones' creativity to design a space suited for the square footage available.	Besides being an excellent guide for interested teachers, this resource can be used to present MS ideas directly to young students. In schools without a MS and only able to perhaps host 1 or 2 stations, having involvement from students in the decision making process would be a valuable buy-in.	Adaptable to any subject area, creativity to design space, student involved design process	2
Projected effectiveness of the MH:				
How can teacher candidates use the MH to engage students and extend their learning?	Ask their students to design a Makerspace floor plan and identify the stations and supplies. Maybe the challenge is the creation of a Makerspace with free or existing resources to alleviate cost.	Being aware of what a MS is and what MS culture encompasses is valuable in and of itself. TCs would begin to see the world a bit differently and hopefully pass this enthusiasm on to their students. Creatively incorporating curriculum links into MS would allow for an enhanced learning experience.	Student design, resources, makerspace culture, curriculum connections	2
How does this resource promote growth of the key future ready skills? (critical thinking and problem solving; creativity and innovation; collaboration and communication)	Oh my goodness, the resource covers all the "Cs"!	This resource lays the groundwork for activities that require future ready skills. Most of the stations, require the use of future ready skills in order to complete the activities. These skills are encouraged in an organic, fun and inviting way.	All Cs covered, future ready skills, fun	3
What elements of the MH support the ability of a teacher candidate to use makerspaces in their teaching practice?	Mentioning the IRC as a role model and giving our students the opportunity to experience Makerspace at the beginning of the year! Very important that the IRC is reflected in the MRP!	The MS handbook is an enjoyable read, written with clear enthusiasm for the subject matter. It presents the MS activities as an easily manageable undertaking.	Opportunity to experience, clear, manageable subject matter and activities	1, 2
What additional conceptual knowledge about makerspaces or the maker mindset do you feel needs to be included in this resource?	I think you have it covered!	The history and evolution of makerspace might be a nice addition. Mention of Makerspace leaders and/or national/international event listings might be valuable to some.		
Considerations for future improvements:				
What are some suggestions for improvements of this resource?	Next steps - take this information and work with Crabtree to write a book!!!	It might be a good idea to attach appropriate grade levels to each station/activity or even to have variations on activities based on grade level. Add approximate costs to each station/activity. Add safety concerns to each station (i.e., “danger of burns – supervision may be necessary” etc.)	Write a book, add safety, grade levels, costs per station	1

*Note.* Code 1: Stations and activities; Code 2: Maker culture; Code 3: Future ready skills.

A few other recommendations, although valid, fall outside of the focus of this study and are therefore not being added to the handbook at this time. These suggestions pertained to adding curriculum connections, grade levels, and age-specific recommendations for particular activities.

### **Ethical Considerations**

The ethical principles of research—including respect of human dignity, respect for free and informed consent, respect for vulnerable persons, respect for privacy and confidentiality, respect for justice and inclusiveness, and balance of harm and benefit—were followed in the treatment of the data collected from the reviewers and in working with the reviewers to collect the data.

The reviewers were not asked to use the handbook to design or implement a makerspace event or learning environment, but simply provide feedback on the appropriateness of the materials included in the handbook for supporting pre-service teacher candidates in learning about makerspaces. Therefore, no formal ethics review was conducted. This study respected the rights of the reviewers and ensured confidentiality by adhering to the guidelines and procedures outlined by Brock University's Research Ethics Board. Reviewers' names and identities were kept secure through the use of pseudonyms.

### **Restatement of the Area of Study**

The purpose of this research project was to develop a makerspace handbook that would be useful in supporting pre-service teacher candidates with integrating makerspaces and maker mindset in their classrooms and lesson planning. The intent in the creation of this handbook was to provide practical, hands-on guidance for getting started with makerspaces.

## CHAPTER FOUR: THE RESOURCE

The resource, *The Making of a Makerspace: A Handbook on Getting Started*, presented in this chapter contains two sections. Section 1 explores what is makerspace and maker mindset, my first experience with makerspace, planning your makerspace event, and future ready skills. This section shares some of my makerspace journey which helps to make connections for creating your own makerspace story.

Section 2 of the resource provides over 20 examples of makerspace stations including a brief description of the station, supplies, tools, and materials suggested for the particular station, including consumable items for re-stocking. As well, icon identifiers have been shared with each station showing a couple future ready skills that are developed through the exploration and hands-on experience of each specific station. Some additional templates, resources and great links have also been shared throughout this section of the resource. Overall, this resource will provide a strong foundation for getting started with makerspace and maker mindset.



# The Making of a Makerspace: A Handbook on Getting Started

Developed by:

Shannon Welbourn

Brock University, 2019



## PREFACE

*When I was just a little girl, we lived in a big old farmhouse. I felt like I was a princess in my castle - a castle that was always under renovation and change, but magical, nonetheless. My parents were always removing layers of wallpaper, or pulling up old layers of carpet and linoleum flooring to get back to the beautiful hardwood floors that had been covered up over the years. They tore down walls to make more useful spaces, and closed in other areas to add a bathroom, a study, a sunroom and extend the kitchen. My brother and I would run around and play, chasing each other through newfound pathways and openings in the walls. We even uncovered a staircase that had been built in between walls!*

*Of all the renovations my parents accomplished, my favourite space they built, was my craft room. It was filled with construction paper, glue, crayons, pencil crayons, markers, popsicle sticks, scissors, paint, paint brushes, glitter, beads, stickers, cardboard, tissue paper, shoe boxes, yarn, buttons, sewing supplies, my grandma's old knee press sewing machine, and all sorts of other bits and bobs. It was the ultimate imagination and creativity room where no one told me what I had to do (other than the weekly reminder to keep things tidy), and every day was filled with endless possibilities.*

*I didn't realize at the time, but I was already developing critical thinking skills and problem solving at a very early age. I set challenges for myself and designed and created things to "fix" or solve the challenges. When I couldn't figure something out or needed help, I would ask my parents or brother for their ideas to help me work through things from another angle. I was learning and growing from my mistakes, often using trial and error to solve the various challenges I had set for myself. I was developing a maker mindset - long before it would become a common term of today. And these experiences were impacting me in ways that would follow me into adulthood and highly influence my philosophy of education.*

*Then, a few years ago, I attended a conference focusing on connecting technology and education. As with most conferences, there were a wide variety of workshops from which I could choose to attend. I remember sitting in one that actually got me excited - because I could connect my own beliefs and philosophy of education to what I was hearing presented in the workshop. For example, I believe strongly in students being given opportunities to learn through self-directed, inquiry learning. I believe in students being able to work collaboratively with others, and on their own. I believe in the benefit of making mistakes and learning through trial and error. And I believe in supporting student creativity. As I listened to the presenters speak and share stories, I continued to see connections between examples being shared and how the key components I believed were needed for a valuable classroom environment could be found in makerspace and maker mindset.*

*The next couple years took me into alternate educational settings, and I did not find myself in a classroom or school environment where I could personally implement these ideas. I did continue to follow the maker movement and once I became the Library and Media Services Supervisor in the Instructional Resource Centre (IRC) of Brock University's Hamilton Campus, I pursued makerspaces and maker mindset within a library-like setting. In collaboration with the IRC Manager, IRC staff and support of the Faculty of Education, we created makerspaces in each of our Instructional Resource Centres, and we hosted several makerspace events for our pre-service teacher candidates and teachers in the community. A strong focus of our makerspace was built on our belief of what was needed to prepare students with future ready skills and aligns with P21 Partnership for 21st Century Learning framework where they state "A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future" (retrieved from <http://www.p21.org/our-work/p21-framework>).*

*This handbook outlines the specific stations we host at our makerspace events and includes all the tools and materials we provide at each station, as well as a list of consumable items which need to be re-stocked as they get used up. Also, templates, reproducibles, and any additional information or instructions we have gathered for the stations will be shared with each station section, including links to activities, ideas, or where to shop for specific items. These are suggestions to help get you started – but remember, the most important thing when getting started is to personalize your makerspace to meet the needs of your students.*

*Get creative, have fun, be inspired and inspire others to do amazing things!*

Shannon ☺

**“VULNERABILITY IS THE  
BIRTHPLACE OF INNOVATION,  
CREATIVITY AND CHANGE.”**

**Brené Brown**

## CONTENTS

PREFACE.....	55
<b>SECTION 1:</b> .....	<b>59</b>
WHAT IS MAKERSPACE & MAKER MINDSET?.....	60
MY FIRST EXPERIENCE WITH MAKERSPACE.....	61
PLANNING YOUR MAKERSPACE EVENT.....	71
FUTURE READY SKILLS.....	72
<b>SECTION 2:</b> .....	<b>73</b>
SEWING & TEXTILES.....	74
CARDBOARD CONSTRUCTION.....	77
MICROCONTROLLERS.....	78
BEADING.....	79
PAPER CRAFTING.....	80
ELECTRONICS.....	81
3D PRINTING.....	83
WOODWORKING.....	84
MINI ROBOTS.....	87
GREEN SCREEN.....	88
SLIME.....	89
DESIGN CHALLENGE.....	91
VIRTUAL REALITY.....	96
CODING WITH OSMO.....	97
PAPER CIRCUITS.....	98



BLOXELS .....	104
SNAP CIRCUITS.....	107
LEGO .....	108
MOUSE MAZE .....	109
DUCT TAPE .....	110
ROBOTS .....	111
MARBLE MAZE.....	112
STOP-MOTION ANIMATION .....	113
SCRATCH CODING .....	115
<b>APPENDICES</b> .....	118
<b>BIBLIOGRAPHY</b> .....	122

# SECTION 1:

## Making & Makerspaces

## WHAT IS MAKERSPACE & MAKER MINDSET?

Makerspaces give us a place to tinker, to create, to try new things, and extend our knowledge, to build and use our imagination. Makerspaces provide a safe space, and also opportunities for students to work collaboratively with others and use trial and error to solve problems. These opportunities allow for students to experience learning in new or different ways, by encouraging hands-on creativity and critical thinking. These spaces are fun and exploratory, and do not promote cookie-cutter ideas.

One of the first Makerfares that I attended was contradictory of this. I walked through several pavilions, past booth after booth. Almost every vendor was flashing their 3D printer and supplies, sharing why their tools were better than any others on the market - and everyone believed that their tools were the best! I remember walking away being very disappointed and discouraged. Makerspaces, being a Maker, and Maker Mindset is more than 3D printing! Makerspaces are not a one-size fits all. Don't get me wrong, 3D Printers are a great addition to any makerspace, they just don't make a makerspace as a standalone.

When thinking about creating a makerspace, it is important to not get caught up on the "space", but to think creatively about how to integrate makerspace technologies into student learning opportunities. You may have a space that can always be set up with makerspace supplies and technologies, such as a library or common area, or you may have space within individual classrooms, or maybe even mobile makerspace carts that can be personalized for a specific subject area and brought into different classrooms.

Beyond the space, is the maker mindset. When students are given opportunities to experience makerspace, encouraged to take risks, fail and make mistakes, students persevere, learn and grow in innovative ways. Embracing a maker mindset allows for thinking about things in different ways, and encouraging how one can grow through making mistakes, we provide a culture of learning where students can feel safe and empowered in their pathways to success.

**"MAKING IS FUNDAMENTAL TO WHAT IT MEANS TO BE HUMAN. WE MUST MAKE, CREATE AND EXPRESS OURSELVES TO FEEL WHOLE. THERE IS SOMETHING UNIQUE ABOUT MAKING PHYSICAL THINGS. THESE THINGS ARE LIKE LITTLE PIECES OF US AND SEEM TO EMBODY PORTIONS OF OUR SOULS"**

Mark Hatch

## MY FIRST EXPERIENCE WITH MAKERSPACE

I remember being super excited about going to Texas to attend the workshop on how to hold a makerspace event, but really had no idea what I had signed up for – other than heat! As we arrived at the event, we were directed into a large room that had lots of tables set up. At a quick glance around the room, I saw around the exterior walls of the room there were twelve groupings of tables set up with various materials and themes. In the centre of the room were several tables to make a nametag, and in between the centre tables and exterior tables, were tables and chairs for the attendees to sit at. We were immediately thrust into the making by creating our own name tag. There were so many different supplies and materials to use. I walked around the tables and saw what caught my eye. A chipboard circle for the base, scrabble letters for my name, and other blingy stickers to embellish my name tag. Hot glue guns and other adhesives were available to affix items to the tags, and lots of different types of ribbons, strings, yarns and materials that could be used for the neck tie/lanyard part of the name tag.

After we were done making our name tag, we were to walk around the room to explore the various stations they had set-up for the day. There were twelve stations, but we would only have time to go to half of them throughout the day. We had to choose and sign-up for 45-minute time slots at the stations we wanted to explore further. As I walked around the room and tried to quickly take in the variety of different experiences being offered at each station, I found myself becoming intrigued to learn more. Some of the stations had tools and materials which were familiar to me, but I found myself seeing an opportunity to explore more. Other stations included items I knew very little about and again, found myself excited to engage in a bit of the unknown. The following table shows the stations offered to explore.

