Unleashing the Learners: Teacher Self-Efficacy in Facilitating School-Based Makerspaces

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Abstract

This qualitative research project explored the key characteristics, attitudes, and experiences of makerspace facilitators in Saskatchewan. The aim was to gather knowledge and wisdom from early adopters of makerspace from a variety of contexts ranging from *tinkerspaces* to increasingly popular school-based spaces in order to inform early and career-educators of the skills and attitudes conducive to creating and leading dynamic activity spaces. The questions for the semi-structured interviews were based on Bandura's (1977; 1997) self-efficacy expectations: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal. The findings align with those of other studies in that they point towards key areas of experience: the value of productive failure, relinquishing control, and modes of support. We conclude that there is a need to help preservice and early career educators to become prepared and confident makerspace facilitators. To this end, we offer four suggestions for new makerspace facilitators: aim towards unleashing, allow others to be the experts and leaders, celebrate success and failure, and openly seek and offer support.

Keywords: makerspace, self-efficacy, motivation, early career educators, productive failure

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As a counterpoint to today's fast-paced, consumeristic, product-focused society, the makerspace ethos is one of creativity, open sharing, experimentation, problem solving, and iterative prototyping. In general terms, a makerspace is a place where participants create new things and develop skills in an environment promoting discovery and problem-based learning (Bevan et al., 2015; Graves, 2014; Moorefield-Lang, 2015). Failure is embraced; sometimes it is celebrated. Makers, or those participating in a makerspace, are not only producers, but curators, networkers, and members of digital and physical communities. Participants may also negotiate and shift between various roles such as leader, learner, teacher, problem identifier, problem solver, inventor, designer, engineer, and manufacturer. In sum, makerspaces are more than just places, but represent an open movement wherein each makerspace instance reflects the unique characteristics of the participants, spaces, and resources available.

As makerspaces grow in popularity in primary and secondary schools in Canada, there is increasing need to train facilitators to support maker activities. Therefore, it is useful to know what skills, attitudes, proclivities, and support can help facilitators in developing dynamic and creative activity spaces. This project explored the self-efficacy of current facilitators and what they felt they needed to thrive as leaders within the maker environment. We defined facilitator self-efficacy as an individual's belief in his or her capacity to organize and guide a makerspace activity as well as his/her ability to encourage creativity, problem solving, sharing, making, and collaboration.

This paper begins with a brief description of the historic and pedagogical background of makerspaces, an examination of current research on makerspaces in teacher training, and finally a discussion of self-efficacy in relation to makerspace facilitation. The methodology section briefly outlines the process of recruitment, data collection, and analysis. After providing information about the participants' demographics, the results section offers excerpts drawn from qualitative coding analysis of the transcripts. Finally, the discussion highlights the main sources of tension and success that should be considered in designing training and experiential opportunities for preservice and in-service teachers.

Literature Review

What is a Makerspace?

Making things is not new; humans have been inventing and crafting by hand for centuries. Koole et al. (2016) provided an outline of the evolution of makerspaces from crafting societies held in libraries in the 19th century to the first computers and computer networks in the 1960s to the growing accessibility of personal computers in the 1980s. From the 1990s until today, the Internet has become increasingly ubiquitous and influential in the access and sharing of information, challenges, problems, solutions, and resources within today's makerspace context.

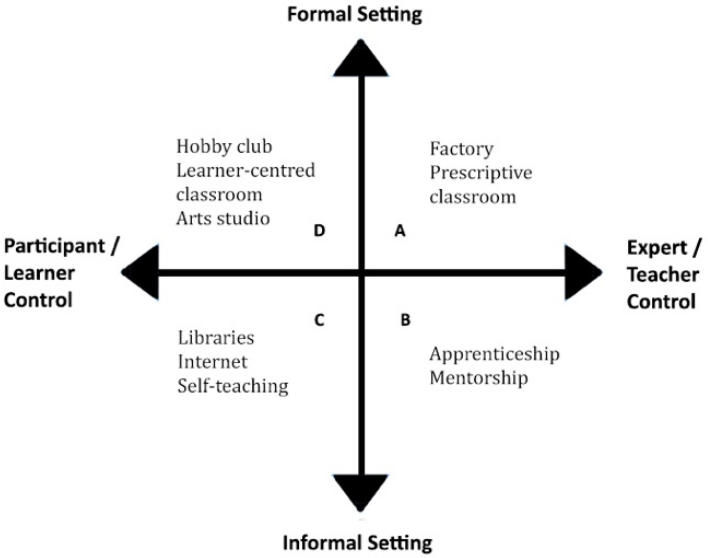
Pedagogically, John Dewey and Seymour Papert are considered to be the progenitors of the maker movement. While Dewey promoted active participation in one's own learning (Dougherty, 2012; Fleming, 2015; Martinez & Stager, 2013), Papert emphasized the importance of construction over knowledge transmission (Halverson & Sheridan, 2014). As personal

computers became available, Papert developed Logo, a programming language for children (Halverson & Sheridan, 2014). Since that time, other programming tools have been released for children such as Scratch. More recently, physical computing tools have begun to appear such as the Raspberry Pi (Arduino), Micro:Bits, and a variety of robots.

