DESIGNING A MAKERSPACE FOR PRE- AND IN-SERVICE TEACHERS

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Many educators view makerspaces as a means of increasing student engagement in K-12 classrooms. As faculty and staff of the College of Education at the University of Saskatchewan, we have noted low comfort levels in using and experimenting with technology. For this reason, we decided to create a place in which pre-service teachers could test and discuss technologies that they could eventually use in their teaching practice. Our endeavor eventually morphed into a space for current teachers, student teachers, technical support staff, faculty members, and interested community members. Having piloted workshops for six months, we are now evaluating our decisions and shaping new approaches for the current academic year. Our main challenges include ensuring inclusivity across age, gender, and culture; adopting suitable facilitation styles; and ensuring the workshops lead to useful discussions of technology and teaching practice.

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INTRODUCTION

The Educational Technology Critique (ETC) Studio Makerspace emerged from an informal gathering of faculty and staff members affiliated with the College of Education at the University of Saskatchewan. Each of the four original contributors has an interest in how technology can be integrated into the kindergarten to Grade 12 (K-12) curriculum in logical, seamless ways. A key factor driving our discussions was how the appropriate use of technology could complement learning and increase learner engagement not only in science, technology, engineering, art, and math (STEAM) subjects, but also in other subject areas *across* the curriculum such as language arts and social studies. In the 2015-2016 academic year, we decided to run a pilot project consisting of monthly workshops introducing makerspace technologies and activities to people involved in any level of teaching.

As a design case, our participant demographic is what makes our makerspace endeavor both unique and challenging. Our workshop participants comprise pre-service teachers (undergraduate students), in-service teachers, technical support staff, and faculty members. In addition, our goal was not to create a "true" makerspace per se, but rather a series of workshops to help current and soon-to-be educators conceptualize, discuss, and share ideas about makerspaces. Inclusivity has become an intriguing part of our experience—particularly with regards to how we might expand the diversity of our participants.

The following is an account of our design decisions as we navigated the uncharted territory of how to provide makerspace-training for educators. First, we will discuss our objectives—what we hoped to learn and what we hoped the participants would gain. Then, we will describe our team and stakeholders. Logistical challenges included locating,

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accessing, and shaping the meeting space; scheduling; coping with budgetary constraints; and choosing communications tools. As we proceeded with the workshops, we designed and collected workshop evaluations. With this data and commentary in mind, we will then describe our first six workshops with regard to participant demographics, technological comfort, and comments. We will share our observations regarding the strengths and weaknesses of our makerspace, which are now guiding our activities in the 2016-2017 academic year.

GOALS

The philosophical basis of the makerspace movement is one that is guided by collaboration, experimentation, and discovery. The literature often references social constructionism as an inspiration for makerspace learning (Burke, 2015; Libow Martinez & Stager, 2013; Resnick, 2012; Stager, 2013). In particular, Bevan, Gutwill, Petrich, and Wilkinson (2014) list theorists such as Dewey, Froebel, and Papert. The activities endemic in the maker movement that complement such a philosophical perspective include self-direction, sharing, helping one another, repurposing ideas and tools, exploring, identifying problems, solving problems, seeking feedback, testing hypotheses, and applying solutions. These activities are often already part of teachers' pedagogical toolboxes.

Many educators now are viewing makerspaces and maker education as a natural corollary to their current practices. Within such spaces, teachers can provide increasingly individualized and hands-on approaches to learning compared to the traditional bricks-and-mortar classroom approaches of the industrial age (Kurti, Kurti, & Fleming, 2014). Fuelled by our own interest in learning about new technologies and how they could be used effectively in education, we envisioned a gathering place where we could acquire, test, and discuss technologies alongside teachers, school technical support staff, and education students. We felt that it was important to provide access to technology to those who already teach with technology *and* those who normally do not. Additionally, our workshops are intended to attract participants across the demographic spectrum in terms of gender, age, and cultural background. We were interested--and remain interested--in learning about practical and attitudinal issues concerning the integration of makerspace technologies, activities, and approaches into teaching and learning.

TEAM MEMBERS AND STAKEHOLDERS

Initially, there were four of us who collaborated on creating the ETC Studio. All of us are affiliated with the Department of Curriculum Studies in the College of Education at the University of Saskatchewan. Dr. Marguerite Koole, Assistant Professor of Educational Technology and Design, has a background in instructional design and multimedia production

including Web development, 3D, audio, video, and crafts such as embroidery, knitting, and beadwork. Mr. Jordan Epp, Instructional Designer of Online and Distance Education, has a background in media production and design, experience with open-source microprocessor technologies, and a passion for vintage motorcycle mechanics. Dr. Mohamed Hossain, Assistant Professor of Science Education, brought a wealth of experience in teaching science in the K-12 system as well as teaching pre-service teachers how to teach science to K-12 students. Mr. Robert Hepner is an industrial arts teacher who was seconded to the College of Education. Mr. Hepner brought to the team knowledge of carpentry, welding, and other industrial arts skills. He is also a Ph.D. candidate in Educational Administration.