Station #	Station Name	Station Contents
1	Green Screen and Do Ink App	The Do Ink app, the green screen with lights and umbrellas, and props to build a set and costumes
2	Build It	Kevo Planks, Structures and Contraptions sets
3	Coding	Scratch and Scratch Jr., Makey Makey
4	Robots	Sphero, Bee-bot, Dot & Dash, Ozobots, Tcl (pronounced "tickle" simple programming language), Wonder app
5	Repurpose	Cardboard, makedo toolkit containing cardboard knife and plastic screws, Klever Cutters
6	Bead It	Large assortment of beads in various colours, sizes, types, along with stretchy cord, fishing line, leather strands, and jewellery making tools such as pliers, crimpers, wire cutters
7	Textiles	Crocheting, knitting, weaving, weaving looms, variety of yarns and weaving loops
8	Osmo	Tangram, Newton, Masterpiece, Coding Awbie
9	Circuits	Chibi Lights, copper foil strips, conductive dough - squishy circuits, draw circuits circuit scribe maker kit with conductive ink, snap circuits
10	More Making	Suspend balance game
11	3D Printing	Makerbot, 3Doodler, 3Doodler Start (kid-friendly, safer than a glue gun)
12	Drones	Parrot Drone, Tcl (programming language)

The stations I chose to explore were: Station 1 - Green Screen and DoInk App; Station 4 - Robots; Station 6 - Bead It; Station 7 - Textiles; Station 9 - Circuits; Station 11 - 3D Printing; and I snuck a little bit of time into Station 3 - Coding, and Station 5 - Repurpose.

### Station 1 - Green Screen and Do Ink App



<https://www.youtube.com/watch?v=icnClyiTUMQ&feature=youtu.be>

At the Green Screen and Do Ink App station, I met up with some minions! We selected some props, chose a background, and captured a video with all of us. This was my first experience with green screen. The app *Do Ink* was very user-friendly and one that the others said they had used in their own classrooms and the students were able to easily navigate. The app cost is \$3.99 and is only available for ios devices such as iPad and iPhone. We were using an iPad that already had the app installed onto it. It helped that a least one of the women had used the app quite a bit in her own classroom, so she was able to give us a quick demo on how the app worked. She made it look really easy - and it was! It was great to have others to collaborate with and learn from. I was able to hear ideas about how they were using the green screen in their classrooms and the tools that they used. All agreed the app was definitely worth spending \$3.99 to purchase and loved the green screen studio setup that was

offered. The studio setup included reflective umbrellas and lights on stands and the green cotton muslin fabric hung on an adjustable height frame stand. If the budget allows, having the studio setup is really fun and would make the students feel more professional. But, there are so many alternatives such as painting a wall with a chromakey green, draping green fabric on a wall, using green bristol board, using a green plastic tablecloth from the Dollar+ store, etc. if you are trying to stretch the budget a little further. The lights and umbrellas, although very useful, could be left out as well to save money.

#### **Station 4 – Robots**

At the robot station I was introduced to some new robot friends! Dot and Dash are colourful teal blue and orange robots, created by Wonder Workshop. Dot is stationary and has lights, sounds, and sensors that can be programmed using a drag and drop coding app. Dot also has some pre-programmed features, such as making Dot similar to a magic 8 ball. Dot can be used alone or as a companion to Dash. Dash is a robot that can move and “go on adventures” as many of the Dash lessons suggest. Dash also has lights, sensors and noises, but with added movement can be programmed to do so much more than



*Retrieved from [http://bit.ly/dash\\_dot](http://bit.ly/dash_dot)*

Dot. Dot can act as a controller for Dash which allows Dot to be kept in the fun of coding.

Another robot I met was Bee-bot. A bright yellow robot that looks like a bumble bee, created by TTS (Teacher Technology Solution) International. The Bee-bot has



*Retrieved from <http://bit.ly/yellowbeebot>*

buttons which can be used for hands-on programming. The buttons program directional moves in 6" steps or 90 degree turns up to 40 moves. The Bee-bot was fun to play with. It was easy to use the programming buttons and then you could press go to see if your programming sequence was correct to get the Bee-bot to a specific spot on the floor mat. If not successful, you could add to the sequence you initially programmed, or clear it and start again. It allows for great problem solving and critical thinking skills and challenged us to keep trying until we got it right.

### **Station 6 - Bead It**

At the beading station there was a huge assortment of beads all organized by colour in compartment trays. I was greeted by a woman at the station who was a local beading artisan. She had donated her time and brought her entire bead collection to share with us - which is definitely more beads than you would normally have available. It was almost overwhelming looking at so many beads, but the woman handed me a tiny dixie cup and asked me to choose 20 to 25 beads that I liked. I began looking closely at the beads and was immediately drawn to some sparkley iridescent crystal-like beads, and then some glass painted beads, and some that looked like blown glass. By the end of my choosing, I had a beautiful selection of colours, shapes and types of beads. I was then told to pour them onto this fabric placement which helped the beads stay put and not roll around. Then we started playing around with the arrangement of beads - of course there is no right or wrong at this point, choosing to use a pattern or symmetry or however you would like to arrange the beads was more about personal choice than any specific rules. The woman was happy to offer suggestions if we got stuck or were over analyzing our bead placement too much. We also found by the end of the arranging that not all of our selected beads were going to make the final creation. Although we liked something about each of the chosen beads, not all of them worked together. Then, once we figured it all out, we strung the beads together to create a bracelet, keyring, or lanyard.



**Station 7 - Textiles**

At the textiles station there was a full group with five other people sitting with me. We sat around a round table and each chose a small project to work on. Some picked up knitting needles or a crochet hook with some yarn, and some of us worked on a small individual weaving loom. Once I collected some weaving loops, I found it was a fairly relaxing, hands-on activity that each of us worked on individually, but we all talked while we worked. One of the women shared how she uses weaving in her class to talk about oral tradition and the passing down of stories. It provided for a great discussion about community and tradition. We also talked about how this could offer an opportunity to learn about and celebrate various cultural handiworks. This was the only station where I felt I was going to run out of time before completing my weaving project, but I persevered and got it finished with about 30 seconds to spare.

**Station 9 - Circuits**

The Circuit station was a lot of fun to explore, because who doesn't get excited about lighting things up! There was a table full of various supplies such as *Chibi Lights*, copper foil strips, 3V cell batteries, conductive dough, conductive ink, and snap circuits, as well as some colouring pages with markers and pencil crayons. An example card with Van Gogh's *Starry Night* had been left on the table, using the *Chibi Lights* and some copper foil strips. The example had one star lit up, but I decided I wanted to have three of the stars light up. Again, there were opportunities to problem solve, and felt very rewarding when the lights successfully lit up where I wanted them to. I didn't realize at the beginning that it wasn't just a matter of placing lights where you wanted shining stars, but that you have to be able to power all of the lights. As we were using just a small 3V cell battery, as more lights were added, the brightness of the light diminished a bit. It was a very fun experience, and I found myself comfortable to explore and try new things. Maybe because it all started with colouring *Starry Night* on the front of the card, and

colouring can be stress reducing, so I was able to de-stress before any stress and uncertainty could move in.

### **Station 11 - 3D Printing**

I was really excited to explore at the 3D printing station as I was still new to the idea, and although we had a Makerbot 3D Printer that would be for use in the IRC, it had not been set up yet, and we were waiting on policy to be drafted regarding its use. At this station, they also had a Makerbot 3D Printer. It was printing as we explored the station, and I was able to see how the printer transformed the spools of coloured plastic filament into a melted stringy substance that comes out of the extruder tip as it puts down layers of the printed object. While watching the process, I quickly realized that the 3D printer takes a long time to complete one small project, and it was likely going to be working on printing the same object for most of the day. The excitement of the 3D printer does fizzle once you realize there is nothing coming out anytime soon. For students in a classroom, they can learn so much through the process of designing and creating an object to print. The learning is in the process, not really in the printing. However, if the print fails, there is again lots of opportunity to learn and troubleshoot why the print may have failed. If the print has completed successfully, the student will love to see how their idea has turned into a finished product that they can hold in their hands.

Another item found at the 3D Printing station was the 3Doodler and 3Doodler start pens. These were handheld tools that heat up and melt a strand of filament, similar to a hot glue gun and glue stick, but it does not get quite as hot. The filament comes out of the pen tip end and you can create free-hand 3 dimensional designs in the air, or use a template from the book to draw directly on the page and attach pieces together afterwards. The 3Doodler was a larger and hotter pen, but the melted plastic was still touchable. The metal tip on this pen is what needs to be avoided, and is therefore not recommended for children. The 3Doodler start on the other hand is a much better choice for safe use by children as there are no parts that get hot. The filament strands for each of these pens are different, and cannot be used interchangeably. I tried my hand at the free-form first, although I stayed flat on the table, and I attempted to write my name. It was much more difficult than I expected it to be. Then I tried using one of the templates that appeared as though you just had to run the pen along to allow the groove to fill up with the melted plastic - this was a little better, but I still wasn't getting a consistent flow. I did not give up though. I continued to create little plastic items and realized while it was still warm you could maneuver the melted plastic, and that I actually had more control over the output than I initially thought. By the end of my time at this station I had created a few decent looking things, and my perseverance paid off.

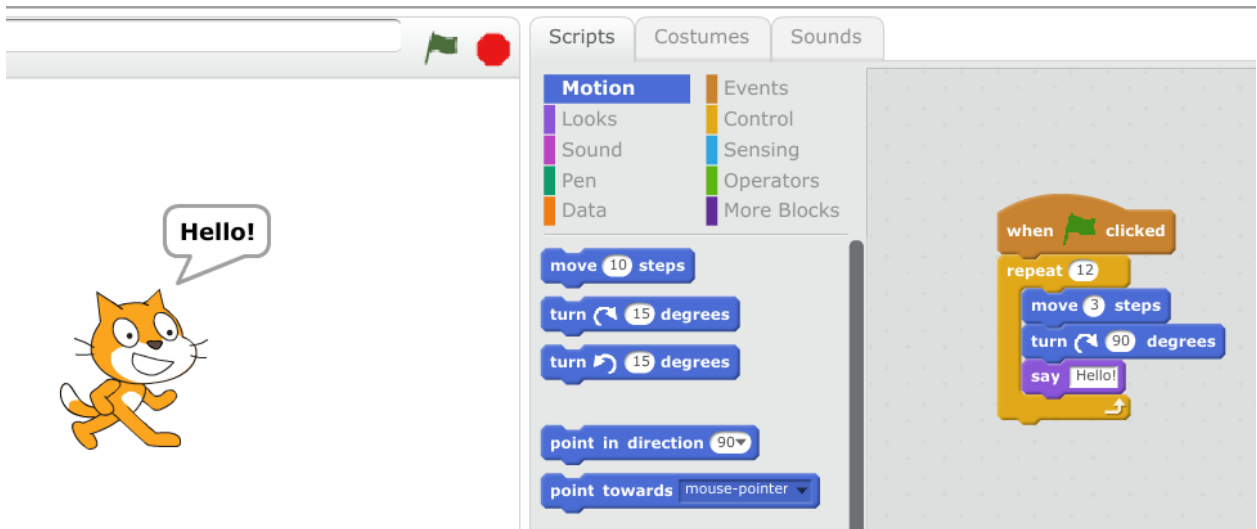

 The logo for 3Doodler start features the word "3Doodler" in a large, blue, bubbly font with a white outline. Below it, the word "start" is written in a smaller, multi-colored font (red, yellow, green, blue) with a white outline.


*Retrieved from <http://bit.ly/3dstart>*

### **Station 3 - Coding**

I was only able to spend a little bit of time at the coding station as it was not within the six stations I had originally chosen to explore for 45 minutes, but when I finished up ahead of time on a station I was quick to jump in and learn whatever I could. For the coding station, with Scratch

and Makey Makey, I had seen these both before, but never had a chance to try them myself. Makey Makey was an item we had already ordered and received just a few days before going to Texas. The Makey Makey was connected with a USB to a laptop that was already on the <https://apps.makeymakey.com/piano/> screen and also five alligator clips attached to five bananas. I was able to touch the bananas one by one, each making a sound of a piano key from C, D, E, F and G. Then I moved over to a laptop with the Scratch program ready to explore. The layout of the screen content was extremely user-friendly and without any guidance, I was able to drag and drop various block coding into place in order to have my Scratch Cat character move, turn and say hello! The movement was faster than I would have liked, but that was all the time I had to spend at that station. I left feeling very confident that I would be able to successfully recreate my Scratch experience and program my character to slow down the motion.



### Station 5 – Repurpose

After finishing up a bit early on one of my originally selected stations, I jumped at the opportunity to check out another station - even if only for a

few minutes. At the Repurpose station, I took a quick stock of what types of supplies and materials were available to explore. Other than a ton of



Retrieved from <https://www.make.do/>

cardboard (empty shoe boxes, cereal boxes, pizza boxes, cut-down cardboard, etc.), I was introduced to some amazing new tools such as the *makedo cardboard construction toolkit* consisting of a *safe-saw*, *scru driver* and two different sizes of *scrus*. The saw was ok for cutting the cardboard, but did not leave a very smooth cut edge. It was very safe

because it was not sharp and was just plastic teeth rather than a blade.

Another tool provided at the station for cutting was the *Klever Kutter*. This tool had a sharp blade, and was able to provide nice clean-cut edges, while still being safe. The design of the *Klever Kutter* keeps the blade recessed with just a part of the blade accessible to go through the thickness of the cardboard.



Retrieved from <http://bit.ly/klever-kutter>

Overall, the experiences of the day were tremendously rewarding and inspiring. I met lovely, like-minded people who were encouraging and informative, and willing to guide along the way once I returned home. This was an important aspect in order to continue building on the momentum and excitement of the day. I was looking forward to implementing the model I experienced, while offering incredible opportunities for our pre-service teacher candidates.

