YOUNG PEOPLE'S INFORMATION PRACTICES IN LIBRARY MAKERSPACES AS INFORMAL LEARNING ENVIRONMENTS

By

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ABSTRACT OF THE DISSERTATION

Young People's Information Practices in Library Makerspaces as Informal Learning Environments

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Within the past decade, the maker movement and culture have received a lot of interest and support from the government, research institutes, museums, libraries, and schools in the United States. Makerspaces are important because they fit in with broader concerns of science, technology, engineering, and mathematics (STEM) education and provide informal learning opportunities for people to engage in situated and practical intelligence that contributes formal learning. A review of the literature on library makerspaces shows a growing but still limited number of empirical studies in Library and Information Science (LIS) that have explored this phenomenon, especially from the perspective of makerspace users, such as young people. It remains unknown how young people engage with information as they participate in library makerspace activities.

This dissertation aims to understand the opportunities and desired outcomes of makerspaces in libraries from the perspective of young people, also to develop a holistic understanding of information practices of young people participating in makerspace activities, and to understand the affordances and constraints of technologies and materials

in young people's information practices. A total of twenty-one young people at two library makerspaces participated in this study.

Based on the analysis of qualitative data from field observations, individual interviews, photovoice, and focus groups, this dissertation shows that from the perspective of young people, the opportunities and desired outcomes of makerspace participation are centered on four major themes: make, learn, social, and interest. Young people's information practices of seeking, using, and sharing at the makerspaces are largely social oriented and embedded in their makerspace activities. One salient practice of becoming informed during makerspace activities is through tinkering and embodiment. Additionally, the makerspaces have a robust culture of asking and information sharing, in which young people can freely generate questions and engage in inquiry. The value of visual information is highlighted in young people's information-searching practices in the library makerspaces. Situations when young people switch from individual to collaborative information practices are further identified.

This dissertation has theoretical, methodological, and practical contributions and implications. Theoretically, it offers an empirical research-based conceptualization of library makerspaces, contributes to the body of scholarly work on young people's information practices in everyday life and informal learning. Implications for professional practices include a visual guide for makerspace activities and strategies in supporting young people's information practices in library makerspaces as informal learning environments.

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> "Makers and builders and doers -- of all ages and backgrounds -- have pushed our country forward, developing creative solutions to important challenges and proving that ordinary Americans are capable of achieving the extraordinary when they have access to the resources they need…To continue to build a Nation of Makers, we are committed to engaging students at every level in the hands-on learning of science, technology, engineering, and mathematics (STEM) to inspire them to pursue their own passions and excel in STEM fields." (Obama, 2015).

1.1 Problem Statement

The opening quotation from the former U.S. President Barack Obama's presidential proclamation for the National Week of Making in 2015 draws attention to the maker movement that started from 2007 in America. Makerspace is defined by Maker Media as: "learning environments rich with possibilities, Makerspaces serve as gathering points where communities of new and experienced makers connect to work on real and personally meaningful projects, informed by helpful mentors and expertise, using new technologies and traditional tools" (Hlubinka et al., 2013, p.1). Makerspaces are important because they fit with broader concerns of STEM education in the U.S. and provide informal learning venues for people to engage in situated and practical intelligence that contributes to formal learning. The value of informal learning on "shared cognition", "tool manipulation", "contextualized reasoning", and "situation-specific competencies" has been pointed out by Resnick (1987) in her seminal paper challenging the field of education (p.13-15). According to her, "school is a special place and time for people—discontinuous in some important ways with daily life and work" (p.13). In reality, learning does not merely take place in school but across a wide range of activities in everyday life, such as going to museums, walking in a garden, and having a conversation at family dinner table (Barron, 2006; Falk & Dierking, 2000). Experience

and exploration in these informal settings may lead to development of interests, motivation, social competence and learning in subject knowledge (Bell, Lewenstein, Shouse, & Feder, 2009).

In particular, in STEM education, Bell et al. (2009) argue that:

> Contrary to the pervasive idea that schools are responsible for addressing the scientific knowledge needs of society, the reality is that schools cannot act alone, and society must better understand and draw on the full range of science learning experiences to improve science education broadly (p.12).

Situated in this broad cultural background and educational agenda, an increasing number of libraries, museums, and other institutions have embraced the maker movement and made room for makerspaces (e.g., Benton, Mullins, Shelley, & Dempsey, 2013; Colegrove, 2013; Noh, 2016). In the state of New Jersey, approximately 400 makerspaces have been developed in the past few years and that number continues to rise (personal communication with the librarian at the public library makerspace in this dissertation, March 2, 2018).

However, a review of the literature on makerspaces in library settings shows that a growing but still limited number of empirical studies in the field of Library and Information Science (LIS) have explored this phenomenon. Much of the literature on makerspaces is of rhetorical and communicative nature, such as short reports on individual makerspaces or personal blogs or opinion pieces. In addition, a scant number of studies have investigated makerspaces from the perspective of users, such as young people, with two exceptions (Bowler & Champagne, 2016; Koh, 2015). Yet none of these studies have investigated a fundamental question of what makerspaces are, from the perspective of young people.