In decision-making, we endeavor to keep our "space" safe, that is, we share our ideas non-judgmentally. Any ideas for technologies and possible sessions are welcome. The group is democratic and we plan our sessions collaboratively. Meeting each week, we share sample technologies and ideas. Part of this process has involved discussing how we could best introduce maker technologies to in-service and pre-service teachers.

Choosing technology has been an important decision point for our group. Open-source often permits manipulation of hardware and software, which enables a wide variety of options and design possibilities. The online communities of practice around open-source also tend to be rich with helpful information and troubleshooting suggestions when makers encounter difficulties. This, along with a typically modest price point, are among the benefits of the open-source choices we made (such as Arduino). That said, the proprietary technologies available from educational technology companies certainly have benefits as well. Often designed for plug-and-play interactivity, these technologies often reduce requirements for prior knowledge of basic electronics and/or coding. Makers can more quickly engage in curriculum-related activities. On the other hand, these proprietary technologies are sometimes incompatible with other common software or hardware and might be too costly for teachers to incorporate into their classrooms. For our purposes, we decided to engage in both proprietary and open source technologies because our main stakeholders may be interested in trying these options for themselves. If we were to choose only open source, for example, then we would deny our participants the opportunity to choose the technologies best suited to their needs, capabilities, and budgets.

From the open source spectrum, we have engaged in cardboard car building using recycled toy engines as well as Arduino-based electronics projects. During this pilot project, we have also collected a number of proprietary teaching tools such as the Sphero, littleBits, Makey Makey, printnbot Play (3D), and TinyBoy 3D printer (see Table 1). We had

enduring discussions about the role of proprietary versus open source resources in makerspace contexts. The four of us overcome the open-source-proprietary tensions through our interest in experimentation and learning. So although our technological preferences and philosophies differ, what draws us together and cements our group is our curiosity.

HARDWARE	WEBSITE
Arduino	https://www.arduino.cc/
littleBits	http://littlebits.cc/
Makey Makey	http://www.makeymakey.com/
printrbot Play	https://printrbot.com/
TinyBoy Fabrikator	http://www.tinyboy.net/
3D Printer	
Sphero	http://www.sphero.com/

TABLE 1. Resources acquired

The participants themselves represent the main group of stakeholders. Although our College of Education undergraduate students were our initial target audience, it occurred to us that in-service teachers would also benefit from similar opportunities to test and discuss new technologies. We also realized that we, ourselves, would benefit from the in-service teachers' observations and experiences with technology in their classrooms. In providing the workshop sessions, we hoped that the current teaching professionals would bring additional interests and skills to the sessions, and that they would share anecdotes of their experiences in using technologies in their teaching or support roles. Professionals (teachers, librarians, and technicians) within the school system would know what equipment and materials are available in their teaching environments and, possibly, where to acquire resources. From the pre-service teachers (undergraduate students), we hoped to elicit novel strategies and knowledge of their current skills and interests. By gathering this diverse group, we could potentially learn how to design our workshops to better support them. The benefit to all participants, in theory, was to gain exposure and confidence in using a variety of technologies for effective pedagogy. A second, but no less important benefit was the development of a professional network for sharing ideas and support. With all this in mind, our plan morphed into a pilot project in which we would create a studio space for tinkering, experimentation, and sharing knowledge across a larger community: pre-service teachers (students), teachers, technologists, and anyone else within the local community who might be interested.

Other stakeholders include the College of Education, the University, and the surrounding communities. From the beginning, we have noted growing interest and support from the College of Education. The College awarded Dr. Koole a small grant to hire a graduate student to conduct

research on teacher self-efficacy with makerspace technologies. As we continue to offer our workshops, other areas of the university are beginning to express interest, including Library staff, educators in the College of Medicine, various instructional designers involved with faculty support, and some students from Engineering and Computing Science. Recently, our network has increased beyond the university and local teachers. Members of a local makerspace in the city are now collaborating with us to offer workshops on 3D modeling, soldering, and, potentially, robotics. This suggests to us that we may need to consider the needs and interests of diverse groups beyond the teaching community as we plan future workshops.

SPACE DECISIONS

The space in which makers meet has a direct impact on the types of activities that can occur—and, hence, the type of makerspace that can emerge. We began meeting weekly in a comfortable, but forgotten video conference room ("Room 8") in the basement of the College (see Figure 1). There, we have Internet access, a whiteboard, a chalkboard, and a projection screen.

As we met and began hosting the monthly workshops, we accumulated a variety of sensitive equipment. We realized that we needed consistent meeting space. Ideally, ongoing access to Room 8 would greatly facilitate our meeting and workshop preparations by reducing the need to transport materials and equipment between locations. In some cases, transportation can have deleterious effects upon sensitive equipment. For example, jarring can knock a 3D printer out of calibration, prototyped wiring arrays for Arduino projects can become unplugged, and other tools can be dropped and broken. For these reasons, we formally requested to convert Room 8 into our makerspace headquarters.