## PLANNING YOUR MAKERSPACE EVENT

### How many stations do you need?

This depends on how many people are attending. Pre-registration is recommended for this purpose.

### Here is the formula:

*Number of students divided by number of seats at each station  
equals the number of required stations*

*ie: 100 students ÷ 6 seats per station = 16.7*

*which means you need a minimum of 17 stations in order to have a seat available for each student to explore on each rotation. Over 20 station examples are provided in section 2 of this handbook.*

### Sample Timetable for day and Rotation Schedule

8:30am - Check in, receive info sheet, select stations, make a name tag.

9:00am - Keynote Speaker

9:30am - Station Choice 1

10:15am - Station Choice 2

11:00am - Station Choice 3

11:45am - break for lunch

12:30pm - Station Choice 4

1:15pm - Station Choice 5

2:00pm - Station Choice 6

2:45pm - wrap-up and survey/questionnaire

See Appendix for Info Sheet, Station Sign-up Chart, and Exit Survey

## FUTURE READY SKILLS

The makerspace events, set up by Instructional Resource Centre, model a variety of makerspace ideas for pre-service teacher candidates and although the set-up is structured for the purpose of modelling, there is plenty of room for curiosity and the maker mindset to develop.

Pre-service teacher candidates, through their own self-directed exploration and discovery, are able to think about how they could bring these maker ideas into their own classroom, and also recognize the importance of student voice.

Innovation and critical thinking are skills that develop over time, or through multiple attempts and perseverance. One cannot teach a student to be innovative, if they do not have the mindset and desire to keep trying. This is why it is so important to think about how we teach and the delivery of information so we can better prepare our students for the future.

The following section outlines over 20 station examples, including suggested materials, supplies, technologies, tools, and consumables to help get you started. Choose a few to try or come up with your own ideas. These are only suggestions – make a space that works for your students.

Each station has the potential benefit to increase all of the future ready skills including critical thinking and problem solving; creativity and innovation; and collaboration and communication, however, each activity will have 1-2 focus icons for a quick at a glance identification.

CRITICAL THINKING AND PROBLEM SOLVING

CREATIVITY AND INNOVATION

COLLABORATION AND COMMUNICATION



# SECTION 2:

## Examples of Makerspace Stations

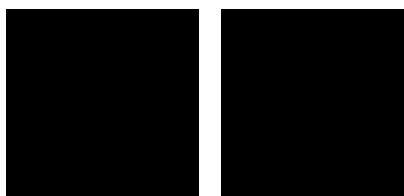


## SEWING & TEXTILES

This station provides opportunities to explore sewing by hand or with the sewing machine, knitting, crocheting, weaving, and working with various types and textures of fabrics and textiles

- Bobbins
- Crochet hooks
- Cutting mat
- Knitting & crochet patterns
- Knitting needles
- Measuring tape
- Needles
- Pin cushion
- Safety pins
- Scissors
- Sewing Binder
- Sewing Lessons
- Sewing machine
- Sewing patterns
- Straight pins
- Templates
- Weaving looms

<b>CONSUMABLES</b>	<input type="checkbox"/> Buttons	<input type="checkbox"/> Thread
	<input type="checkbox"/> Embroidery Thread	<input type="checkbox"/> Velcro
	<input type="checkbox"/> Fabrics	<input type="checkbox"/> Weaving Loops
	<input type="checkbox"/> Felt	<input type="checkbox"/> Yarn
	<input type="checkbox"/> Ribbon	<input type="checkbox"/> Zippers



## GREAT LINKS for Sewing & Textiles

Sewing Projects for Kids on Pinterest

<https://www.pinterest.com/erakol/sewing-projects-for-kids/>

Tiny Sewists: Teaching Kids to Sew, Setup and Safety

<http://www.ajennuinelife.com/2014/01/tiny-sewists-teaching-kids-to-sew-setup.html>

Sewing for Kids 101: starting to sew on a machine

<http://www.gatheredthreads.co.uk/2015/09/sewing-for-kids-101-starting-to-sew-on.html>

Kids sewing projects, learning to sew one stitch at a time

<http://www.kids-sewing-projects.com/beginning-sewing-projects.html>

Skip to my Lou, sewing activities for kids

<https://www.skiptomylou.org/category/sew/>

Sew so easy

<http://so-sew-easy.com/fun-easy-sewing-projects-kids/>

Sewing tools and equipment to Sew

<http://sewing.about.com/od/beginner1/ig/Sewing-Tools/>

Sewing Videos

<https://www.thesprucecrafts.com/sewing-videos-to-learn-how-to-sew-2978183>

How to teach Adults and Children to sew

<http://sewing.about.com/od/beginner1/ss/teachingsewing.htm>

Free Simple to Learn to Teach Sewing and Projects

<http://sewing.about.com/od/beginner1/tp/Free-Simple-To-Learn-To-Teach-Sewing-Patterns-And-Projects.htm>

Sewing for a cause

<http://www.tessiefay.com/blog-five/ssiefay.com/2013/10/sewing-for-cause.html>

Inspire a Child to love the art of sewing: sewing activities for Kids

<http://www.craftsy.com/blog/2014/05/sewing-activities-for-kids/>

Dot-to-dot sewing

<http://www.skiptomylou.org/wp-content/uploads/2013/03/Dot-to-Dot-Sewing-Sheet.pdf>

Sewing maze

<http://www.skiptomylou.org/wp-content/uploads/2013/03/Maze-Sewing-Sheet.pdf>

Do It Yourself: Cardboard Box Play Sewing Machine

<https://littleredwindow.com/diy-cardboard-box-play-sewing-machine/>

Sock Monkey

<http://www.abeautifulmess.com/2012/04/sock-monkey-and-friend-diy.html>

Fun Kids Craft: How to Sew a Tote Bag

<https://www.canadianliving.com/home-and-garden/diy-and-crafts/article/kids-craft-how-to-sew-a-tote-bag>

Sewing Machine Driver's License

<https://www.thesprucecrafts.com/teach-adults-and-children-to-sew-2977517>

## **ACTIVITIES**

Sewing with Kids – Course Outline

Includes:

1. Parts of the sewing machine;
2. Having control of the fabric;
3. Threading the sewing machine;
4. Sewing a straight line;
5. Hand stitching;
6. Sewing on a curve;
7. Ribbon casing;
8. Adjusting the stitch;
9. Activities, etc.

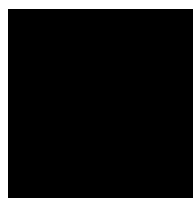
<http://www.yellowspool.com/sewing-e-courses/sewing-with-kids/>

# CARDBOARD CONSTRUCTION

This station provides opportunities to build, create, and prototype using basic materials such as cardboard tubes and cardboard boxes to make anything imaginable.

- Cardboard Screws
- Box Cutters
- Box Tape
- Fasteners
- Hot Glue Guns
- Klever Cutters
- Markers
- Masking Tape
- Sample Projects
- Scissors
- Straws
- String
- Styrofoam Balls in a variety of sizes
- Twine
- Xacto Knives

<b>CONSUMABLES</b>	<input type="checkbox"/> Hot Glue Sticks	<input type="checkbox"/> Egg Cartons
	<input type="checkbox"/> Tape	<input type="checkbox"/> Shoeboxes
	<input type="checkbox"/> String/Twine	<input type="checkbox"/> Paper towel tubes
	<input type="checkbox"/> Styrofoam Balls in a variety of sizes	<input type="checkbox"/> Cut-down boxes & cardboard
	<input type="checkbox"/> Pompoms	<input type="checkbox"/> Foam Blocks

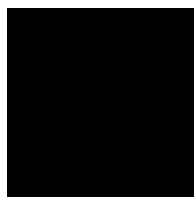


# MICROCONTROLLERS

This station provides opportunities to explore a variety of small programmable computers.

- Alligator Clips
- Arduino
- Hummingbird
- Makey Makey
- Markers
- Microbit
- Raspberry Pi
- Scissors

CONSUMABLES	<input type="checkbox"/> Bananas
	<input type="checkbox"/> Cardboard Pieces
	<input type="checkbox"/> Foil
	<input type="checkbox"/> Tape

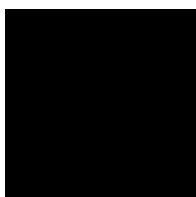


## BEADING

This station provides opportunities to explore all different types of beads, such as: pony, perler, seed, glass, plastic, crystal, wood, etc, in a variety of colours, shapes and sizes, to create bracelets, keychains, patterns, symmetrical designs, and more.

- Beads - variety
- Fishing Line
- Hemp Cord
- Jewellery Mats
- Jewellery Pliers
- Key Rings
- Leather Cord
- Pipe Cleaners
- Scissors
- Stretchy Cord
- String
- Thread
- Wire

<b>CONSUMABLES</b>	<input type="checkbox"/> Beads - variety	<input type="checkbox"/> Pipe Cleaners
	<input type="checkbox"/> Fishing Line	<input type="checkbox"/> Stretchy Cord
	<input type="checkbox"/> Hemp Cord	<input type="checkbox"/> String
	<input type="checkbox"/> Key Rings	<input type="checkbox"/> Thread
	<input type="checkbox"/> Leather Cord	<input type="checkbox"/> Wire



# PAPER CRAFTING

This station provides opportunities to explore various types of paper crafting including origami, card making, rubber stamping, to create various textured and colourful pieces of art.

- Button Maker
- Buttons
- Cardstock
- Felt Sheets
- Foam Sheets
- Coloured Ink Stamp Pads
- Construction Paper
- Decorative Scissors
- Die Cut Press
- Ellison Die Cuts
- Glue Sticks
- Hot Glue Guns
- Hot Glue Sticks
- Markers
- Paper
- Paper Punches
- Pencil Crayons
- Rubber Stamps
- Scissors

<b>CONSUMABLES</b>	<input type="checkbox"/> Baby Wipes	<input type="checkbox"/> Foam Sheets
	<input type="checkbox"/> Buttons	<input type="checkbox"/> Hot Glue Sticks
	<input type="checkbox"/> Clothespins	<input type="checkbox"/> Pompoms
	<input type="checkbox"/> Cardstock	<input type="checkbox"/> Stickers
	<input type="checkbox"/> Construction Paper	<input type="checkbox"/> Tape
	<input type="checkbox"/> Felt Sheets	<input type="checkbox"/> White Glue



# ELECTRONICS

This station provides opportunities to explore electronic components to create a variety of projects by following provided task activities or you can create your own. Both neurons and littleBits have easy to connect pieces.

- Makeblock Neurons
- iPads
- littleBits

## CONSUMABLES

- 9V Batteries





## GREAT LINKS for Electronics

Makeblock Neuron

<http://bit.ly/neuron-guide>

<http://bit.ly/neuron-block-cards>

<http://bit.ly/makeblock-education>

littleBits

<http://bit.ly/littlebits-guide>

## 3D PRINTING

This station provides opportunities to explore various aspects of 3D printing and design using Thingiverse and Tinkercad. Also, 3Doodler Start pens allow for free form creation in the air or flat on a template.

- 3D Printed Examples
- 3D Printer
- 3Doodler Created Examples
- 3Doodler Pens
- 3Doodler Start Filament
- 3Doodler Templates
- 3Doodler Workbook
- Basic Instructions for 3D Design
- Basic Instructions for 3D Printing
- Laptops with Thingiverse
- Laptops with Tinkercad
- Printer Filament

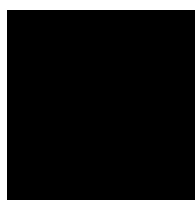
CONSUMABLES	<ul style="list-style-type: none"> <li>□ 3Doodler Start Filament in a variety of colours – must use only 3Doodler start filament with 3Doodler start pens</li> </ul>	<ul style="list-style-type: none"> <li>□ Printer Filament for 3D printer in various colours</li> </ul>
-------------	--	--

# WOODWORKING

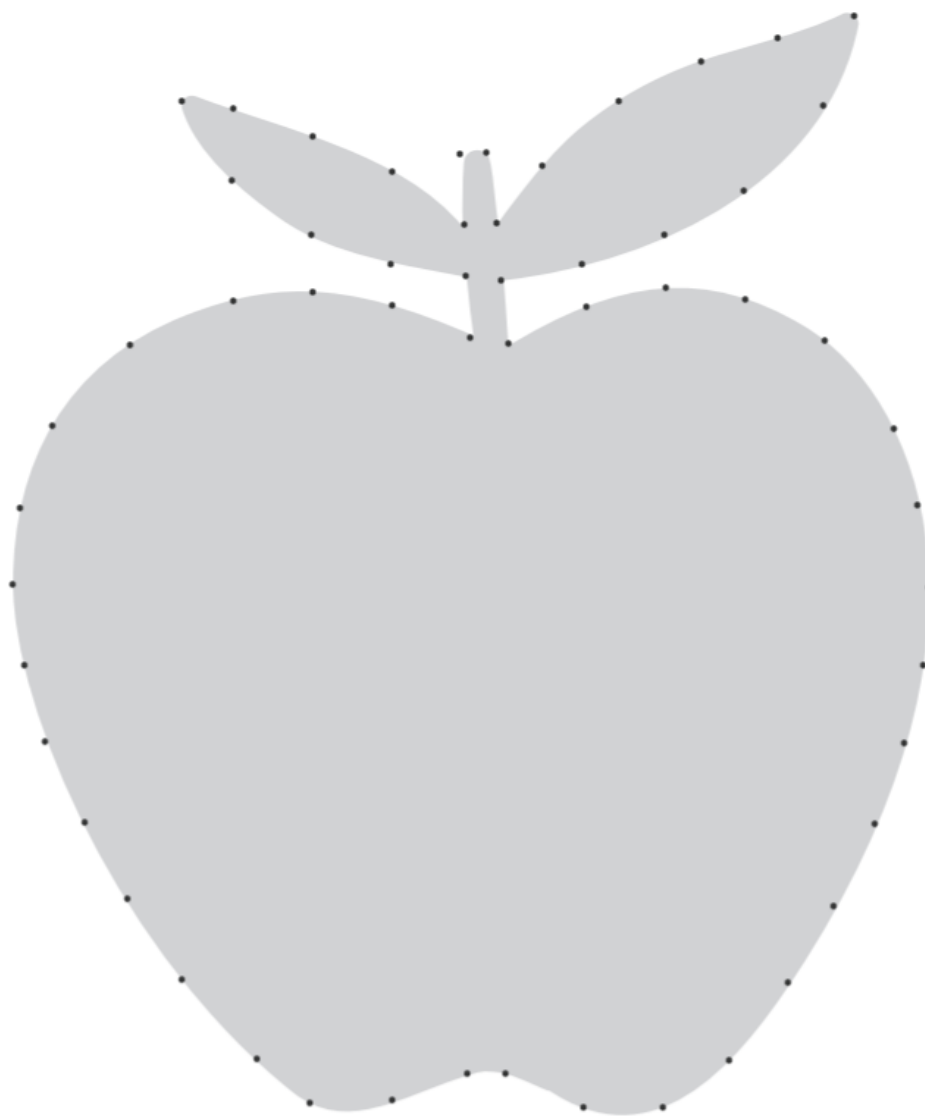
This station provides opportunities to explore a variety of wood types to create and build using hammer and nails, wood burning designs, string art, or various other combinations the imagination ignites.