Although computers often play a significant role in makerspaces, programming or other "high tech" machines are not necessarily the focus of today's makerspaces. Rather, makerspaces emphasize physical and digital making, communication, problem solving, authentic learning, and active creation (Bevan et al., 2015). Makerspace proponents also highlight the self directed, iterative and creative nature of the "making" process. To many, the making process—inclusive of problem identification, exploring, hypothesizing, creating, prototyping, testing, and multiple iterations—is considered the goal of makerspaces, rather than the means to a product as typified by traditional production models (Smith, 2017). Makerspaces can also occupy any location on the formal-informal, learner-expert-control continua (see Figure 1) (Koole et al., 2016).

Figure 1

Formality and Control Continua



Note. In other words, a makerspace can take a variety of forms such as an apprenticeship/mentorship model, a prescriptive, teacher-driven classroom, a hobby club, or an open space for self-teaching.

Interestingly, the term "makerspace" has become problematic (i.e., it has become "turf" or conceptual "property") by those who see it as an exclusive, adult-based "tinkerspace" in which highly skilled experts work with high-end technologies. Makerspaces have also drawn criticism from those who view making as vehicle for egalitarianism and self empowerment. According to some critics, for instance, the encroachment of corporate interests and product focused making in makerspaces is anathema to the democratic foundation of the maker-movement (Smith, 2017) Although for-profit makerspaces certainly exist, this project examined non-corporate spaces. Moreover, this paper supports a much broader view of makerspaces as an open, grassroots movement characterized by a creative mindsets and varying contexts, where

participants of any age and skill level can engage in making or sharing (Bevan et al., 2015; Dougherty, 2012; Fleming, 2015; Graves, 2014; Moorefield-Lang, 2015).

Makerspaces have also been criticized for their resource intensiveness and wastefulness rather than taking advantage of "product life extension" opportunities through "repair, remanufacturing, refurbishment, reuse and recycling" (Prendeville et al., 2017, p. 277). For this reason, there is need for critical dialogue in terms of how to facilitate ethical, sustainable, and pedagogically meaningful makerspaces—not only in Kindergarten to Grade 12 but in community and corporatized makerspaces as well.

Teachers' Perceptions and Experiences of Makerspaces

As makerspaces and making in schools become increasingly popular, there is a corresponding need to help educators integrate making into their pedagogical practice. Other researchers have echoed this imperative (Stevenson et al., 2019) and new research on this topic has begun to emerge. As a result, research has shown that educators face a number of challenges when leading maker-based activities including the need to balance structure with student autonomy (Kajamaa et al., 2019; Rowsell & Shillitoe, 2019). A number of specific aspects that may be important for future teacher professional development include providing adequate structure for learning, embracing a culture of failure, effective preparation and planning, learning how assess problem based learning, and acknowledging the pedagogical value of maker based activities (Cohen et al., 2017; Kajamaa et al., 2019; O'Brien et al., 2017; Paganelli et al., 2017; Wilson & Gobeil, 2017). In one specific example, researchers observed 94 elementary students who participated in a weekly educational makerspace over one semester (Kajamaa et al., 2019). Researchers found that teacher-facilitators most commonly used an authoritative teaching strategy by directing the learners' work and decision making. Rather than asking questions, for example, some teachers would offer step-by-step instructions, which encouraged students to passively follow the steps without engaging in critical thinking or creative problem solving. The least used strategy, however, was the *unleashing* intervention strategy in which students are encouraged to explore their "existing knowledge … to compare and test their own ideas, and to identify conceptual or material resources for their work and reasoning" (p. 9). Since makerspace activities are complex, non-linear, iterative, and draw upon many domains of knowledge, the activities require creativity and freedom to explore. Thus, to stimulate student creativity, it is important for facilitators to move from authoritative strategies towards the unleashing of students, where students engage in self directed, creative and critically reflective making.

Rather than study how teachers facilitate makerspaces, some studies used professional development interventions simulating makerspace environments where the teachers took on the role of learners. Such experiences provided teachers with a unique perspective on the making process and its implications for learning and learners (Cohen et al., 2017; O'Brien et al., 2017; Paganelli et al., 2017). For example, in one study, participants noted the importance of the diversity of approaches in the accomplishment of the tasks and were not only able to see the benefits of collaboration but were also able to see connections to student engagement and learning as whole (Cohen et al., 2017).

Paganelli et al. (2017) conducted a phenomenological study involving 25 practicing teachers who were participating in a makerspace as students. During their qualitative analysis,

three main themes emerged as points of tension for the participants: the emotional component of the experience (i.e., confidence and doubt), the need for makerspace concept knowledge (i.e., creativity, engagement, hands-on, presentation methods, and collaboration), and the educational setting (i.e., perceptions of the pedagogical value). Paganelli et al. (2017) also noted that some of the teacher-participants, "struggled with the open-ended, problem-solving nature of makerspace sessions" (p. 234). In a similar study of a simulated environment, O'Brien et al. (2017) observed four preservice teachers facilitating a balloon rocket station activity at a Maker Faire. While guiding young learners through the design-thinking process, the four teachers in the focus group noted four areas of tension: the need for preparation in order to ensure learner success; the need to provide structure to the activity through such things as instructions, modelling, and guiding questions; the need for checking understanding (assessment); and the influence of parents' opinions. Thus, these studies reveal that teacher facilitators themselves often lack the confidence, skills, and knowledge needed to foster open, creative and self-directed making activities with students.