The College of Education views community outreach as an important part of their mandate. As such, our request was met with enthusiasm. However, the College administration needed to ensure the safety of the makerspace participants as well as the College property. Our request was passed to the Facilities Management Division (FMD) who then required a description of the types of activities that would occur in the room. Because the room was not equipped with industrial ventilation, we would not be permitted to operate equipment that would produce large amounts of dust, smoke, or off gassing from chemicals. We also agreed to ensure supervision of workshop participants and students. This resulted in a Terms of Use (TOU) document stipulating the rules of conduct for all participants within the room and posted on the ETC Makerspace homepage (see <http://sites.usask.ca/make>). With permission, much of the TOU was modeled after an established Australian makerspace: Makerspace & Company (see <http://makerspace.org.au/terms-conditions/>).

FIGURE 1. Room 8 prior to acquisition.

The types of activities available in our makerspace are also subject to the characteristics of Room 8 itself. In an ideal makerspace setting, there should be spaces for clean activities such as computing and dirty activities that can create dust (Hlubinka et al., 2013). Because ours is a single room, our TOU stipulates that makers must tidy up before leaving the room. It is important to turn off the computers, unplug power tools and glue guns, and put materials back into their bins. Floors need to be swept and refuse put into the garbage bins. We decided to include these rules because loose cords, equipment, and debris on the floors can become a safety hazard.

Our next consideration was the furniture. Initially, the room was equipped with a lovely oak conference table and large boardroom chairs (see Figure 1). As we met and began to hold monthly workshops, the college administrators became concerned about possible damage to the expensive table. Therefore, following our successful request to semi-permanently occupy the former video conference room, we traded the large conference table for several older, slightly

FIGURE 2. Computer stations.

damaged tables held in storage. Acquisition of old tables might not appeal to everyone, but for us, it meant that we could expand our workshops to include rougher activities that would include glue guns, utility knives, and shop tools. It also meant that we could rearrange the tables as needed. Some tables arranged along the walls have been set up as computer stations with 3D printers and laser printers (see

FIGURE 3. Glass shelving unit.

Figure 2). We kept the large boardroom chairs to maintain a sense of comfort for our workshop participants, and, we kept the smaller, stackable chairs ready for larger groups.

Storage remains problematic. One wall now bears shelving upon which we keep plastic, transparent containers full of materials. We selected transparent containers so that we can more easily see the contents. We have recently acquired a lockable, glass shelving unit in which we can showcase completed projects and secure some of the smaller, expensive tools (see Figure 3). We have also acquired large, stackable plastic tubs for electronics components and miscellaneous materials.

As an emergent practice made possible by 21st-century technologies, it made sense that we also occupy virtual space for communications (Koole, Dionne, Todd-McCoy, and Epp, 2016). One of our members designed a WordPress website hosted on a University server on which we have administrative privileges for the themes and plugins (see <http://sites.usask.ca/make/>). The site provides visitors a schedule of upcoming events, links to other local makerspace activities, articles related to makerspaces in education, links to inspiring maker technologies and projects, and contact information. It also archives previous makerspace sessions for those who are unable to attend and showcases some of the maker projects of the ETC Studio Makerspace members. Ongoing updates to these projects—we hope—will continue to motivate others to engage in making and to try new projects in the spirit of the do-it-yourself (DIY) maker movement. To ensure ease of communications, we also provide an email

alias (etc.make@usask.ca). In order to know the numbers of people intending to participate, we have set up a simple sign-up sheet using Google forms. Although numbers vary from the sign-up roster, the roster provides a rough indication of the quantities of equipment and materials needed for each session. It also helps us determine whether or not we need to book a larger room.

WORKSHOP DESIGN DECISIONS

Selecting the Type of Makerspace

Opening the workshops to a larger audience meant we had to consider how to design the workshops and consider what kind of makerspace we would emulate. We could not assume, for example, that all participants

would already have teaching experience or that the participants would work or study in regions with reliable broadband. In consulting the current literature on makerspaces, we discovered that the variety of makerspace types and activities to choose from was extensive. Davee, Regalla, and Chang (2015) reviewed 51 makerspace sites of which they note 45 different descriptions and names projecting images of clubs and spaces for learning art, problem-solving, idea generation, youth and children activities, testing, laboratories, workshops, and play.

Because the majority of our stakeholders would be primarily educators (or soon-to-be educators), we decided to maintain a teacher-education focus for each workshop rather than offer a pure maker, tinker, or fabrication lab. What this means is that we would choose activities and technologies that would be within the budgetary range, knowledge capacity, interest levels, and curricular needs of most K-12 teachers in Saskatchewan. This range of teachers is still large, but one of our goals is to engage teachers and technologists in discussions on how they can implement technology and maker movement learning philosophies into their teaching within their contexts.