- Cutting Mats
- Embroidery Thread
- Glitter Glue
- Hammers
- Hot Glue Guns
- Hot Glue Sticks
- Markers
- Nails
- Popsicle Sticks
- Sandpaper
- Skewers
- String
- Toothpicks
- Variety of Wood
- White Glue
- Wood Beads
- Wood Blocks
- Wood Burning Iron
- Wood Shapes for Wood Burning

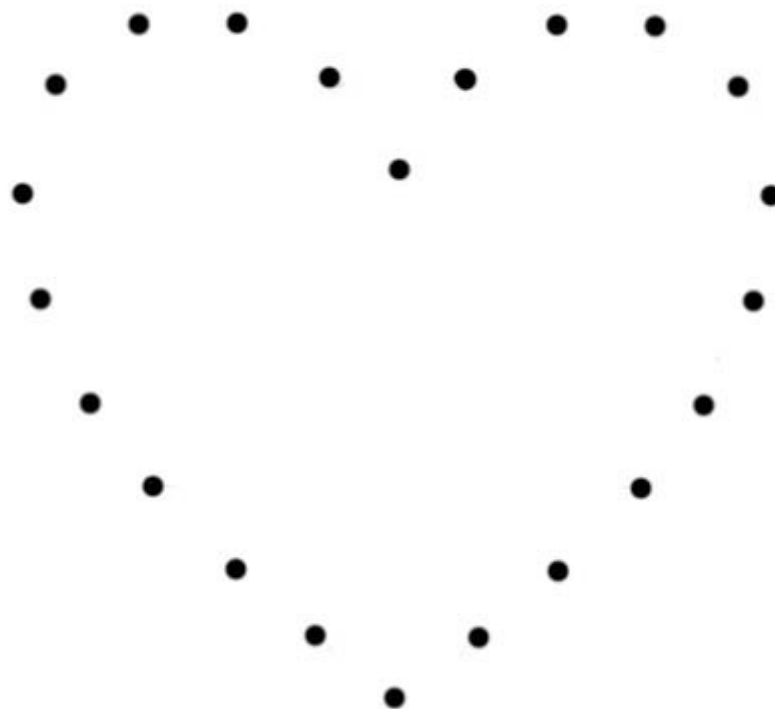
<b>CONSUMABLES</b>	<input type="checkbox"/> Embroidery Thread	<input type="checkbox"/> String
	<input type="checkbox"/> Glitter Glue	<input type="checkbox"/> Toothpicks
	<input type="checkbox"/> Hot Glue Sticks	<input type="checkbox"/> White Glue
	<input type="checkbox"/> Nails	<input type="checkbox"/> Wood Beads
	<input type="checkbox"/> Popsicle Sticks	<input type="checkbox"/> Wood Blocks
	<input type="checkbox"/> Skewers	<input type="checkbox"/> Wood Shapes



## String Art Templates



Retrieved from <http://bit.ly/applestringart>



*Retrieved from <http://bit.ly/heartSA>*

# MINI ROBOTS

This station provides opportunities to explore various types of coding using hands-on robot blocks, colour codes, and various forms of block coding in accompanying apps.

- Cubelets
- Instructions
- Markers
- Ozobots
- Paper
- Template codes

CONSUMABLES	<input type="checkbox"/> Paper
	<input type="checkbox"/> Markers - Black
	<input type="checkbox"/> Markers - Blue
	<input type="checkbox"/> Markers - Green
	<input type="checkbox"/> Markers - Red



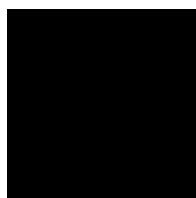
## GREEN SCREEN

This station provides opportunities to explore green screen technology, putting you in places anywhere around the world or elsewhere, alongside anyone across time, by isolating and replacing the green backdrop with a scene of choice.

- Green fabric backdrop on stands
- Lights
- Reflective Umbrellas
- iPads with DoInk (cost of app is \$3.99 per device)
- Variety of Props

### APPLICATION

A green screen refers to the bright green backdrop cloth or paint used behind images or while videoing people, showing an alternate backdrop and placing the person or image somewhere else. It is a technique common to movie making and videography, being used daily on weather reports and applied to many movies. It has the ability to take our imagination to places we would not normally be able to go to, and to capture us with people, animals or creatures outside of our reach. An example of this technology appears in the movie *Forrest Gump* in Gary Sinise's portrayal of Lt. Dan Taylor, double leg amputee and Vietnam war vet, where he wore socks up to his knees or had fabric wrapped around the lower portion of his legs, that could be isolated and edited out later. This same technology was used to put Tom Hank's character, Forrest, in a scene talking to John F. Kennedy.



# SLIME

This station provides opportunities to explore how to make slime and the various ingredients that you can add into the mix to create different results such as gooey, stretchy, glittery, glow in the dark, colour changing, etc.

- Foam Beads
- Food Colouring
- Hand Cream
- Measuring Cups
- Measuring Spoons
- Mixing Bowls
- Mixing Spoons
- Recipe cards
- Scents
- Shaving Cream
- Storage Containers
- White Glue

<b>CONSUMABLES</b>	<input type="checkbox"/> Foams beads	<input type="checkbox"/> Storage Containers
	<input type="checkbox"/> Food Colouring	<input type="checkbox"/> White Glue
	<input type="checkbox"/> Hand Cream	<input type="checkbox"/> Borax
	<input type="checkbox"/> Scents	<input type="checkbox"/> Glitter
	<input type="checkbox"/> Shaving Cream	<input type="checkbox"/> Baking Soda





## Slime Recipes

Fluffy slime:

- shaving cream
- glue 4oz
- hand cream
- food dye (optional)
- borax solution

1st you will add your glue and shaving foam in the bowl and mix them together. Then add hand cream and food dye (optional) and mix all together. After that you will add your borax solution until activated. Then you have your perfect slime!! Enjoy!

Jiggly slime:

What you will need

- Glue 4oz
- Water 3oz
- Food dye (optional)
- Borax solution

Instructions: 1st you will add 4oz of glue into a bowl. 2nd you will add 3oz of water and food dye (optional). 3rd you will add borax solution until your likability.

*Recipes Courtesy of Olivia from Lemonade.Slimmes*

## DESIGN CHALLENGE

This station provides opportunities to explore a variety of different challenges and use critical thinking and problem-solving skills to come up with different designs with limited resources.

- 3D Printed connectors
- Challenge Cards
- Construction Paper
- Glue
- Masking Tape
- Scissors
- Straws

CONSUMABLES	<input type="checkbox"/> Construction Paper
	<input type="checkbox"/> Glue
	<input type="checkbox"/> Masking Tape
	<input type="checkbox"/> Straws
	<input type="checkbox"/> Paper Clips



## Speedy Architect Competition



### OBJECTIVE

In this project you will serve as architects working to design new buildings for your client. To ensure the client is satisfied with the buildings, you must make sure that your buildings satisfy the **Critical Design Requirements** given a set amount of materials and time.

You will be tasked to build **2 buildings**, with different **Critical Design Requirements** (on the back of this page).

### RULES

#### Planning

1. For each building, you have **5 minutes** to plan your structure before you start building.
2. During this time, you will “shop” for your materials. **Try to estimate as best you can**, as you will lose points for taking too much or too little materials!

#### Building

1. You will have **15 minutes** to construct each building.
2. All buildings will be measured at the end of the time limit, but you may have your building measured multiple times throughout the activity.
3. You can rebuild your building as much as you want, but whatever is standing at the end of the time period is what will count as your final measurement.
4. **ONLY** use the materials you select during the planning phase. If you run out of materials, you can get more, but you will have a small penalty.
5. Your building must stand **ON ITS OWN** and remain standing while being measured - **no leaning against the wall, taping to the floor, magic, etc.**
6. Give your buildings creative names!

---

### EXTENSION

Write a reflection on the building and design of your structures. This paper should be 8-10 sentences (or more) and should include the following information:

- A description of your final designs
- Your initial design/plan
- How did this initial design change as you built your structures?
- Did you ever start over?
- The final height of your Building 1? How much weight could your Building 2 hold?
- What was the hardest part of building your structures?
- Anything else you learned while building?
- *The title of your paper should include the name of your design*

## **BUILDING DESIGN REQUIREMENTS**

### **BUILDING 1 – Tallest Building**

Using your materials provided, you need to build the **TALLEST** possible structure that can **stand on its own** and remain standing while being measured.

*Critical Design Requirements (10 points each)*

- Safety/Structural Integrity: Stands on it's own, unsupported
- Capacity: Is taller than **36 inches**
- Minimal Waste: Uses most materials (less than 10 connectors and 10 straws wasted)
- Planning: Did not need to "re-buy" materials

*Secondary Design Requirements (2 points each)*

- Cosmetic: Is taller than **48 inches**
- Zero Waste: Uses ALL materials provided
- Space Saver: The Base of your tower is less than **10 inches x 10 inches**

### **BUILDING 2 – Strongest Building**

Using your materials provided, you need to build the **STRONGEST** possible structure that can withstand 5 lbs. of weight for at least 5 seconds.

*Critical Design Requirements (10 points each)*

- Safety/Structural Integrity: Stands on it's own, unsupported
- Strength: Can hold **5 lbs. for 5 seconds** without breaking/falling apart (some bending is OK)
- Minimal Waste: Uses most materials (less than 10 connectors and 10 straws wasted)
- Planning: Did not need to "re-buy" materials

*Secondary Design Requirements (2 points each)*

- SUPER Strength: Can hold 10 lbs without breaking/falling apart (some bending is OK)
- Zero Waste: Uses ALL materials provided
- Space Saver: The Base of your tower is less than **10 inches x 10 inches**

## Speedy Architect Rubric



### Speedy Architect

#### Building 1: Critical Design Requirements (10 points each)

	10 points Meets Requirement	8 points	6 points	4 points	2 points	0 points Does not Meet Requirement
<b>Safety/Structural Integrity</b>	Structure stands on its own, unsupported	-	-	-	-	Structure does not stand on it's own
<b>Capacity:</b>	36" or taller	-	Taller than 30"	-	-	Less than 30"
<b>Minimal Waste:</b> Uses most materials	Less than 10 connectors and 10 straws wasted	Less than 11 connectors and 11 straws wasted	Less than 12 connectors and 12 straws wasted	Less than 13 connectors and 13 straws wasted	Less than 14 connectors and 14 straws wasted	More than 14 connectors and 14 straws wasted
<b>Planning</b>	Did not need to "buy" additional materials	Needed to "buy" additional materials ONCE	Needed to buy additional materials MORE THAN ONCE	-	-	-

#### Building 1: Secondary Design Requirements (2 points each)

	2 points Meets Requirement	0 points Does not Meet Requirement
<b>Cosmetic</b>	Is taller than <b>48 inches</b>	Less than 48 inches
<b>Zero Waste</b>	Uses ALL materials provided	Does not use ALL materials provided
<b>Space Saver</b>	Building base measures <b>10" x 10"</b> or less	Base is larger than 10" x 10"

**Building 2: Critical Design Requirements (10 points each)**

	<b>10 points</b> <i>Meets Requirement</i>	<b>8 points</b>	<b>6 points</b>	<b>4 points</b>	<b>2 points</b>	<b>0 points</b> <i>Does not Meet Requirement</i>
<b>Safety/Structural Integrity</b>	Structure stands on its own, unsupported	-	-	-	-	Structure does not stand on it's own
<b>Strength</b>	Can hold a 5 lb weight for <b>5 seconds</b> without breaking (bending OK)	Can hold a 5 lb weight for <b>4 seconds</b> without breaking (bending OK)	Can hold a 5 lb weight for <b>3 seconds</b> without breaking (bending OK)	Can hold a 5 lb weight for <b>2 seconds</b> without breaking (bending OK)	Can hold a 5 lb weight for <b>1 seconds</b> without breaking (bending OK)	Cannot hold a 5 lb weight without breaking
<b>Minimal Waste:</b> Uses most materials	Less than 10 connectors and 10 straws wasted	Less than 11 connectors and 11 straws wasted	Less than 12 connectors and 12 straws wasted	Less than 13 connectors and 13 straws wasted	Less than 14 connectors and 14 straws wasted	More than 14 connectors and 14 straws wasted
<b>Planning</b>	Did not need to "buy" additional materials	Needed to "buy" additional materials ONCE	Needed to buy additional materials MORE THAN ONCE	-	-	-

**Building 2: Secondary Design Requirements (2 points each)**

	<b>2 points</b> <i>Meets Requirement</i>	<b>0 points</b> <i>Does not Meet Requirement</i>
<b>SUPER Strength</b>	Can hold a 10 lb weight without breaking (bending OK)	Cannot hold a 10 lb weight without breaking
<b>Zero Waste</b>	Uses ALL materials provided	Does not use ALL materials provided
<b>Space Saver</b>	Building base measures <b>10" x 10"</b> or less	Base is larger than 10" x 10"

Retrieved from <http://bit.ly/speedyarchitect>

# VIRTUAL REALITY

This station provides opportunities to experience and interact with virtual reality. There are several VR headsets to choose from - each offering slightly different selling features. In the IRC, we have the Oculus Rift headset and controllers.