More importantly though, research suggests that teacher preparation and training can have a positive impact on a teacher's confidence and makerspace related skills. In a 2019 mixed methods study, Australian-based researchers found that participants' confidence and enthusiasm for integrating 3D printing into their classes increased as a result of professional development and "in many cases changed their practice towards more flexible, inquiry-oriented and student-centred pedagogies" (Stevenson et al., 2019, p. 1272). The greatest increases to confidence were found in teachers who reported the lowest confidence in the preprofessional development stage of the study (Stevenson et al., 2019). Similarly, in an exploratory, qualitative study, Cohen et al. (2017) studied the effect of makerspace training on educators' perceptions. Participants, who had little to no previous experiences with makerspaces, were enrolled in a university level course in which, "the majority of the class time was devoted to work on project-based activities designed to allow students to experience making" (Cohen et al., 2017, p. 5). As a result of the semester-long course, participants reported positive perceptions of makerspaces and showed a deeper appreciation and understanding for the collaborative and community-building potential of makerspaces. Researchers also noted that teacher candidates appeared more comfortable giving support and requesting help as a result of their immersive makerspace experiences. Thus, these professional development activities appear to be particularly effective in helping novice teachers develop the skills they need to confidently engage in makerspace facilitation. These studies suggest that professional development not only helps to build the knowledge, skills, and predispositions necessary for facilitating makerspaces, but may be particularly important for those with limited makerspace experience, as may be the case with pre-service teachers.

As shown, research indicates that professional development can be effective in developing teachers' comfort with maker-based activities and positively influencing their perceptions of makerspaces in general. However, there is little research on how facilitators view their own abilities. Depending on the makerspace context (as per Figure 1), a facilitator may be charged with provisioning resources, suggesting and/or guiding activities, or more generally supporting the interests and needs of the participants. The degree to which a facilitator is confident and competent undertaking these various tasks, however, will be influenced by their perceptions of self-efficacy. Therefore, in this study, we set out to explore facilitators'

perceptions of self-efficacy in the hopes of identifying the factors most consequential to their expectations for success.

What is Facilitator Self-efficacy?

A facilitator's beliefs about their own effectiveness can influence their willingness to engage in a novel situation or experience, like a makerspace activity. In his use of the term, *self-efficacy*, Bandura (1977) hypothesized that "expectations of personal efficacy determine whether coping behaviour will be initiated, how much effort will be expended, and how long it will be sustained in the face of obstacles and aversive experiences" (p. 191). Alternatively, educational researchers, Tschannen-Moran et al. (1998), apply Bandura's definition of self-efficacy to an education-specific context and define teacher efficacy as: "the teacher's belief in his or her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 73). We have drawn upon, combined and modified these definitions in keeping with the makerspace-specific context of this study. As a result, we define a *makerspace facilitator's self-efficacy* to be an individual's belief in their capacity to organize and guide a makerspace activity as well as their ability to encourage creativity, problem solving, sharing, making, and collaboration.

As a result of his extensive research on self-efficacy, Bandura (1977) argued that higher self-efficacy expectations are likely to lead to greater perseverance and motivation in the face of threatening situations or seemingly difficult tasks. Bandura (1977) designed the self-efficacy theoretical framework to "explain and predict psychological changes achieved by different modes of treatment" (p. 191) and developed a self-efficacy scale to observe individuals and quantitatively measure successful performance in relation to threats and efficacy expectations (Bandura, 1977). Bandura's self-efficacy scale is also further delineated into two types of expectations: *outcome expectancies* and *efficacy expectations.* Outcome expectancy is defined as a belief in the likelihood that a "given behaviour will lead to certain outcomes" (p. 193), while an efficacy expectation is defined as one's belief that s/he can perform a specific or set of behaviours, which will lead to the expected outcome. As summarized in Table 1, there are four dimensions of efficacy expectations.

Table 1

Summary of Efficacy Expectations (Bandura, 1977, pp. 195–200)

Efficacy expectations	Description	Modes of induction
Performance accomplishments (PA)	Personal mastery experiences in which the individual is successful will increase expectations; repeated failures will lower them. A positive sense of mastery may increase resilience in instances of failure.	- Attempting performance; - Performance desensitization; - Self-instructed performance.
Vicarious experience (VE)	Observing others performing tasks successfully can help build	- Modelling; - Observation;

	a sense of self efficacy.	- Comparison to others.
Verbal persuasion (VP)	When individuals are told that they can successfully perform a task, their efficacy expectations are likely to rise.	- Suggestion; - Self encouragement; - Exhortation.
Emotional arousal (EA)	Recognition of and reduction of anxiety, fear, and vulnerability can increase efficacy expectations.	- Relaxation; - Attribution (cognitive awareness and labelling of emotional state).