Having met informally for approximately two months, we decided to begin offering workshops immediately—without having collected many resources. There are publications that offer long lists of expensive tools and materials for new makerspaces (Burke, 2015; Hlubinka et al., 2013; Libow-Martinez & Stager, 2013). Indeed, there is no dearth of advocates for

SESSION	DATE	PARTICIPANTS
Augmented Reality	February 25	13
Simple Circuitry	March 24	9
Wiimote Hacking	April 21	7
3D Printing	May 26	15
Toy Car Building	June 23	12
Arduino Night	July 21	5

TABLE 2. Workshop Sessions

Join us for an evening of
Augmented Reality

Come get some hands-on experience with one of the NMC Horizon Report's "Emerging Technologies" for education in this makerspace event making use of the Aurasma AR app and Google Cardboard VR technologies.

presented by
Educational Technology Critique
ETC
MAKERSPACE

Register online for free at
etcmakerspace0216.eventbrite.ca

THURS FEB. 25
7PM-10PM

Rm 8 Education Bldng
28 Campus Dr U of S

Department of
Curriculum Studies
College of Education
University of Saskatchewan
usask.ca

sites.usask.ca/make

FIGURE 4. Sample poster.

expensive computers, 3D printers, laser cutters, cameras, sewing machines, software, and proprietary electronic controllers (Chang et al., 2015; Jacobs & Buechley, 2013; Kurti, Kurti & Fleming, 2014). However, expensive materials and equipment are unattainable for us. The economic situation is similar for most teachers in the public schools in the surrounding areas.

Fortunately, we realized that expensive materials and equipment are unnecessary; creative thought, problem-solving, and the DIY spirit of making can occur with simple-to-use, low-cost equipment—thereby keeping cost and knowledge barriers low. In fact, many makerspaces use recycled physical and digital materials (Gershenfeld, 2015), materials donated or brought by makerspace participants (Peppler & Bender, 2013), and simple craft supplies such as tape, scissors, glue, markers, and yarn (Plemmons, 2014). Graves (2014) describes how her library started conducting workshops with "minimal to no cost" (p. 11). For example, her library started by making Mother's Day presents with duct tape. We extended our search to non-academic websites, blogs, and social networks. These sources revealed many different kinds of activities requiring little expense. Some key examples include cardboard creations such as Caine's Arcade (2016), useless robots (Jamieson, 2016), duct tape creations, and simple science experiments with common household items.

With this in mind, we knew that we could keep costs very low by choosing our activities carefully. As we began our pilot project, we scrounged the hallways, our basements, and second-hand shops for materials. We have since found some funding sources—albeit limited—to purchase basic equipment and materials (such as glue, scissors, and paper). In addition, we already had a vast array of skills and knowledge amongst the four of us. Before we knew it, we were prepared to offer at least four workshops with basic materials and information at hand.

Session Design

Table 2 lists our first six workshops. The workshops were scheduled at 7:00 pm every third Thursday of the month. We chose evenings in mid-week because our intended participants were students and teachers both of whom would be unable to attend daytime sessions.

FIGURE 5. Using Aurasma: trigger image (background), video (foreground).

We had also considered weekends, but many students and teachers would likely have children enrolled in sports and other activities. We have had no requests for weekend sessions.

Because of the participants' professional and educational schedules, we knew that the sessions had to be *stand-alone*, that is, we could not demand advanced preparation (e.g., reading) or homework afterwards. We wanted the sessions to be unthreatening, enjoyable, inviting, low/no cost, and low preparation. To provide enough time for active, hands-on learning, we decided to schedule the sessions for approximately three hours in duration.

Because we did not expect advance preparation, the basic design of each workshop was to involve a brief and informal introduction to the technology. After the introduction, the participants would have an opportunity to discuss, design, and build something either individually or together. We aimed for an informal atmosphere in which participants could ask questions and share their knowledge. At the end of each session, we would encourage a discussion on the applicability and learning affordances of the technology(-ies). In practice, however, the organization of the workshops deviated from this show-try-discuss pattern.

Description of the Sessions

Augmented reality

Our first session was held on Thursday, February 25, 2016. This introductory session followed a try-discuss-try-discuss

pattern. The workshop focused on augmented and virtual reality technologies. Because of budgetary constraints, we could not supply smartphones or tablet devices. So, our email invitations, electronic announcements, and posters (see Figure 4) suggested a bring-your-own-device (BYOD) strategy in which participants would bring their own, personal devices on which they could install applications for Google Cardboard and Aurasma in advance of the session.

The Augmented Reality session began with the participants using Aurasma to complete a scavenger hunt worksheet with ten questions about the makerspace movement. The participants were asked to download the Aurasma application to their phones or tablets. They were told to type in a particular URL to connect the

app to the correct images. Then, with the Aurasma application engaged, they directed the cameras on their mobile devices (smartphones and/or tablet computers) at pictures on the wall (triggers). The pictures elicited videos containing answers to the questions (see Figure 5).

This activity led to a discussion of makerspaces and the goals for the pilot workshops that we would be offering for the next six months. Next, the participants constructed simple Google Cardboard viewers (\$5.00 CAD), downloaded some free Google Cardboard applications onto their smartphones, and discussed the potential for pedagogical use.

One participant brought her 11-year old son who helped her download, install, and collect the answers to the scavenger hunt worksheet. Later, he assisted her in constructing her cardboard viewer. We observed him to be highly engaged with the race-car app on the viewer, and, he actively sought to show the adult participants what he was discovering.