- Oculus Rift headset and controllers
- Large TV or projector screen

**APPLICATIONS**

Virtual Reality has been increasingly finding its way into education and many other aspects of our lives. With the use of a headset and hand controllers, you are immersed in an experience within a virtual space which you can explore and interact with.

In addition to classroom educational settings, VR has been used to transform medical training, improve public speaking, offer guided meditation, and has the capacity to help children with ASD. ([virtualrealityforeducation.com](http://virtualrealityforeducation.com))

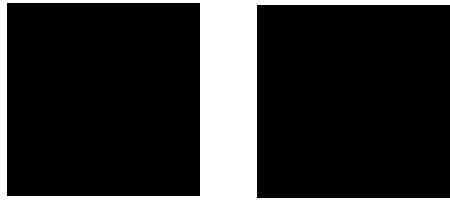


# CODING WITH OSMO

This station provides opportunities to experience hands on coding using a variety of different Osmo apps and accompanying kits to explore such things as music, letters and numbers, tangrams, drawing and creativity.

- Osmo Creative Kit with Monster
- Osmo Coding Jam Kit
- Osmo Tangram and Words Kit
- Osmo Genius Kit

OSMO APPS	<input type="checkbox"/> Coding Awbie	<input type="checkbox"/> Newton
	<input type="checkbox"/> Coding Jam	<input type="checkbox"/> Numbers
	<input type="checkbox"/> Masterpiece	<input type="checkbox"/> Tangram
	<input type="checkbox"/> Monster	<input type="checkbox"/> Words



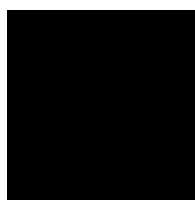


## PAPER CIRCUITS

This station provides opportunities to explore circuits using copper foil tape, LEDs and a 3V battery. Templates are provided to help learn various types of circuits, or circuits to light up a specific part on a card. Once the concept is understood, students can have fun creating their own designs.

- Markers
- Multimetre
- Paper Fasteners
- Pencils
- Pencil Crayons
- Pencil Sharpener
- Rulers
- Scissors
- Templates
- Paper Clips

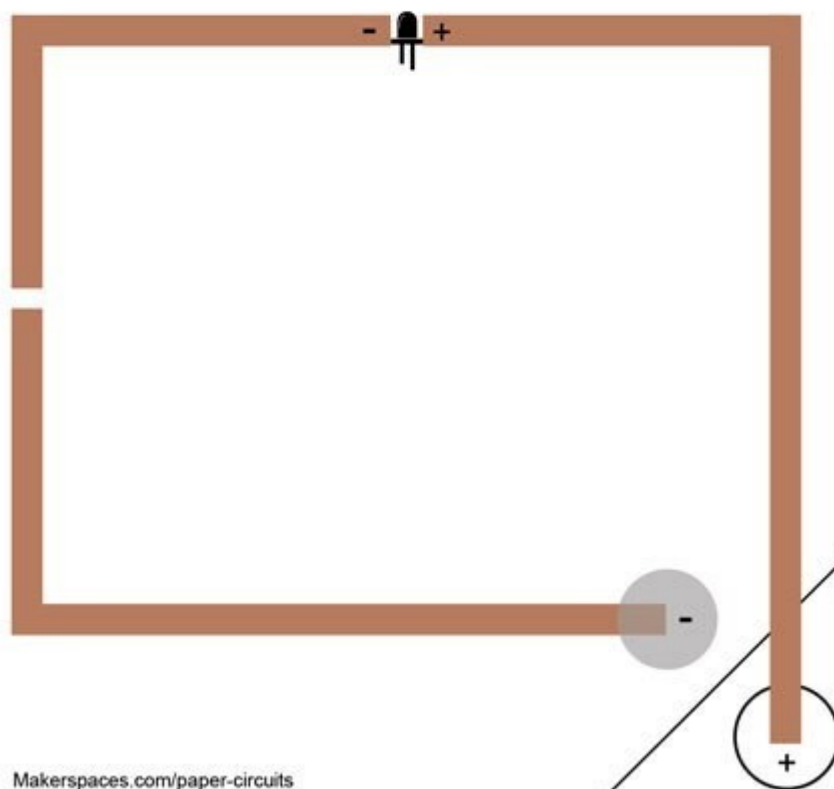
<b>CONSUMABLES</b>	<input type="checkbox"/> 3V Cell Batteries	<input type="checkbox"/> LEDs - White
	<input type="checkbox"/> Copper Foil Tape	<input type="checkbox"/> LEDs - Yellow
	<input type="checkbox"/> LEDs - Blue	<input type="checkbox"/> Paper Fasteners
	<input type="checkbox"/> LEDs - Green	<input type="checkbox"/> Tape
	<input type="checkbox"/> LEDs - Red	<input type="checkbox"/> Templates



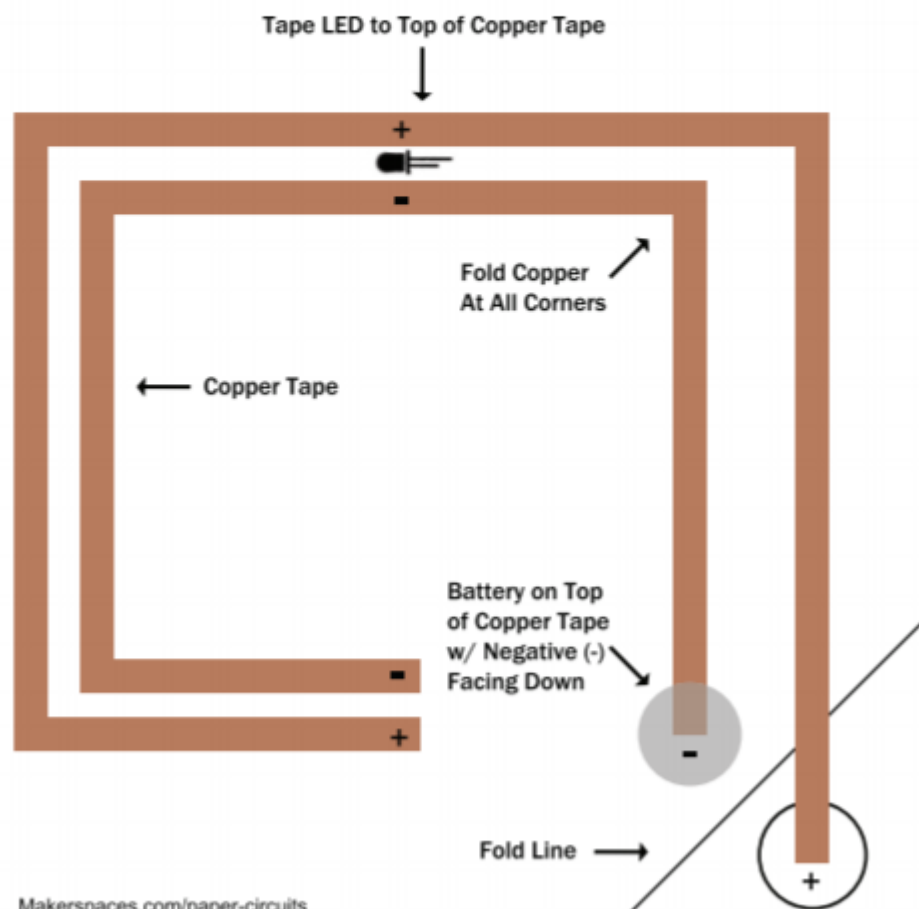
## Paper Circuit Templates

# Simple Circuit

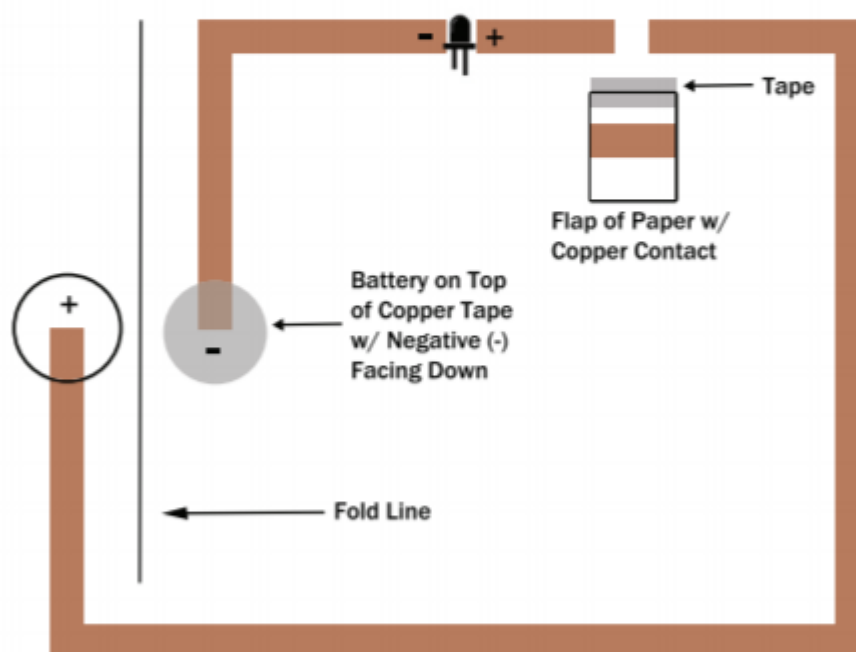
with switch



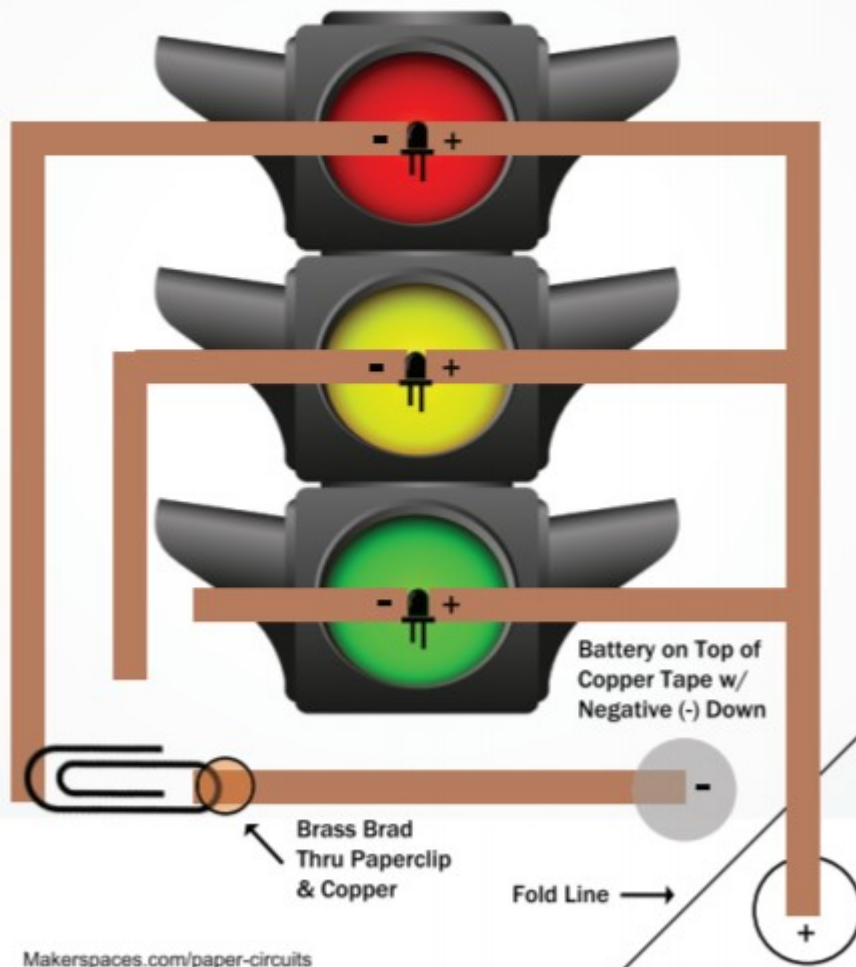
# Parallel Circuit



# Flap/Tab Switch



# Traffic Lights



## Paper Circuit Troubleshooting

Is your LED not lighting? Most of the time it's a very simple fix. Here is a list of the common ways to make your paper circuit functional.