Bandura (1997) and other researchers (Morris & Usher, 2011; Poulou, 2007) argued that all four efficacy expectations combined would have the greatest influence over an individual's self-efficacy, but of the four, performance accomplishments were the most influential and emotional states were the least.

Interestingly, studies which have attempted to measure the influences of and relationships between efficacy expectations have yielded inconsistent results. For example, in their qualitative study of Vietnamese, English as a foreign language (EFL) teachers, Phan and Locke (2015) found, that social persuasion was the most significant factor of all the efficacy expectations. For these teachers, social persuasion not only included verbal affirmation, but also forms of collegiality, sharing materials, and institutional support. This finding suggested to the researchers that, perhaps, cultural and environmental factors were also important to facilitators' perceptions of self-efficacy and questioned the narrowness of Bandura's framework. In some cases, vicarious experience emerged as the most influential factor, such as in studies involving preservice teachers (Johnson, 2010) and teaching assistants where trainees sought affirmation from their professors (Mills, 2011). In contrast, Morris and Usher (2011) noted that vicarious experience can sometimes be unimportant, particularly when the individual, such a professor, lacks opportunities to observe others. Instead, these authors argued, individuals might draw upon their emotional arousal to measure the quality of their own teaching.

Methodology

Purpose

Our team was interested in how to assist preservice and in-service teachers in becoming better equipped, motivated, and more confident in utilizing makerspace technology. The main research question was: How are self-efficacy expectations experienced by makerspace facilitators? Our study does not use a rating scale in a quantitative manner. Instead, this study uses the four self-efficacy expectations (Table 1) to qualitatively explore the attitudes, experiences, and needs of makerspace facilitators.

Participants

As criteria for inclusion, study participants had to be over 18 years of age and had to have facilitated one or more makerspace workshops/sessions at any level of education, after-school

program, or community organization. The participants were located and recruited through email, social media, the local university portal, advertisement through a teacher-oriented professional development organization, and word of mouth. All recruitment tools and consent forms clearly defined the term makerspace and described makerspace-type activities as per our definition (above).

Our team interviewed 13 facilitators. There were seven males and six females ranging in age from 30 to 59 years old. Table 2 shows the range of makerspace types with which the interviewees were affiliated. To clarify, we used the word, *classroom,* to describe a makerspace in which instructional time is dedicated to makerspace activities within a school (formal). *School-based* refers to a situation in which physical space is allocated for makerspace activities, but activities do not take place within classroom instructional time (informal). *Teacher-directed* means that the teacher or facilitator actively selects the making activity and directly guides the learners (teacher control). Finally, *maker-directed* refers to a setting in which the makers (children and/or adults) determine the problem to be solved, how to solve it, and take primary responsibility for doing the activity (learner control).

Table 2

Facilitator Demographics

Facilitator (Pseudonym)	Age Range	Gender	Position/Role	Type of Makerspace	Makerspace Participant Age
Andrew	30-39	Male	Board member (of makerspace)	Community based Maker directed	Any age
Howard	60+	Male	Principal (retired)	School based Maker directed	Elementary to junior high school
Bob	50-59	Male	Educational consultant	Classroom Teacher directed	Elementary to high school
Pat	40-49	Female	Technology consultant	Classroom Teacher directed	Elementary to high school
Amy	40-49	Female	Teacher	School based Teacher directed	Junior high to high School
Rose	30-39	Female	Public library manager	Public library Maker directed	Any age
Jim	30-39	Male	Teacher and technology instructor	School based Teacher directed	High school

May	40-49	Female	Teacher-librarian	Classroom Teacher and maker directed	Elementary
Tom	40-49	Male	Teacher	Classroom Teacher directed	High school
Ken	30-39	Male	Teacher and technology instructor	School based Community/maker and teacher directed	Any age
Linda	40-49	Female	Teacher-librarian	School based Classroom Teacher and maker directed	Elementary to high school
Cindy	40-49	Female	Teacher-librarian	Classroom Teacher directed	Elementary
Chuck	30-39	Male	Teacher	School based Teacher directed	High school

Data Collection and Analysis

Each semi-structured interview was approximately one hour in duration. The transcripts were coded and analyzed using Nvivo according to categories corresponding to the four efficacy expectations in Table 1.

Results

After coding the transcripts using the four self efficacy categories, the results were quantitatively summarized. As can be seen in Table 3, the largest number of coded segments occurred under performance accomplishments. The categories in Table 3 are listed from most to least prevalent. Since the purpose of this study was to qualitatively explore facilitators' self-efficacy perceptions, the codes were further analyzed in order to identify the key themes in each self-efficacy category.

Table 3

Top Level Category Coding Trends

Code category	Sub-categories	Number of quotes	Percent of total

Performance accomplishments (PA)	• Knowledgeability • Management	110	33%
Emotional arousal (EA)	• Excitement • Frustration • Fear of failure • Contagiousness	89	26%
Vicarious experience (VE)	• Networking • Learning from makers • Accessing references	77	23%
Verbal persuasion (VP)	• Verbal support • Concrete support • Breakdowns in support	61	18%
Total		337	100%

Performance Accomplishments

The transcripts contained anecdotes of mastery experiences, all to varying degrees of success. After reviewing the anecdotes, two main sub-categories emerged as shown in Table 4.