Simple circuitry

The Simple Circuitry workshop began with a *try-show-discuss* pattern. Without providing any instruction, we asked the participants to light a small bulb using only a light bulb, a wire, and a battery (see Figure 6). Although some already knew how to do this, others did not.

FIGURE 6. Lighting a bulb.

FIGURE 7. Body drum.

We provided a video about MIT engineering graduates who also had difficulties with this task (Martin, 2013). Then, we launched into a discussion of why such a skill is important in developing learners' knowledge of circuitry. The other two sample technologies that we shared during the workshop included Snap Circuits and Makey Makey.

We asked the participants to work in pairs to follow the Snap Circuits instructions. For the Makey Makey, we provided bananas and a URL to a Flash-based piano keyboard and asked the participants--working in small groups--to make a banana piano. Asking the participants to try the technologies before showing or discussing was very engaging, and significant concepts arose naturally. In the case of Makey Makey, the notion of "ground" emerged as the participants struggled to play their pianos (they had to touch the ground wire to complete the circuit). After some discussion and demonstration, we ended the workshop by asking them to create their own novel creations amongst which emerged a voodoo doll and a body drum (see Figure 7).

At this session, one of the facilitators brought his 9-year old son. By observing him, we saw a high level of engagement in choosing to make, for example, a Makey Makey video game controller (see Figure 8).

In using the Makey Makey, our 9-year old participant discovered how electrical currents would pass through connected human bodies. He asked a number of the adult participants to hold hands while he tested to see how many people could be connected and still be able to play a banana piano. Because the adult participants already knew that electrical currents would behave in this way, they did not experiment in the same way as the 9-year old.

At this early stage in our pilot project, we began to see a pattern:

children could show us, the teachers, the pedagogical value of the technologies and activities.

Wiimote hacking

For session three, the Wiimote whiteboard, we found that the *show-try-discuss* pattern was successful. Although some

FIGURE 8. Cardboard game controller.

FIGURE 9. Soldering an infrared pen.

participants had played with a Wii in the past, none had ever used it as an input device for other purposes. The facilitator introduced Wiimote hacking and posted step-by-step instructions on our website. He then showed a video about our Wiimote whiteboard project. The participants gathered the parts to build their own infrared pen (see Figure 9) for use with the whiteboard system and began to assemble the pieces.

Once again, we noted important points in the learning experience by observing when knowledge/skill was lacking. Soldering, for example, was a new skill for some and, hence, was a source of both frustration and hands-on learning.

Those with little or no soldering experience quickly found help from those with more experience (see Figure 10). It was fascinating to see the peer-to-peer interactions amongst participants as those with the skills rose to the challenge of instructing those without. By the end of the night each of the participants had either constructed a working infrared pen or stated they were confident that, given another opportunity to use the makerspace equipment, they would be successful in completing their projects.

3D printing

Due in part to the recent popularity of 3D printing, this session was the second best attended. The 3D printing session completely deviated from our workshop patterns. By the time we hosted the session, we had acquired only one printnbot Play (see Figure 11).

The guest facilitator brought a Makerbot 3D printer. However, transporting the printer had disrupted its calibration. By the end of the session, it was online again, and the participants could watch it deposit layers of plastic. For this session, however, the goal was to introduce 3D printing and discuss its variations (such as additive, subtractive, and resin-based). With a limited number of printers and computers on hand, we knew that we could not provide a hands-on experience. As such, this session was not hands-on, but show-discuss in nature. Even though the session was lecture-style, it maintained an informal atmosphere, and the

participants appeared to appreciate it as much as the hands-on sessions. The participants' engagement was apparent during the presentation through the volume of questions.

The majority of the participants at this session were males. Several of them indicated that they had some prior

experience with 3D printing and computing. The post-lecture conversation included some highly technical terminology. There were only two females: Dr. Koole and a professor from the College of Arts and Science. The Linguistics professor indicated that she had no formal background in computing and 3D printing. She asked some questions but appeared uncomfortable. She has not attended subsequent sessions. Dr. Koole later commented that the session *felt* like a "male" space. She noted that the focus was on the technology rather than what could be done with it. This has led us to ponder how we might create spaces that are more neutral and/or inclusive. We are still evaluating what *neutral* and *inclusive* means and how it can be achieved.

Toy car building

Toy car building attracted the largest number of participants—particularly parents with children (see Figure 12). An undergraduate research assistant facilitated this session. A large part of the maker movement encourages the reuse and recycling of materials, and we wanted to see what we could do to encourage this spirit in our space. After a few trips to the local thrift store toy

FIGURE 10. A group learning to solder.

FIGURE 11. printrbot Play.

FIGURE 12. Building toy cars.

FIGURE 13. A breadboard with wires and sensors.

department, we had gathered up a large number of broken and abandoned radio-controlled cars. These were disassembled and scavenged for motors, servos, wheels, gears and pulleys. The night of our makerspace session we used hot glue, cardboard, elastic bands, drinking straws, toothpicks and whatever we could find to design and develop our own electric powered race machines. We then raced our creations on a makeshift Arduino-based drag strip that we laid out in the hallway.