1. Make sure that the LONG leg of your LED is secured to the positive (+) side of the circuit because this is easy to mix up.
2. Sometimes the LED legs are just not contacting the copper tape well enough. Rub the clear tape that secures the LED to ensure there is a solid connection with the copper tape below.
3. Inspect the battery. Make sure the negative (-) of the battery is touching the negative side of the copper tape and the same goes with the positive. Furthermore, make sure there is a solid connection between the battery and copper. Sometimes you need to tape the battery down using clear tape.
4. It's highly recommended that you try to maintain a continuous strip of copper foil versus cutting it. But sometimes you just need to make a cut. Make sure you push down and rub the two pieces of copper that are taped together. There needs to be a solid connection.
5. Ensure all copper tape has been smoothed down on the paper with as few wrinkles as possible.
6. Is there a short in the circuit? A short can happen when the positive and negative copper tape make contact with each other. Check around the battery area and the LED area which are common places for this to happen.
7. If you're using a LilyPad switch make sure it is taped down firmly to the copper tape below it. Also, there needs to be a gap in the copper directly below the switch as outlined on the template.
8. Finally, are your parts even functional? At times you might just have a bad battery or bad LED. One easy way to test both of these items is to place the LED directly onto the battery. Make sure the LONG leg is touching the positive side of the battery.

*Retrieved from <https://www.makerspaces.com/paper-circuits>*

# BLOXELS

This station provides opportunities to explore video game creation. Use your imagination to create your own gameboards and characters that can be captured in the Bloxels Builder app to play on your mobile device.

- Bloxels Kits – one kit per person
- iPads – one per person

## APPLICATIONS

Bloxels, created by Mattel share:

You don't need to understand fancy code and own super expensive computer programs to make video games anymore. All it takes is your Bloxels Gameboard, some blocks and a mobile device and, of course, your imagination to take the guesswork out of building your own video games!

Build games and tell stories about anything you can imagine! With Bloxels the possibilities are endless

Our 13x13 Gameboard and blocks allow you to create all your levels, characters, and any other art you have in mind.

Use our free Bloxels Builder app to capture your Gameboard and edit your layouts and art, and animate your heroes and enemies.

[home.bloxelsbuilder.com](http://home.bloxelsbuilder.com)



## Coloured Blocks Game Elements



Use different coloured blocks to customize and design a variety of game elements



### Green Blocks

Green blocks are terrain. Use them as ground for your character to run and jump on.



### Blue Blocks

Blue blocks are water. They affect the physics of your character like it's in water.



### Red Blocks

Red blocks are Hazards. Touching these blocks will damage your hero's health.



### Yellow Blocks

Yellow blocks are coins. Characters collect them throughout the game.



### Purple Blocks

Purple blocks are enemies. They fight against you and can patrol, fly or be stationary.



### Pink Blocks

Pink blocks are power-ups. These items give your character special abilities like invincibility.



### Orange Blocks

Orange blocks are exploding terrain. Use them like green blocks, but if you shoot them, they explode.



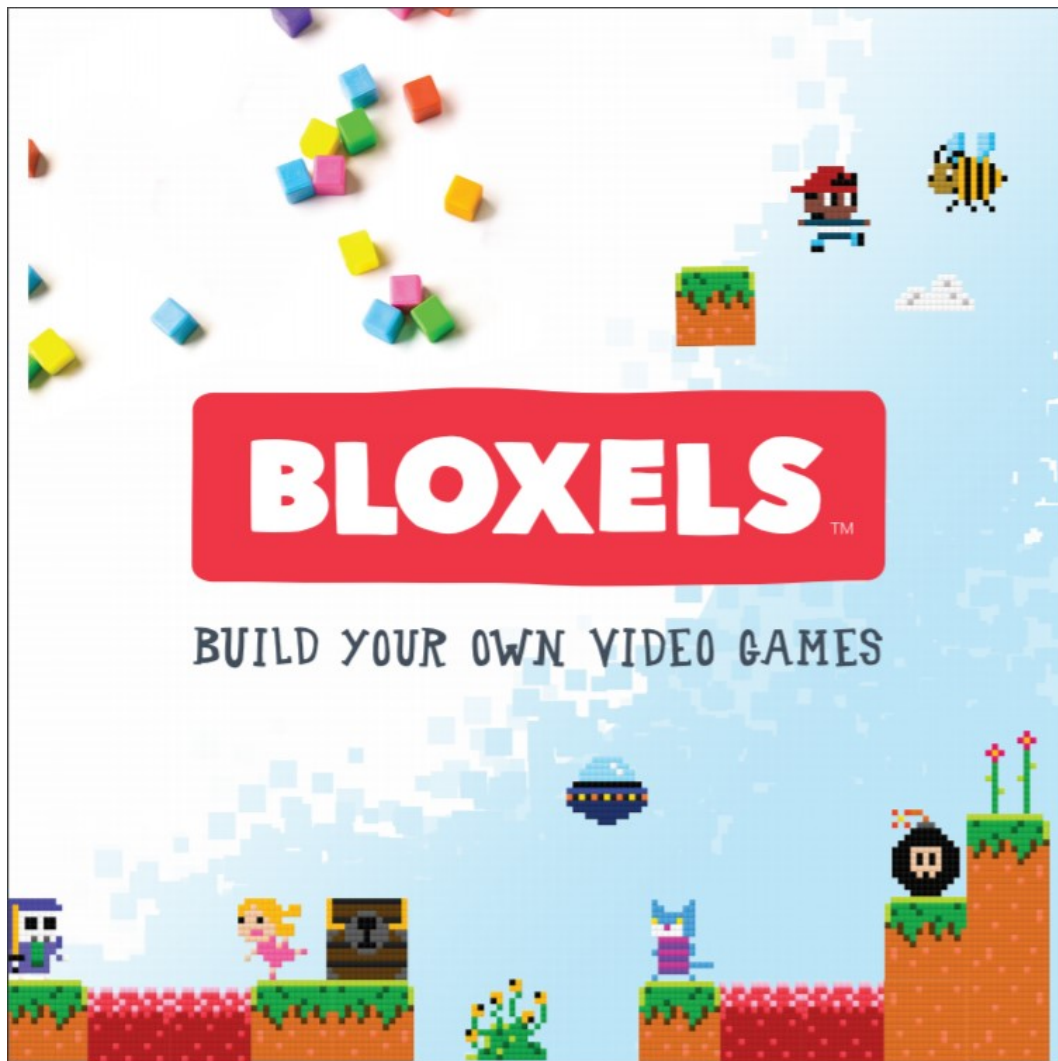
### White Blocks

White blocks are story blocks. Use them as checkpoints, text bubbles and for the end flag.

Retrieved from <http://home.bloxelsbuilder.com/>



## BLOXELS Guidebook



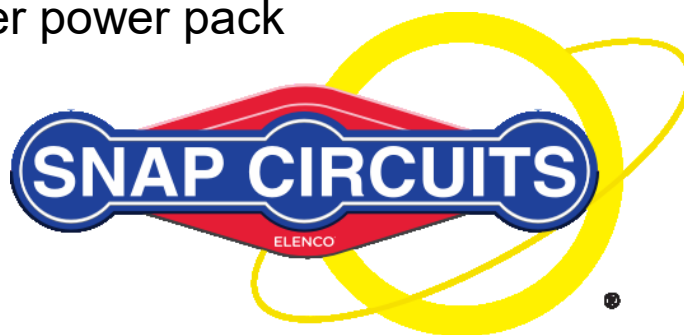
Access the 32-page guidebook:

<https://bit.ly/bloxels-guidebook>

# SNAP CIRCUITS

This station provides opportunities to explore a variety of guided lessons which build upon concepts learned and get progressively more difficult, or you can freely create your own circuits by snapping various units together.

- Snap Circuits Extreme
- Snap Circuits Light Experiments
- Snap Circuits Motion Experiments
- Snap Circuits Green Alternative Energy
- Snap Circuits 3D Illumination
- 2-3 AA Batteries per power pack

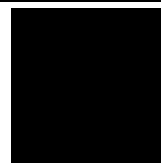
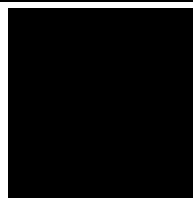


*Retrieved from <https://www.elenco.com>*

## APPLICATIONS

retrieved from <http://www.snapcircuits.net>

Elenco's new Snap Circuits® makes learning electronics easy and fun! Just follow the colorful pictures in our manual and build exciting projects, such as FM radios, digital voice recorders, AM radios, burglar alarms, doorbells, and much more! You can even play electronic games with your friends. All parts are mounted on plastic modules and snap together with ease. Enjoy hours of educational fun while learning about electronics. No tools required. Uses AA batteries.



# LEGO

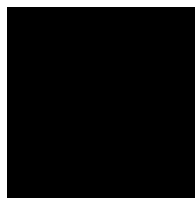
This station provides opportunities to explore in a comfortable space that most are already familiar with. Lego provides for collaboration and creativity while building anything imaginable.

- Lego
- Lego
- More Lego
- You really can't have too much Lego

## PRO TIPS

### Tips for cleaning Lego

Other than elbow grease with dish soap and a toothbrush, some have tried putting Lego into a garment bag and laid it in the top rack of the dishwasher claiming they come out clean and sanitized - others have also used the garment bag and thrown it in the washing machine on a cold water wash. Depending on the agitation of the cycle it could possibly break pieces and you would also want to make sure that the pieces could not work their way out of the bag - especially if using a mesh garment bag. You should do your own research on the various methods to see which you feel most comfortable with.



# MOUSE MAZE

This station provides opportunities to experience hands-on coding, maze building and a lot of trial and error, critical thinking and problem solving to help the mouse find its cheese.

- Code & Go Robot Mouse Activity Set – one activity set can be used individually but collaborating with others is more fun!
- 3 AAA Batteries for each mouse

## CONSUMABLES

- AAA Batteries



Retrieved from <http://bit.ly/mousemaze>

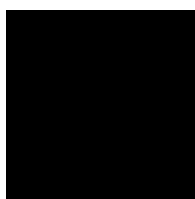


## DUCT TAPE

This station provides opportunities to create anything imaginable with duct tape, such as wallets, bows, backpacks, bookmarks, shoes, book covers, and more!

- Duct Tape – variety of colours, designs and patterns
- Markers
- Ruler
- Scissors
- Duct Tape Examples

CONSUMABLES	<input type="checkbox"/> Duct Tape	<input type="checkbox"/> Elastics
	<input type="checkbox"/> Ribbon	<input type="checkbox"/> Buttons
	<input type="checkbox"/> Velcro	<input type="checkbox"/> Paper
	<input type="checkbox"/> String	<input type="checkbox"/> Ziplock Baggies
	<input type="checkbox"/> Pipe Cleaners	<input type="checkbox"/> Zippers

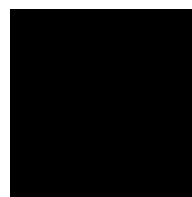
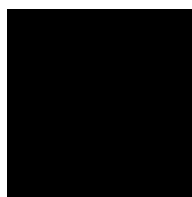


# ROBOTS

This station provides opportunities to explore various types of coding using hands-on coding and various forms of block coding in accompanying apps.

- Dot & Dash
- Cue & Onyx
- Bee-Bot
- Blue-Bot
- Makebot
- EV3
- Cubetto
- Ollie
- Sphero
- Lego Mindstorms
- Lego Boost
- Grid/Map Challenges
- iPads

ROBOT APPS	<input type="checkbox"/> Wonder, Go, Blockly, Path, Xylo	<input type="checkbox"/> FV3 Programmer App
	<input type="checkbox"/> Cue	<input type="checkbox"/> Sphero Edu
	<input type="checkbox"/> Makeblock	<input type="checkbox"/> Creative Toolbox

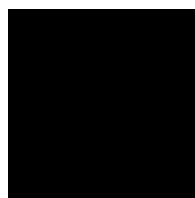


## MARBLE MAZE

This station provides opportunities to experience creativity and design thinking while collaborating with others to solve a problem, such as ring the bell. Buckets of supplies are provided to be used in ways to make things move, or roll, creating a chain reaction of events until the marble reaches the point of solving the problem.

- Pulleys
- PVC Pipe – variety of angles, elbows, joins, etc
- Cardboard tubes
- Dominoes
- Marbles
- Cups
- String
- Little cars
- Tape
- Scissors
- Basket
- Various Balls
- Marble Run Kits – wooden
- Marble Run Kits - plastic

<b>CONSUMABLES</b>	<input type="checkbox"/> Tape
	<input type="checkbox"/> String
	<input type="checkbox"/> Cardboard Tubes
	<input type="checkbox"/> Marbles



# STOP-MOTION ANIMATION

This station provides opportunities to work collaboratively with a partner to create stop-motion animation using a Minecraft kit.

- Minecraft Kits – one kit per two people
- iPads



Retrieved from <http://bit.ly/minecraftstopmo>





## GREAT LINKS for stop-motion animation

<http://www.makerspaceforeducation.com/stop-motion-animation.html>

<https://www.iste.org/explore/Toolbox/Engage-elementary-students-with-stop-animation%21?articleid=128>

<https://www.nfb.ca/playlists/stopmostudio/>

<https://stopmotionclassroom.weebly.com/>

# SCRATCH CODING

This station provides opportunities to explore a programming language online using visual block coding.