Table 4

Performance Accomplishments

Sub-category	Description	Example
Knowledgeability	Prior knowledge, skills and experience.	Bob: I have done robotics for a long time, so I knew which controllers we were going to use.
Management	Orchestrating activities and groups.	Howard: You really had to be prepared; you really had to think about what problems they would have.

Makerspace Knowledgeability

Knowledgeability refers to the state of being well-informed regarding procedures, technology, and facilitating maker activities. Some facilitators indicated that they had technical skills and interests prior to their involvement in their makerspaces. For example, Bob drew upon his prior experience as a science teacher using electronic circuitry and robots. Ken's personal interests in filmmaking, Raspberry Pi, and Web design drew him gradually into teaching technology classes and eventually into leading a makerspace. For others, such as Pat (science

teacher) and Bob (educational consultant), prior knowledge was a source of confidence and helped in the procurement of resources.

Some facilitators also sought out opportunities for hands-on learning about various technologies for their makerspaces through formally arranged professional development (PD) opportunities. In Rose's context, the librarians were assigned personal-learning tasks:

> Rose: Basically, we just take it out of the box and try and figure it out. That has been our strategy. We read about it a bit. But, yeah, we play with it. And also, we have given the staff assignments. . . So, if we're all trying to learn something, we will give one person the assignment of figuring it out and demonstrating it to others and then, they prepare a short assignment for others to do. . . It's been pretty successful.

An important issue for some facilitators was having time for hands-on experimentation with the technologies in an effort to buoy their own knowledge. Lack of hands-on time was sometimes viewed as a personal failing.

Makerspace Management

Management skills such as the organizing of activities and interacting with the makers were also noted. For pragmatic reasons, Linda and Chuck suggested that it is important to start small and let the makerspace grow. Acknowledging her heavy workload in her first year at the school, Linda recalls having purchased too much equipment and recommends to "start small and do it well and then, build from there."

Many of the facilitators learned to manage effectively through experience. Experiences that they deemed ineffective led them to alter their practices such as increasing time spent on writing reflections, planning better prior to a session, re-designing instructions, or encouraging better, sustained interactions in the makerspace. Ken notes his own learning trajectory:

> Ken: The first year, it was kind of a free-for-all. Well, whatever the kids are interested in, we'll help them do that. But we found that … they would do something for a couple of minutes, and then jump to a completely different thing. And there wasn't any direction. At the end of last year, [name] and I sat down and we designed like a passport basically … And then the students get badges for completing projects that answer the criteria of each of those project areas.

Comments by participants suggested that management skills could be honed through continuous reflection on and refinement of the process. In sum, performance accomplishments appear related to the need for capacity building, growth in confidence, and learning better management strategies.

Emotional Arousal

Consistent with Paganelli et al. (2017), we found that the facilitators emotions were a significant aspect of the educators' experiences. A great many expressed excitement but there were also less-positive reactions such as intimidation, fear of failure, and frustration. Table 5 provides a summary of the sub-categories for emotional arousal.

Table 5

Emotional Arousal

Sub-category	Description	Example
Excitement	Positive emotional reactions.	Pat: And the critical thinking skills, and their ability just to like to persevere, and problem solve, and not give up was honestly goose-bumpy.
Frustration	Tension and dissatisfaction.	Tom: Sometimes I feel like I'm running around in every direction.
Fear of failure	Fear, anxiety.	Andrew: It depends on the subject, it was for … 3D modelling one… I had to learn the software, so I was a little bit anxious.
Contagiousness	Sharing emotional reactions.	Amy: It's going to be what you put into it. So, if you're only putting in like a half-hearted approach, or aren't as enthusiastic…kids feed off your enthusiasm.

Excitement

Much of the facilitators' excitement was generated by watching the makerspace participants:

> Linda: You don't usually get [insight into] their thinking so transparently laid out, right?
>
> Bob: Me watching kids learn. There's nothing better . . . So, you can see the kids really digging in and trying things. And what I really like was the prototyping—when the kids would fail.

Tom indicated that he enjoyed managing social interactions and resolving conflict between kids. Other facilitators also expressed excitement at seeing the makers' creativity, inventiveness, perseverance, and problem-solving skills, for example:

> Linda: So, one student might be working on electronics and another student may be really into sewing and textiles and they might, "Oh! Look! I could make kinda wearable technology" or, or you know like, combining things in ways you wouldn't normally think of.

Opportunities that allowed makerspace participants to develop their skills and abilities also elicited excitement. For example, Linda was moved when observing the kids' skills and gifts

emerge during sessions while remarking on the potentially transformative effects upon the learners:

> Linda: I've had students say to me, "I thought I knew what I wanted to be when I grew up, but this changes everything."

An area that also seemed to affect the facilitators was when they noted how the makers overcame anxiety and showed resilience by working through repeated failures. Some comments implied that facilitators could play a valuable pedagogical role in developing resilience by validating the makers' ideas, Linda's for example:

> Linda: We want [the makers] to have those experiences where they fail, but that they build up resilience to get past that and figure what the problem is, and either, ok, maybe we have to abandon that idea and take on a new [approach].