Some of the participants were non-educators. They indicated being attracted by the idea of making toy cars with their children. As mentioned, our target audience is educators. This somewhat different demographic was attracted by the object of making (toys) rather than the use of any specific technology (motors, servos, cardboard, rubber bands, and wheels). We suspect that this might be a clue as to the messaging that we should consider when designing our posters and invitations—that we should emphasize projects and problem solving rather than the actual technologies.

Arduino night

Arduino night was our final session before our summer break in August. The facilitator conducted the session in a *show-do-discuss* pattern. He provided an extensive introduction to help the participants understand what micro-controllers do and how they could be used. He brought sample devices: an automatic plant watering station, a robot car, and a computer numerical control (CNC) drawing device.

With the wires, switches, breadboards (boards allowing circuit connections), and project instructions arranged and labeled on the tables, the participants were given the opportunity to select their project, collect the components, and get to work. When they finished wiring the breadboards, they could access an Arduino integrated development environment (IDE) to copy the corresponding computer program, upload it to the circuit board, and run the program. Although some participants made minor errors in the wiring and programming, all met with success by the end of the workshop (see Figure 13).

One participant commented that her progress was slower than the others because she had not reviewed the diagram of the circuit boards before the Arduino session. As mentioned earlier, there was no expectation of prior reading. The participant never knew what it meant to wire a breadboard. During the session, she was able to wire her first breadboard and program with help from others around her. The first attempt resulted in some smoke emanating from one of the sensors—an outcome that appeared to be most enjoyable

for the participants. Through this participant's attempt, we could see that she needed to be guided to the correct instructions and, perhaps, see a demonstration from another participant. This participant's comment helped us to "see" her learning in progress. In addition, we observed that the re-actions to the smoking sensor suggested that mistakes and unexpected results could be fun in our maker environment.

Mostly adult males attended this session; there was one female. It was also the least well attended--possibly because it was held in late summer when students and teachers go on vacation with their families. In addition, the messaging focused on the Arduino technology rather than developing a project or a useful tool. In this particular case, the Arduino is difficult to describe due to its abstract nature. In offering such a session again, we will design the sessions and invitations to be more project and/or problem centered. For example, we could invite participants to make musical shoes or movement sensing bracelets using Arduinos. In this way, we can informally test the effects of our messaging on participation.

Reflection on Facilitation

From our experience so far, facilitation easily deviated from the show-try-discuss pattern. The way in which a facilitator introduces, explains, guides, and debriefs makerspace activities can be very idiosyncratic. It can also depend on the participants' familiarity with the activity and the degree to which the makerspace is learner-directed (Koole et al., 2016). For our purposes, facilitation depended upon whether or not the session was a presentation or a hands-on workshop. For example, the introduction to 3D printing was a lecture-style presentation because we lacked sufficient equipment at the time. A different approach would be to introduce 3D design applications on tablet or laptop computers and ask the participants to design a printable object. In this way, the participants could bring their own devices, and they continue to work on their projects after they leave. Their designs could be printed subsequently and ready for pick up at a later session.

In our small team of four, we bring an array of technical skills and knowledge. But, more important than already-developed technical expertise and knowledge is an interest in learning *and* sharing in the learning of others. Facilitators need not be the knowledge holders, but rather the cheerleaders. Indeed, through our preliminary examination of the literature and our own facilitation of workshops, the most significant skills are those related to guiding inquiry and engaging participants. Good facilitators can see those teachable moments; they ask the learners questions that lead to additional questions; that is, they know how to lead the learners through in-depth inquiry. Hlubinka et al. (2013) suggest that teachers can take on various roles such as the project manager who tracks and guides projects, the

principal investigator who oversees students researching topics that interest them, the coach who provides guidance and feedback to help the players become more skilled and achieve their goals, and the research librarian who listens to people describe the information they seek and helps them access it. From our initial observations, it is helpful not to be overly prescriptive in makerspace facilitation design. In other words, we would recommend allowing the facilitation to emerge from the needs of the participants and the proclivities of the facilitators. One way to do this is to suggest techniques to potential leaders, but permit flexibility.

Facilitators can create the space in which learners can gather, collaborate, and problem solve together. But, makerspaces are not just about facilitation. In thinking about the six sessions in our pilot, we were able to *observe* learning most readily when a participant openly indicated *not* knowing something. Whenever participants brought their children, we observed how the children would experience discovery, sharing, and collaboration. We now understand that if we intend to design makerspace workshops for in-service and pre-service teachers in the K-12 system, children are a necessary part of the endeavor. By including children, we can gain an understanding of the pedagogical possibilities of makerspace activities and technologies. Our initial design overlooked children as a key group of stakeholders!