- Basic Instructions
- Laptops
- Scratch Coding Books
- Scratch Coding Cards
- URL for Scratch

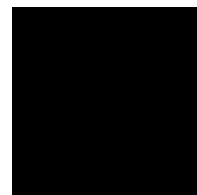
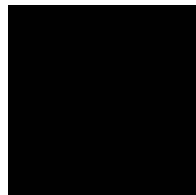
## APPLICATION

Retrieved from <https://scratch.mit.edu/about>

With Scratch, you can program your own interactive stories, games, and animations — and share your creations with others in the online community.

Scratch helps young people learn to think creatively, reason systematically, and work collaboratively — essential skills for life in the 21st century.

Scratch is a project of the Lifelong Kindergarten Group at the MIT Media Lab. It is provided free of charge.



# LEARNING WITH SCRATCH

What do young people **learn** as they create interactive stories, animations, games, music, and art with Scratch?

For one thing, they learn **mathematical and computational ideas** that are built into the Scratch experience. As students create programs in Scratch, they learn core computational concepts such as iteration and conditionals. They also gain an understanding of important mathematical concepts such as coordinates, variables, and random numbers.

Significantly, students learn these concepts in a **meaningful** and **motivating** context. When students learn about variables in traditional algebra classes, they usually feel little personal connection to the concept. But when they learn about variables in the context of Scratch, they can use variables immediately in very meaningful ways: to control the speed of an animation, or to keep track of the score in a game they are creating.

As students work on Scratch projects, they also learn about the **process of design**. Typically, a student will start with an idea, create a working prototype, experiment with it, debug it when things go wrong, get feedback from others, then revise and redesign it. It's a continuous spiral: get an idea, create a project, which leads to new ideas, which lead to new projects, and on and on.

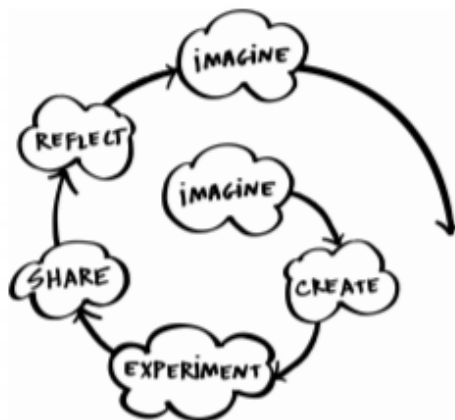
This project-design process combines many of the **21<sup>st</sup> century learning skills** that will be critical to success in the future: thinking creatively, communicating clearly, analyzing systematically, collaborating effectively, designing iteratively, learning continuously.

Creating projects in Scratch also helps students develop a deeper level of **fluency** with digital technology. What do we mean by fluency? To be considered fluent in English, Spanish, or other language, you must learn not only how to read but also to write – that is, how to express yourself with the language. Similarly, to be fluent with digital technology, you must learn not only how to interact with the computer but also to create with it.

Of course, most students will not grow up to become professional programmers, just as most will not become professional writers. But **learning to program** offers benefits for everyone: it enables students to express themselves more fully and creatively, helps them develop as logical thinkers, and helps them understand the workings of the new technologies that they encounter everywhere in their everyday lives.

#### References

Scratch: Programming for All (<http://bit.ly/YcK3n>)  
21<sup>st</sup> Century Learning Skills (<http://bit.ly/119M3wZ>)



Lifelong Kindergarten Group, MIT Media Lab

## Scratch Community Guidelines

We need everyone's help to keep Scratch a friendly and creative community where people with different backgrounds and interests feel welcome.

### **Be respectful.**

When sharing projects or posting comments, remember that people of many different ages and backgrounds will see what you've shared.

### **Be constructive.**

When commenting on others' projects, say something you like about it and offer suggestions.

### **Share.**

You are free to remix projects, ideas, images, or anything else you find on Scratch – and anyone can use anything that you share. Be sure to give credit when you remix.

### **Keep personal info private.**

For safety reasons, don't give out any information that could be used for private communication - such as real last names, phone numbers, addresses, email addresses, links to social media sites or websites with unmoderated chat.

### **Be honest.**

Don't try to impersonate other Scratchers, spread rumors, or otherwise try to trick the community.

### **Help keep the site friendly.**

If you think a project or comment is mean, insulting, too violent, or otherwise inappropriate, click "Report" to let us know about it.

Scratch welcomes people of all ages, races, ethnicities, religions, abilities, sexual orientations, and gender identities.



## APPENDICES

Appendix A: Info Sheet

Appendix B: Station Sign-Up Chart

Appendix C: Feedback Form

## APPENDIX A: Info Sheet



Welcome!

1. Make a Name Tag
2. Choose your Activities for the day
  - Walk around the gym and see the various stations we have set up for you to explore
  - Write your name on a sticky note and place it in the time slot you wish to attend (each station offers up to 6 spaces during each timeslot - for VR virtual reality, select a numbered sticker for your two-minute demo and you will be called up when it is your turn)
  - Record which station you have chosen for each timeslot below

TIME	STATION NAME
9:00-9:30	PRESENTER
9:30-10:15	
10:15-11:00	
11:00-11:45	
11:45-12:30	LUNCH (provided in cafeteria)
12:30-1:15	
1:15-2:00	
2:00-2:45	
2:45-3:00	WRAP-UP

3. Share your ideas (and any curriculum connections you think of) in the reflection books at each station
4. Each session is 45min - you will be alerted at 5 min before the session end time, and when the bell rings it is time to move onto your next station
5. Have Fun!

#ircmakerspace



## APPENDIX B: Station Sign-up Chart

## STATION NAME

	1	2	3	4	5	6
9:30am						
10:15am						
11:00am						
11:45am						
12:30pm						
1:15pm						
2:00pm						



Thank you for attending Makerspace. We would appreciate your feedback.

1. Would you recommend this event to other Teacher Candidates?

---

---

2. What was your favourite station?

---

---

---

3. How would you integrate maker mindset into your classroom?

---

---

---

---

---

---

4. What can we do better, or what do you feel was missing?

---

---

---

---

5. Other Comments:

---

---

---

---

---

---

---

#ircmakerspace





## BIBLIOGRAPHY

*Bloxels*. (n.d.). Retrieved from Mattel: Powered By Pixel Press:

<http://home.bloxelsbuilder.com/>

*Bloxels Guidebook*. (2016). Retrieved from <https://bit.ly/bloxels-guidebook>

*DIY Apple String Art*. (2016, June 1). Retrieved from Sarah M Style:

<http://bit.ly/applestringart>

*Easy String Art Tutorial Heart Template!* (n.d.). Retrieved from Doodlecraftblog.com:

<http://bit.ly/heartSA>

*Learning Resources Stem Robot Mouse Coding Activity Set*. (n.d.). Retrieved from

Amazon.ca: <http://bit.ly/mousemaze>

*Learning with Scratch*. (n.d.). Retrieved from Scratch.mit.edu:

<https://llk.media.mit.edu/scratch/Learning-with-Scratch.pdf>

*Minecraft Stop-Motion Movie Creator Kit*. (2015). Retrieved from Mattel Shop:

<http://bit.ly/minecraftstopmo>

*Minion Makers*. (2016, 07 15). Retrieved from YouTube:

<https://www.youtube.com/watch?v=icnClyiTUMQ&feature=youtu.be>

*Paper Circuits for Makerspaces*. (2014-2019). Retrieved from Makerspaces.com:

<https://www.makerspaces.com/paper-circuits>

*Snap Circuits*. (2019). Retrieved from Elenco: Learn by doing: <https://www.elenco.com/>

*Speedy Architect Project*. (2016, August 18). Retrieved from Thingiverse:

<http://bit.ly/speedyarchitect>



## CHAPTER FIVE: SUMMARY, DISCUSSION, AND IMPLICATIONS

The purpose of this study was to develop a resource to support pre-service teacher candidates in bringing makerspaces and maker mindset to their classroom teaching practices. *The Making of a Makerspace: A Handbook on Getting Started* is designed to be a practical guide to the set-up, organization, and materials, tools and technologies based on what we offer at a variety of our makerspace stations to promote student growth in key future ready skills. The handbook gives pre-service teacher candidates a starting point of what kinds of technologies could be offered and what needs to be organized and considered in preparation of each type of station. Pre-service teacher candidates can use the handbook as a guide to easily duplicate the contents of each station or use it to form a basis and get ideas on which to build upon and personalize to the needs of their learners. *The Making of a Makerspace: A Handbook on Getting Started* was presented to two reviewers with expertise in makerspace design and implementation, who provided feedback for improvement of the handbook. The feedback was guided by the set of questions found in Chapter 3 (and the Appendix), which were designed to gauge the experts' perceptions of the projected effectiveness of the handbook to support teacher use of makerspaces in the classroom. This chapter will summarize, discuss, and draw implications from their responses.

### Summary

In order to gauge the effectiveness of the handbook, *The Making of a Makerspace: A Handbook on Getting Started*, a resource guide to assist pre-service teacher candidates in implementing makerspace technologies in their own classrooms, this chapter presents the findings from the email questionnaire completed by the

reviewers, who were media specialists with expertise in facilitating makerspaces. Electronic copies of the handbook were emailed to these two media experts who were asked to review the handbook and respond to a questionnaire. The responses to the questionnaire were returned through email and then reviewed and coded using an emergent coding process whereby data was categorized into main ideas and themes. The themes that emerged from the analysis of the data included how the handbook supported three areas of makerspaces: (a) stations and activities, (b) the maker culture, and (c) future ready skill development. These themes are examined more fully in the Discussion section below.

### **Discussion**

The resource, *The Making of a Makerspace: A Handbook on Getting Started*, was created to assist pre-service teacher candidates in implementing makerspaces and making experiences within their own classrooms and school learning environments. As the intention was for the handbook to be a practical resource for pre-service teacher candidates, it is important to note that overall, reviewers' feedback was favourable and concurred that the handbook would be a valuable resource for pre-service teacher candidates as a beginning guide.

### **Detailed Stations and Activities**

The handbook resource provided detailed station descriptions and outlines of required tools, materials, supplies and consumables for over 20 stations. Both expert reviewers stated that the stations included were appropriate, engaging, do-able, and incorporated a variety of types of activities. The stations and activities provided are suitable across a range of grades and ages and lend themselves to be easily modified or

extended by adding more materials and supplies, or less, based on the specific student needs or desire to explore specific outcomes. The activities are inquiry based and therefore the details provided for each stations' materials, supplies and consumables allow for a wide assortment of activities and students can engage on a variety of levels.

Furthermore, the review of the handbook revealed that the level of detail provided in the handbook for each station made it easy for pre-service teacher candidates and teachers alike to use and develop their own knowledge of makerspace. One expert shared, "The level of detail and the step by step description of activities and events make it easy for an interested instructor to jump in with little or no knowledge of Makerspace." Additionally, the second reviewer felt that the "types of stations and very important lists of the materials" are appealing as they are important in helping pre-service teacher candidates to begin integrating makerspace technologies.

Reviewers did suggest that detailed stations might also be extended to include specific activities suited to specific grade levels; costs associated with each station; and safety concerns specific to each station. Feedback received from one of the experts regarding how the handbook can be used to engage students and extend their learning (as suggested by Kurti et al., 2014) was to "ask their students to design a Makerspace floor plan and identify the stations and supplies." This would allow the students to include stations and learning activities that they were interested to include in their space. Another expert shared "in schools without a makerspace and only able to perhaps host one or two stations, having involvement from students in the decision-making process would be a valuable buy-in." The handbook provides over 20 stations that students could choose from or even use the ideas to do a rotation of a couple selected stations each month.

## **Learning About Maker Culture**

Hughes (2017) notes that a maker culture develops in a space that promotes a growth mindset where students learn from making mistakes, persevere through trial and error and problem solving, are encouraged to take risks, and develop critical thinking skills. One reviewer felt that “being aware of what a makerspace is and what makerspace culture encompasses is valuable in and of itself. Teacher candidates would begin to see the world a bit differently and hopefully pass this enthusiasm on to their students.” The handbook addresses how pre-service teacher candidates might learn about makerspaces by presenting resources, suggestions, and recommended activities that build that maker culture and engage students.

The handbook also has a section that outlines how I experienced makerspaces in Texas and Nottingham, and how these experiences were transformed into greater opportunities for our pre-service teacher candidates by providing safe spaces to explore and develop a maker mindset. Reflections of my own experiences from a variety of stations, and maker culture, influenced the type of information and content that was included in the handbook, so pre-service teacher candidates will be able to gain deeper understanding about the maker mindset, while jumping into a variety of activities and beginning their own makerspace journey.

## **Promoting Future Ready Skills**

Future ready skills (e.g., critical thinking and problem solving; creativity and innovation; collaboration and communication) are intertwined throughout the hands-on exploration of various makerspace stations and are developed further by the opportunity of experiential learning. Dougherty (2016) suggests that the type of learning that occurs

when one is given the opportunity to take an idea, share it, and become makers as they make it into something tangible promotes future readiness. In response to how the handbook promotes key future ready skills, one expert stated:

This resource lays the groundwork for activities that require future ready skills.

Most of the stations, require the use of future ready skills in order to complete the activities. These skills are encouraged in an organic, fun and inviting way.