Some facilitators, particularly the teachers and teacher-librarians expressed delight and affirmation when the makers would ask to continue, as seen in Amy's comment:

> Amy: The kids would ask me, "We're going to do that again?" Like when the kids want to do it, that's a good sign that you're doing something right.

Frustration

Sources of frustration reported by the facilitators were most often related to workload. Cindy's comment, for example, suggests that the number of makers per session and the integration of makerspace activities within the formal curriculum could be unwieldy:

> Cindy: [It] was frustrating. Like, because it's all one-on-one at the beginning and there's two of us and 26 of them.

Fear of Failure

Most commonly, facilitators indicated fear of failing to harness the technology and fear from having inadequate background knowledge. Jim noted how, at first, he was afraid of failing, but his confidence grew with experience:

> Jim: Now, when I'm designing something, if I get it right after like the third or fourth try, I'm celebrating 'cause it takes five, six, eight, sometimes ten times to get it right … Cause if you're a perfectionist going in, it'll be very scary for you. If you have that attitude of "I can't fail," then, you're not going to like being in a makerspace I don't think.

There was evidence that some facilitators felt they needed to be the "experts." These individuals emphasized the importance of being prepared. Tom suggested that locating and conceptualizing activities is a part of the responsibilities of a facilitator. Bob recounted the need for "ensuring all hardware is configured and supplies are available." For Tom, control started with "coming up with good project ideas." Amy, meanwhile, recommended being "uber-prepared" and doing practice runs prior to facilitating sessions.

While some facilitators felt that advanced preparation was essential, others were comfortable iterating through problems alongside the makers and even relinquishing control or *unleashing*. Tom, for example, was open to learning from his students, believing that they would

"really have to know what they're talking about" in order to teach something to him. Jim, too, was unphased by "not knowing something." In Chuck's case, he would ask the makers what they wanted to do and "gauge from them" how to proceed. Cindy, Tom, and Howard noted that prior experience taught them to anticipate potential difficulties, to know when to intervene, and when to let the activities evolve. Many commented on the fear associated with unleashing the learners:

> May: I think that sometimes people are intimidated by giving kids so much leeway and space in their learning. But I found they never disappointed and I could never come up with the ideas that they did.

Several facilitators, particularly Linda, who appeared comfortable in their facilitation role showed greater appreciation of others' knowledge as well as the benefits of allowing the makers to shine as the experts:

> Linda: … these kids surpass my knowledge right away with robotics. So, you know, I think when you're talking about characteristics of people who are willing to launch these kinds of spaces, you have to be willing to not be the expert.

Contagiousness

Throughout the interviews, our team noted that emotions were often shared amongst the makers and facilitators, such as Jim's response:

> Jim: … Joy, like watching them figure something out or watching them design it and seeing that look in their eyes or seeing them get excited about it. So, that spills over to me, for sure.

Negative emotion emotional reactions can also spread. Tom said that he was bothered when the makers were disengaged and described how it would affect the entire group. Jim, too, was frustrated when the kids did not appear motivated. To this point, May noted feeling "muddled" and frustrated:

> May: … hard core muddling through it. A couple kids got it. One kid was like, "I can't stand this!" [laughs] … And I thought, "Hey! It's ok. I am not enjoying myself either."

Facilitators' comfort levels with expertise seemed to fall along a continuum and the degree of the makers' control in the makerspace was connected to the facilitators' personal preferences. Higher levels of preparation and control were considered important for facilitators who identified more closely with the expert role while freedom and maker control were highlighted by facilitators who did not need to self-identify as experts. In sum, emotional reactions, both positive and negative, appeared significant for the facilitators' motivation and resilience.

Verbal Persuasion

Our team found evidence of both overt verbal support from self or others and other more concrete forms of support. Table 6 summarizes the key sub-categories.

Table 6

Verbal Persuasion

Sub-category	Description	Example
Verbal support	Social persuasion; indirect support.	You can do it.
Concrete support	Provision of materials, funding, and time.	Jim: And, [the administrators] said they'd put some [learning] time in our schedules.
Breakdowns in support	Interactions that have a deleterious effect upon facilitators.	Cindy: ... you are a good team. You just ... plan together, and you come in and you seem to just really bounce off each other. Other times, it feels like it's more on me and so then I try to make more room for the teacher to be involved.

Verbal Support

There are few explicit examples in which our interviewees described having been directly encouraged (i.e., "You can do it"). But, our interviewees—particularly those who occupied official support roles—shared anecdotes in which they verbally encouraged others. This was true for Cindy, May, and Linda (teacher-librarians) as well as Bob (educational consultant).

> Bob: So, right now we're actually looking at getting the teachers together to help them facilitate. We'll spend about an hour with the teachers saying, "Well, these are the kinds of things you can do. This is probably what you're going to see."

Comments in the transcripts suggested that working with like-minded colleagues provided a source of both support and stimulation. Chuck, for example, noted positive experiences in which teamwork with librarians, educational assistants, caretakers, teachers, and student services helped distribute the workload of a makerspace endeavour.