EVALUATION

In order to evaluate the workshops and help us with planning, we collected survey data at the end of each session. The surveys contained questions about the participants' comfort and experience with various teaching technologies, their experience during the workshop, and requests for future sessions. In the first six months, the surveys were modified three times, making the data too disjointed for accurate statistical reporting. Also, the surveys were optional as were the questions within the surveys. Nevertheless, the results have provided us with a general barometer of the participants' demographics, initial competencies, and expectations. In September 2016, the surveys were standardized, but they remained optional, and questions within the survey remained optional as well. Participation in the ETC studio makerspace is voluntary, and we do not wish to create any barriers by making the evaluations mandatory.

Gender

The basic demographic information that we have collected on our surveys are helping us examine our efforts to advertise our workshops and, to some extent, reflect on who is attracted to makerspaces and why. Over the six workshops that we have held, those that attended are primarily males. Many of the participants came to multiple sessions. Of 28 survey responses, 19 men and 7 women completed the gender question (2 people indicated "other"). The surveys

indicate only 25% of the participants were women. The gender representation appears similar to that noted by researchers. For example, Make magazine (2012) published a report that examined the demographics of a sample of Maker Faire exhibitors and Make magazine and newsletter subscribers. "The survey found that 8 in 10 makers are male, their median household income is \$106 000 [US], and 80% have a postgraduate education" (Make, 2012, p. 24). Chang et al. (2015) suggest that the demographics of makerspaces are similar to the demographics of STEM fields, which have difficulty attracting women. The work of Chang et al. (2015) also indicates a lack of diversity in socio-economic status and ethnic representation in the maker movement.

An Intel report (2014) on engaging women and girls in STEM through making, suggests that women differ from men in terms of the purpose of making and the artifacts they create. According to the report and other research, women have indicated that collaboration and community building is a key motivator in their desire to "make" (Bean, Farmer & Kerr, 2015; Fox, Ulgado & Rosner, 2015; Intel, 2014). Simultaneously, one of the barriers to women's participation in STEM careers and making is the lack of mentorship (Intel, 2014). To address these needs for community and mentorship, it may be helpful to organize a "women's only" making night or to establish an online support community where women can share their experiences and exhibit their products (Bean et al., 2015). Research also suggests that women are more concerned with making that has a social impact or to see technology as a "means to an end," rather than as an end in itself (Faulkner & McClard, 2014). Therefore, incorporating workshops or projects that require collaboration, address a social need, solve a problem, and/or is project focused may help to engage more women. In terms of what is produced through "making," women are more likely to access making through arts and crafts (Fox et al., 2015; Intel, 2014). Thus, higher female participation could be encouraged by offering workshops, projects or materials that allow for multiple access points to creation, such as, sewable or paper electronics and circuits. Finally, Bean et al. (2015) suggest that practical changes could also ameliorate barriers to female participation, such as, having childcare available or offering workshops that allow for child participation.

Age

There were 24 participants who completed the age question (see Table 3). The majority of the participants fit in the "31 to 35" year range, but there is good representation across the age categories. Because the focus of the ETC Studio was initially on pre- and in-service teachers, we did not collect data on the children who accompanied the adult attendees.

AGE RANGE	N
18-25	4
26-30	3
31-35	9
36-40	3
41-45	0
46-50	4
51-55	1

TABLE 3. Age ranges of participants

Professional status

Our intent to encourage participation from undergraduate students in Education seems to be relatively unsuccessful—we were more successful in attracting teachers. Table 4 shows the diversity of backgrounds of the participants. Interestingly, the teachers who attended described themselves as mid-career to mature teachers, in other words, they had at least 4 or more years of teaching experience.

STATUS	N
Pre-service teacher (undergraduate student)	2
New teacher (3 years or less)	0
Mid-career teacher (4-10 years)	6
Mature teacher (+11 years)	3
Faculty member (college)	1
Faculty member (university)	1
Technical support (K-12)	0
Technical support (college)	1
Technical support (university)	1
Other	7

TABLE 4. Student/professional status

Of the "other" category, there was one engineer, two non-education university students, a graduate student, a technology evaluation coordinator for a school division, and two friends came along with teacher-participants. Although not indicated on the surveys (because of their optional nature), we learned through discussion during the sessions that some of the teachers were also graduate students enrolled in a variety of programs such as Educational Technology and Design, Educational Foundations, and Educational Administration.

Initially, in our planning, we were hoping to entice more pre-service and early-career teachers. Reflecting upon the under-representation of teacher candidates, we have considered that the evenings scheduling might be inconvenient for busy students. Education undergraduates often have four or five classes per semester or might be doing their practicum

in the schools. Childcare might be problematic for students who are parents. It is also possible that makerspaces are unfamiliar to some. However, we are uncertain why early-career teachers are underrepresented. This has led us to examine our posters and email messages to ensure that we are using terminology that is meaningful to our target audience rather than overly technical jargon.

The subject areas of the teachers and pre-service teachers are shown in Table 5. Only 11 responses were submitted. What is interesting is that representation of science, technology, engineering, and mathematics (STEM) subject teachers is higher than other areas such as language arts and social studies. Initially, we were hoping to provide makerspace exposure to pre-service teachers across all subject areas. However, the volunteer nature of workshop participation leads to self-selection of those who perceive makerspaces as relevant to their work. Again, we are left questioning how we might advertise in a way that could attract non-STEM teachers and how we might then demonstrate that makerspace activities can be interesting and pedagogically useful across the curriculum.