Additionally, each of the stations in the handbook has been identified with one to two focus icons that represent the various future ready skills including critical thinking and problem solving; creativity and innovation; and collaboration and communication that have the potential to be gained through each of the stations and activities provided.

Based on the makerspace events held at Brock over the last 2 years, the handbook was designed to provide these connections to future ready skills through the iconic notations added in the handbook. This allows a pre-service teacher candidate to quickly identify which stations and activities best promote each future ready skill. So a pre-service teacher candidate who was seeking to engage students in activities that promoted the future ready skill of critical thinking can flip through the handbook to select a variety of stations and activities that have the critical thinking and problem solving icon, such as the mini robots station or paper circuits station where their students can work through the activities and build their critical thinking and problem-solving skills.

### **Implications for Practice**

The handbook is beneficial to pre-service teacher candidates who want to integrate makerspace and maker mindset into their classrooms and learning environments. The resource outlines over 20 makerspace stations that can be easily

duplicated in a large-scale event setting or in a smaller setting where just a few stations are chosen at a time. The resource also provides information on how to set up a makerspace, including the equation for how to calculate the number of stations needed based on the number of learners attending and sample charts for how to organize the schedule and rotations for an event. However, the handbook should not be viewed as the ultimate guide to makerspaces, but as a simple guide for getting involved in the making mindset and makerspaces in teaching practice—which means, it should be thought of as a starting point. From the multitude of makerspace activities and resources found online, it is apparent that no one person is the keeper of knowledge and therefore educational resource sharing is abundant. The handbook assists in compiling a variety of activities which align to future ready skills and allows the reader to share in my growth from the experiences with makerspace and maker mindset.

### **Implications for Future Research**

Upon completion of this research project and consideration of its limitations, there are implications to note for future research. First, a very small sample was used for data collection of feedback regarding the effectiveness of the handbook. Although the participants were experts in the facilitation and implementation of makerspace events, and their feedback was valuable for this phase of the project, it would be of great benefit to have a larger sample of respondents who have expertise in facilitating makerspaces answer the questionnaire about the handbook.

Secondly, the handbook is intended to be valuable for assisting pre-service teacher candidates with integrating makerspace and maker mindset into their own classrooms and learning environments. For this reason, it would be beneficial to have



several pre-service teacher candidates use the handbook on their own to set-up a makerspace event or various stations to evaluate if the documentation provides enough information to guide them on this integration and implementation.

### **Concluding Remarks**

The overall goal of this research project was to develop a practical handbook that would assist pre-service teacher candidates with integrating makerspace and maker mindset in their own classrooms so they could encourage their students to develop future ready skills. A resource such as this can grow and evolve but was designed to provide a foundation for pre-service teacher candidates getting started with makerspace design in teaching practice. I have enjoyed sharing my makerspace journey in developing this handbook and hope that others will be inspired to build on my experiences with experiences on their own makerspace journey.

## References

- Ackermann, E. (2001). Piaget's constructivism, Papert's constructionism: What's the difference? In *Constructivism: uses and perspectives in education*. Geneva, Switzerland: Research Center in Education. Retrieved from [https://learning.media.mit.edu/content/publications/EA.Piaget%20\\_%20Papert.pdf](https://learning.media.mit.edu/content/publications/EA.Piaget%20_%20Papert.pdf)
- Adams Becker, S., Brown, M., Dahlstrom, E., DePaul, K., Diaz, V., & Pomerantz, J. (2018, April 12). *Horizon report 2018: Higher education brought to you by EDUCAUSE*. Retrieved from <https://www.learntechlib.org/p/184633/>
- Bannan, K. (2016, October 10). Makerspaces encourage students to innovate and build critical thinking skills. *EdTech Focus on K-12*. Retrieved from <https://edtechmagazine.com/k12/article/2016/10/makerspaces-encourage-students-innovate-and-build-critical-thinking-skills>
- Blackley, S., Sheffield, R., Maynard, N., Koul, R., & Walker, R. (2017). Makerspace and reflective practice: Advancing pre-service teachers in STEM education. *Australian Journal of Teacher Education*, 42(3), 22-37.  
doi:10.14221/ajte.2017v42n3.2
- Bonagura, R. (2017). *Embrace makerspace: A pocket guide for elementary school administrators*. Lanham, MD: Rowman & Littlefield.
- Choe, J. (2018, April 12). Understanding the potential of AR and VR for autistic children. *Virtual Reality for Education*. Retrieved from <http://virtualrealityforeducation.com/understanding-the-potential-of-ar-and-vr-for-autistic-children/>
- Cohen, J. (2017). Maker principles and technologies in teacher education: A national survey. *Journal of Technology and Teacher Education*, 25(1), 5-30.

- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage.
- Dewey, J. (1938). *Experience and education*. New York, NY: Collier.
- Dougherty, D. (2013). The maker mindset. In M. Honey & D. E. Kanter (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 7-11). New York, NY: Routledge.
- Dougherty, D. (2016). *Free to make: How the maker movement is changing our schools, our jobs, and our minds*. Berkeley, CA: North Atlantic Books.
- Dweck, C. (2006). *Mindset: The new psychology of success*. New York, NY: Random House.
- Educause. (2013, October 25). *7 things you should know about makerspaces*. Retrieved from <https://library.educause.edu/resources/2013/10/7-things-you-should-read-about-makerspaces>
- Figg, C., & Jaipal, K. (2009). Unpacking TPACK: TPK characteristics supporting successful implementation. In *Society for Information Technology & Teacher Education international conference* (pp. 4069-4073). Chesapeake, VA: AACE.
- Figg, C., Rowsell, J., Welbourn, S., & Pelchat, K. (2018). Using informal learning of makerspaces to enhance technological pedagogical and content knowledge (TPACK). In *Society for Information Tecnology & Teacher Education international conference* (pp. 2037-2040). Washington, DC: AACE.
- Fleming, L. (2015a, October 17). A thematic approach to planning your maker space. *School Library Journal*. Retrieved from <https://www.slj.com/?detailStory=a-thematic-approach-to-planning-your-maker-space>

- Fleming, L. (2015b). *Worlds of making: Best practices for establishing a makerspace for your school*. Thousand Oaks, CA: Corwin Press.
- Fleming, L. (2018). *The kickstart guide to making great makerspaces*. Thousand Oaks, CA: Corwin Press.
- Freeman, A., Adams Becker, S., Cummins, M., Davis, A., & Hall Giesinger, C. (2017). *NMC/CoSN horizon report: 2017 K-12 edition*. Austin, TX: New Media Consortium.
- Gerstein, J. (2014). Moving from education 1.0 through education 2.0 towards education 3.0. In L. Blaschke, C. Kenyon, & S. Hase (Eds.), *Experiences in self-determined learning* (pp. 83-98). Retrieved from [https://uol.de/fileadmin/user\\_upload/coer/Experiences-in-self-determined-learning.pdf](https://uol.de/fileadmin/user_upload/coer/Experiences-in-self-determined-learning.pdf)
- Hatch, M. (2014). *The maker movement manifesto: Rules for innovation in the new world of crafters, hackers, and tinkerers*. New York, NY: McGraw-Hill Education.
- Hsu, Y., Baldwin, S., & Ching, Y. (2017). Learning through making and maker education. *Tech Trends*, 61, 589-594. doi.org/10.1007/s11528-017-0172-6
- Hughes, J. (2017, April). Meaningful making: Establishing a makerspace in your school or classroom. *What Works? Research into Practice*. Retrieved from [http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/meaningful\\_making\\_en.pdf](http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/meaningful_making_en.pdf)
- Kolb, D. (1984). *Experiential learning: Experience as the source of learning and development* (Vol. 1). Englewood Cliffs, NJ: Prentice-Hall.
- Krishnamurthi, A., & Rennie, L. J. (2013). *Informal science learning and education: Definition and goals*. Retrieved from [http://www.afterschoolalliance.org/documents/STEM/Rennie\\_Krishnamurthi.pdf](http://www.afterschoolalliance.org/documents/STEM/Rennie_Krishnamurthi.pdf)

- Kurti, S., Kurti, D., & Fleming, L. (2014, June). The philosophy of educational makerspaces: Part 1 of making an educational makerspace. *Teacher Librarian*, 41(5), 8-11.
- MacKenzie, T. (2016). *Dive into inquiry*. Irvine, CA: EdTechTeam Press.
- Maker Media. (2013). *The makerspace playbook: School edition*. Retrieved from [https://cdn.makezine.com/makerspace/Makerspace-Playbook-Feb-2013.pdf?utm\\_source=MakerPro+20160901&utm\\_medium=email&utm\\_term=&utm\\_content=text&utm\\_campaign=newsletter](https://cdn.makezine.com/makerspace/Makerspace-Playbook-Feb-2013.pdf?utm_source=MakerPro+20160901&utm_medium=email&utm_term=&utm_content=text&utm_campaign=newsletter)
- Martinez, S., & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering in the classroom*. Torrance, CA: Constructing Modern Knowledge Press.
- Martinez, S., & Stager, G. (2014). *The maker movement: A learning revolution*. Retrieved from <https://www.iste.org/node/6653>
- McKibben, S. (2014, June). If you build it: Tinkering with the maker mind-set. *Education Update*, 56(6), 5-7.
- McLeod, S. (2017, October 24). *Kolb—Learning styles*. Retrieved from <https://www.simplypsychology.org/learning-kolb.html>
- McMillan, J. H., & Wergin, J. F. (2006). *Understanding and evaluating educational research*. Boston, MA: Pearson.
- Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.
- P21 Partnership for 21st Century Learning. (2019). *Framework for 21st century learning*. Retrieved from <http://www.battelleforkids.org/networks/p21/frameworks-resources>

- Papavlasopoulou, S., Giannakos, M., & Jaccheri, L. (2017). Empirical studies on the maker movement, a promising approach to learning: A literature review. *Entertainment Computing, 18*, 57-78. doi:10.1016/j.entcom.2016.09.002
- Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York, NY: Basic Books.
- Piaget, J. (1972). Some aspects of operations. In M. W. Piers (Ed.), *Play and development* (pp. 15-27). New York, NY: Norton.
- Piaget, J. (1973). *To understand is to invent: The future of education*. New York, NY: Grossman.
- Provenzano, N. (2016). *The nerdy teacher presents: Your starter guide to maker spaces*. Middleton, DE: Blend.
- Rix, K. (2014). Meet the makers. *Scholastic Administrator*. Retrieved from <http://www.scholastic.com/browse/article.jsp?id=3758299>
- Robinson, K. (2006). Do schools kill creativity? *TED: Ideas Worth Spreading* (Video file). Retrieved from [https://www.ted.com/talks/ken\\_robinson\\_says\\_schools\\_kill\\_creativity?language=en](https://www.ted.com/talks/ken_robinson_says_schools_kill_creativity?language=en)
- Roffey, T., Sverko, C., & Therien, J. (2016). *The making of a makerspace: Pedagogical and physical transformations of teaching and learning*. Vancouver, BC: University of British Columbia. Retrieved from [http://www.makerspaceforeducation.com/uploads/4/1/6/4/41640463/makerspace\\_for\\_education\\_curriculum\\_guide.pdf](http://www.makerspaceforeducation.com/uploads/4/1/6/4/41640463/makerspace_for_education_curriculum_guide.pdf)
- Schrum, L., & Levin, B. (2016). Educational technologies and twenty-first century leadership for learning. *Educational Technologies, 19*(1), 17-39. doi:10.1080/13603124.2015.1096078

- Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., & Gaved, M. (2013). *Innovating pedagogy 2013: Open University innovation report*  
2. Milton Keynes, UK: The Open University. Retrieved from  
<https://iet.open.ac.uk/file/innovating-pedagogy-2013.pdf>
- Shively, K. (2017). Reflections from the field: Creating an elementary living learning makerspace. *Learning Communities Research and Practice*, 5(1), 1-14.
- Smay, D., & Walker, C. (2015). Makerspaces: A creative approach to education. *Teacher Librarian*, 42(4), 39-43.
- Stager, G. (2013). Papert's prison fab lab: Implications for the maker movement and education design. *IDC Short Papers, 2013*, 487-490. Retrieved from  
<https://www.makersempire.com/wp-content/uploads/2018/02/Paperts-Prison-Fab-Lab-Implications-for-the-maker-movement-and-education-design-Stager-13.pdf>
- Vygotsky, L. (1978). *Mind and society*. Cambridge, MA: Harvard University Press.
- Wolpert-Gowron, H. (2016, August 11). *What the heck is inquiry-based learning?*  
Retrieved from <https://www.edutopia.org/blog/what-heck-inquiry-based-learning-heather-wolpert-gawron>

## Appendix

### Questionnaire for Reviewing Makerspace Handbook

#### Perceptions of teacher use in classroom:

- What aspects of the Makerspace Handbook do you feel would appeal to a classroom teacher?
- How could this resource be implemented in a classroom?

#### Projected effectiveness of the Makerspace Handbook:

- How can pre-service teacher candidates use the Makerspace Handbook to engage students and extend their learning?
- How does this resource promote growth of the key future ready skills? (critical thinking and problem solving; creativity and innovation; collaboration and communication)
- What elements of the Makerspace Handbook support the ability of a pre-service teacher candidate to use makerspaces in their teaching practice?
- What additional conceptual knowledge about makerspaces or the maker mindset do you feel needs to be included in this resource?

#### Considerations for future improvements:

What are some suggestions for improvements of this resource?