Concrete Support

Instead of receiving verbal statements of encouragement, comments from some interviewees suggested that support for them was demonstrated in more pragmatic, concrete ways from various sectors such as administration, community members, and technologists. Sometimes administrative support came in the form of budgetary assistance which allowed acquisition of resources and opportunities for professional development such as in Ken's school-based, community makerspace:

> Ken: It's really surprising. The administration has been really supportive; whenever I feel like buying a new toy or something like that, they've kind of been like, "Yeah, sure." … I

think that kind of foundational getting buy-in from the people that make the decisions and who set the budget priorities can be a huge boost for that sort of thing.

Breakdowns in Support

Community members could also be a source of criticism rather than support. Linda, a teacher-librarian, provided a glimpse into how parents might influence a makerspace facilitator:

> Linda: We ended up buying too much equipment and then, you know, I've weathered the feedback from parents like, "Well, that resource is not very well used." And, parents don't always understand that I'm in their school [only] two days a week.

Similarly, teamwork could sometimes break down, leading to a lack of support for facilitators. Linda and Cindy describe some situations in which they had to reach beyond a support role because the teachers' already heavy workloads often precluded more intense participation in maker activities. May noted that teamwork and sharing amongst community members could also breakdown if reciprocity was perceived as lacking:

> May: Makers are very generous. They want to help, and they want to collaborate, and they want you to come up with your best ideas … People might close themselves off a little bit if they feel that it's gone from a sharing or reciprocity to a taking [situation] … is that someone takes your idea just a little bit further, but markets it in a way that, maybe doesn't honour your intellectual property.

The facilitators' comments suggested that support from administrators and parents can play a key role in a facilitator's effectiveness and motivation.

Vicarious Experience

Seeing others perform a task successfully can raise expectations of success for the observer. The facilitators described how they would learn how to make things by observing the makerspace participants, engaging in reciprocal sharing, and accessing information online. This interpretation emerged from the sub-categories summarized in Table 7.

Table 7

Vicarious Experience

Sub-category	Description	Example
Networking	Contacting other facilitators and visiting other makerspaces.	Rose: And [the other librarians] are skilled in puppetry and so they have used a Cricut machine to design and print puppets—shadow puppets. So, yeah, I've hooked up with them and they're going to train us or give a little demonstration anyway in how to use the Cricut machine.

Learning from makers	Learning from the makerspace participants.	Cindy: I think it's really changed my view of kids as experts 'cause they really are little experts in lots of different ways.
Accessing references	Locating relevant non-human resources.	Bob: The teachers don't have to actually, maybe, know it all about a topic. But they have to know on the Internet where to find it.

Networking With Others Involved in Makerspaces

Our interviewees indicated that they actively sought out connections by visiting other makerspaces at other locations such as schools and talking to experts and other teachers. They described how sharing knowledge and information helped them become better facilitators. In some cases, they sought out organizations in order to more quickly acquire skills. Pat, for example, attended a "coding for girls" class where she learned Scratch (a programming language). Tom seemed to prefer interaction with people admitting, "I need people to teach me and I need to be able to network with people" and indicated a desire to visit some of the big universities in the United States to "find out what is going on." Others described situations in which they collaborated directly with other teachers and facilitators.

Learning From the Makerspace Participants

Some facilitators found personal and pedagogical value in learning from the makerspace participants. For example, Cindy, a teacher-librarian, recounted a situation in which she learned skills through interaction with the makers:

> Cindy: I thought that was kinda clever on [the maker's] part. Like, I really honestly hadn't thought of that . . . So, the bigger battery worked!

Accessing Reference Materials

Several of the facilitators accessed print and online resources to help them gain experience and acquire knowledge. Cindy, for example, referred to a book on assessment while Jim read Popular Science magazine. Rose, meanwhile, accessed numerous different types of resources:

> Rose: … a documentary called "Maker" that I had watched. So, I had an idea of what it was. And that term has been showing up in library professional journals for probably the past ten years, so I started to get curious about what it was and then that's when I did some reading … I also went to the [name of] conference last year and there were a couple of teacher-librarians who were demonstrating what they did with kids.

Online sources also appeared significant to the facilitators such as social media, particularly Twitter and Google. Bob suggested that knowing where to find information was perhaps more important than being the expert in an area.

Discussion

The main goal of this research was to explore how self-efficacy expectations are experienced by early adopters of makerspace facilitators and, subsequently, use this knowledge to help educators acquire the skills and attitudes conducive for leading such activities. What we have observed was that performance accomplishments (33%) and emotional arousal (26%) constituted 59% of our codes (Table 3). At first glance, these percentages support Bandura's (1997) contention that mastery expectations (performance accomplishments) are more influential in perseverance behaviours. However, when we selected comments from the facilitators' perspectives, we found significant amounts of emotional content; in fact, emotions seemed to pervade the other self-efficacy categories.