SUBJECT AREAS	N
Language arts	1
Social studies	0
Mathematics	2
Applied arts & professional studies (industrial arts)	5
Second language(s)	0
Science	2
Special education	1

TABLE 5. Subject areas of teachers and pre-service teacher participants.

GRADE TAUGHT (INTENDED TO TEACH)	N	LEVEL
Kindergarten	1	Elementary
1–3	2	Elementary
4–6	2	Elementary
7	3	Junior High
8	2	Junior High
9	3	Junior High
10	4	High School
11	4	High School
12	5	High School

TABLE 6. Grade levels of teachers and pre-service teacher participants.

Table 6 shows that the teachers and pre-service teachers who participated in our workshops represented all the K-12

grade levels. However, only 4 in total taught (or intended to teach) at the elementary level; 8 taught (or intended to teach) at the junior high level; and 13 taught (or intended to teach) at the high school level. So, what we are seeing is an under-representation of teachers who teach younger children. Again, these numbers might suggest a perception that maker activities are best used with older children. In developing our posters and invitation emails, we may need to make applicability and relevance clearer.

Reasons for attending

Our surveys also provided some insight into why our participants came to the sessions (see Table 7). The number one reason was “curiosity.” Interestingly, there appears to be a near-even split between “I have used the technology” (n=9) and “I want to learn about the technology” (n=8). And, somewhat unexpectedly, only 4 participants indicated that they have to use the technology in the classroom.

REASON	N
I was curious	11
I have tried the technologies used tonight and wanted to learn more.	9
I wanted to learn about the topic	8
I would like to meet other students/teachers	7
I have to use technology in the classroom	4
I am interested in doing research on this technology	1
My friend was attending	1

TABLE 7. Reasons for attending.

We have noted that the majority of our participants also indicated a high technology comfort level. Of the 22 who responded to our question on their comfort level, 12 reported that they learn technology very quickly and 8 considered themselves developers (programmers). Only one participant reported that s/he learned technology slowly. Again, these numbers suggest that our makerspace is attracting participants who are already quite technologically adept. One of our goals early on was to introduce technology to educators of all comfort levels including those who might lack knowledge and skills. However, our makerspace appears to be increasing knowledge and skills amongst those who are already knowledgeable and comfortable. Our goal to provide a networking environment may be appealing to technologically savvy participants looking for others with whom they can discuss technology. It will be interesting to observe how the demographics of our participants might shift if the sessions and invitations begin to emphasize projects and problem solving rather than the technology.

Overall, the evaluations suggest that the participants have been pleased with the workshops and our facilitation style.

Some have even suggested how we might promote them to increase our attendance.

CONCLUSIONS AND DESIGN DECISIONS FOR 2016-2017

As we have moved beyond the conceptualization and find ourselves well within the implementation phase of the ETC Studio, we have come to realize that makerspaces come in many different variations. As Peppler and Bender (2013) note, there is a large variety in makerspace formats; some sessions might be long workshops while others might be short, one to three-hour sessions. Some makerspaces provide open times to access the space and work on any kind of project. Not only was this apparent in the literature, but there was variation within our own workshops. We drew upon the talents, skills, and knowledge of our team (the initial four members) and others who have since joined us. For example, individuals outside our immediate team made the introduction to 3D printing presentation and the 3D design workshop possible. But, those of us who knew and/or were interested in these areas facilitated the augmented reality, simple circuitry, toy cars, and Arduino workshops. In this way, we have come to realize that makerspaces are fluid in their identity. There is no one correct way to develop or facilitate a makerspace; rather, it emerges as a confluence of skills, resources, and knowledge of those present (Koole, et al., 2016).

Our pilot workshops have attracted primarily male participants. Amongst the teaching professionals, the participants self-identified as mid-career to mature-career. It appears that we have been somewhat unsuccessful in reaching female participants, undergraduate students, and those who consider themselves less technically adept. Interestingly, attempts to include women might also increase our pre-service teacher participation because of the high representation of women in teacher education programs. Moving forward, we will closely examine how we can connect with a more diverse demographic by considering how we might

- develop invitations and posters that are written in meaningful, non-threatening language AND that focus more on the projects and less on the technology;
- better communicate the applicability of maker activities for a wider variety of school subjects and school grades/ages;
- include child-friendly and inclusive activities in order to draw students and professionals who are parents; and
- encourage participants to bring their children.

As of writing this paper, we are already engaged in our 2016-2017 workshops, and our participation levels are increasing. We feel that this project is successful and worthwhile. As such we will

- continue to allow the structure of the workshops to emerge according to the needs of the participants, styles of the facilitators, and the nature of the technologies;
- continue to encourage end-of-session discussions regarding the applicability of the tools to teaching and learning; and
- continue to collect feedback using the standardized workshop evaluations.

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