Performance Accomplishments

Similar to the findings of Paganelli et al. (2017), the main tensions that surfaced in the interviews surrounded the facilitators' sense that they needed sufficient hands-on knowledge of the technology and techniques prior to any makerspace activity. There was a general sense that activities needed to be structured, planned, and controlled. The interview comments support observations by O'Brien et al. (2016) regarding preparation and structure. Our results also suggest some of our participants were more comfortable with *authoritative* and *orchestration* teaching strategies rather than *unleashing* strategies (Kajamaa et al., 2019). For one participant, the development of a makerspace passport was an interesting solution; it was attempt to direct learners' focus and sustain attention whilst still offering a degree of learner agency and choice. In other words, the passport provides a form of structure and direction, but also permitted "what if" space (Rowsell & Shillitoe, 2019, p. 2).

Emotional Arousal

Besides frustration with large groups and the need to cover extensive curricula, some anecdotes illustrated that facilitators suffered from a need for perfectionism and control. Some of our facilitators felt they needed to be seen as the experts and needed to ensure all materials were fully sourced and available. Tom even felt he should choose the projects. By contrast, other facilitators aligned well with orchestration and unleashing strategies discussed by (Kajamaa et al., 2019). For example, May commented that when she relinquished control, the learners "seldom disappointed." Linda, too, indicated that the kids "surpassed" her knowledge of robotics. Rather than feeling intimidated, these two facilitators embraced the knowledge and creativity of the makers and even learned alongside them. Both Jim and Linda commented that fear of failure or fear of not being the knowledge keeper would be potentially discomforting for makerspace facilitation and even antithetical to the makerspace ethos. These comments coincide with findings from Cohen et al. (2017) whose teacher-candidate participants came to the realization that "no one can know it all" (p. 8).

The comments coded for emotional arousal certainly indicated the significance of emotions within the creative domain of teaching and learning. Recognizing pedagogical and

social value appeared exciting and inherently motivating. For example, the facilitators expressed positive emotions when observing the creativity, sharing, and "gifts" of the makers. The facilitators were excited to see how the makers worked through problems. Linda noted her excitement when observing how makers with different projects would combine their skills innovatively (such as when integrating electronics and textiles), and when some learners/makers responded positively (such as "but this changes everything"). While Rowsell and Shillitoe (2019) argue that there is a role for affect, we would argue that affect has a significant role in the makerspace experience.

Verbal Persuasion

Overt, verbal persuasion was the least represented code in the transcripts, but there were anecdotes regarding informal and concrete support. Verbal persuasion sometimes showed a degree of pedagogical value when facilitators encouraged other teachers (potential facilitators) who then decided to learn more about the topic or who then incorporated the information or technique into their own teaching practice. Negative forms of verbal support/persuasion appeared to have a deleterious effect on motivation—particularly in cases where the facilitators felt they had to "do all the work" or where there was a perceived lack of reciprocity in sharing ideas and attributing credit. Echoing the findings of Phan and Locke (2015) regarding effective forms of support (i.e., collegiality, sharing, and institutional support), we found that funding and provision of work time are concrete forms of support enabling the acquisition of material and resources—along with time for experimenting with them. O'Brien et al. (2016) noted in their research that some participants were "cautious about integrating these types of activities in their future classrooms due to concerns around peer and administrator support as well as lack of resources" (p. 4). For that reason, we regard this category as significant albeit less obvious in the transcripts.

Vicarious experience

Networking, accessing resources, and learning from others are key components of makerspaces (Koole et al., 2016). In our study, vicarious experience anecdotes suggested increased knowledge and confidence more clearly when the facilitators observed or learned from other makers/experts as opposed to observing or learning from makerspace participants. Similarly, Cohen et al. (2017) found that their teacher-candidate participants appeared more comfortable with asking for and offering help. Their participants also recognized how their colleagues would offer alternative and useful viewpoints during the making process. And, like Cohen et al.'s participants, some of our interviewees also realized that as facilitators/teachers they were in a dialogic, learning relationship with the makers.

Conclusions

In this paper, we defined facilitator self-efficacy as an individual's belief in their capacity to organize and guide a makerspace activity as well as their ability to encourage creativity, problem solving, sharing, making, and collaboration. For our study participants, emotional arousal appeared to underlie all four elements of self-efficacy—but was particularly influential upon confidence and motivation. This led us to conclude that affect is an inherent part of making and the facilitation of making. Also prevalent across all four self-efficacy categories was the importance of learner agency; that is, the need for facilitators to structure and control making activities versus allowing full unleashing of learners. Amongst our participants, those who were

more comfortable with relinquishing control appeared to experience less anxiety. This finding suggests that an egalitarian approach with facilitators and learners sharing expertise may be an important disposition to encourage in future facilitators.

There is a need to help preservice and early career educators to become prepared and confident makerspace facilitators. As a result of our analysis, we conclude that while facilitators need not be experts in programming, robotics, or sewing, they do require programs and supports that strengthen their sense of self efficacy. Using Bandura's four elements of self-efficacy (verbal persuasion, performance accomplishments, emotional arousal, and vicarious experience) to analyze the experiences of current makerspace facilitators, we offer the following suggestions for new makerspace facilitators: start with orchestration and aim toward unleashing; allow others to be the experts, organizers, managers, conceptualizers, problem identifiers, and leaders; celebrate both success and failure; and openly seek and offer support, both concrete and verbal.

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