In addition, for the concern of information researchers and professionals, to design information-rich makerspaces and to provide quality information services for young people requires an understanding of their ways of engaging with information and the role of technologies and materials in their information-related activities. Yet, research in LIS has placed much focus on information phenomena in digital environments and formal education environments where students engage in assigned tasks. Although there is an increasing body of literature on young people's everyday information behavior and practice, the focus has been on daily life information needs (Agosto & Hughes-Hassell, 2006), everyday hassles (Lu, 2011), career decision making (Julien, 1999), and marginalized youth (Markwei & Rasmussen, 2015). It remains unknown how young people engage with information as they participate in informal learning activities.

Furthermore, informal learning activities and environments constitute a social world in which young people have the opportunities to work together with peers and experts. Thus, in addition to understanding young people's information practices, it is critical to understand their collaborative information practices. An understanding of collaborative information practices can help information professionals and services facilitate young people's engagement with information effectively in individual and group situations.

1.2 Research goal and objectives

The research goal of this dissertation is threefold. First, this study chooses the library makerspace as the operationalization of an informal learning environment, with the goal of understanding the opportunities and desired outcomes of makerspaces in libraries from the perspective of young people. Second, it aims to develop a holistic

understanding of both individual and collaborative information practices of young people participating in makerspace activities. Lastly, as library makerspaces provide access to technologies and materials, the study also aims to understand their affordances and constraints in young people's information practices.

1.3 Significance

This dissertation has theoretical, methodological, and practical contributions and implications. The findings of this dissertation have two key theoretical contributions and implications. The first contribution is the empirical research-based conceptualization of library makerspaces from young people's perspective and a conceptual model of library makerspace. The second is a theoretical contribution to the body of scholarly work in LIS on young people's information practices in everyday life, especially to the emerging discussions on embodied information practices.

Methodologically, this dissertation shows the importance and necessity of conducting informative pilot studies in justifying the validity of research questions, selection of sites, and decisions on data collection methods. The use of video-recorded reenactment and photovoice techniques in this dissertation also contributes to an understanding of using visual methods in collecting data and conducting research with young people.

Practically, this dissertation provides a research-based visual tool for librarians and makerspace facilitators to help users have an immediate grasp of what they can do. At the same time, it helps makerspace facilitators understand what users want to achieve through their participations and identify their levels of interest and engagement. It further

provides research-based guidance on makerspace design and services for young people in public libraries and school libraries.

Chapter 2 Literature Review

This chapter reviews scholarly works that inform this dissertation's conceptual framework, research questions, and data collection methods. It is organized first to review the theoretical frameworks commonly applied in information research. Then the central term "information practice" is examined in relation to the notion of information behavior. Following that is a review of sociocultural approaches to learning to inform the interdisciplinary nature of the dissertation. This chapter further reviews empirical research in the following areas, including library makerspace, informal learning, young people's information behavior/practice in everyday life and creative works, and collaborative information practices. The chapter concludes with a summary of the intellectual and methodological gaps identified in the literature.

2.1 Conceptual Framework

2.1.1 Metatheories in information science

Information science is "a complex interdisciplinary research field" that has been characterized based on three meta-theoretical and epistemological stances, including cognitive constructivism, social constructivism, and social constructionism (Talja, Tuominen, & Savolainen, 2005, p.80). These three "isms" indicate fundamentally different assumptions on the origin of knowledge and the relation between human development and learning. Different meta-theoretical positions further suggest the researcher's choices in methods of collecting data and analytic emphasis. Hence, it is important to review these meta-theoretical positions and situate this dissertation in the one that can be most useful for the researcher's investigation on the topic of makerspace and young people's information practices.

Cognitive constructivism takes the view that knowledge is created from individual active construction of an understanding about the world (Talja, Tuominen, & Savolainen, 2005). Social interactions, socio-cultural and historical aspects play the role of supporting how an individual comes to know, but they are not regarded as intrinsic for one's understanding (Bates, 2005; Suthers, 2006; Sanna Talja et al., 2005). This individual epistemology is influenced by Piaget's (1977) theory on equilibration of cognitive structures. According to Piaget (1977), people experience a "cognitive conflict" when there is an imbalance between encountered new information and existing knowledge structure. To solve cognitive conflicts, people either assimilate new information or accommodate their knowledge to achieve a balance between new information and existing knowledge. Both the assimilating and accommodating processes lead to new knowledge. Assimilation is associated with the "quantitative" change of individual knowledge, while accommodation is considered as a "qualitative" change in one's knowledge creation and learning. In LIS, studies framed under this cognitive constructivism investigate changes in mental models and knowledge structures in relation to information activities.

Compared to cognitive constructivism, social constructivism assumes that the individual mind constructs reality. This constructive process not only shapes, but is also shaped by social interactions, socio-cultural and historical contexts in which individuals are situated. Social constructivism implies a social epistemology, which has been recognized as critical to understand LIS (Fallis, 2006). As Fallis (2006) states, "most of our knowledge about the world is acquired through communication with other members of society rather than through direct observation" (p.476).

This social constructivist theoretical framework is largely influenced by Vygotsky's (1978) theory of cognitive development, which suggests a dialectical relationship between human development and sociocultural environment. A key concept in his theory is "the Zone of Proximal Development," which asserts that individuals could achieve higher performance with the help of others who are more capable (Vygotsky, 1978, p.86). These capabilities of imitating the more capable are described as "'buds' or 'flowers' of development rather than the 'fruits' of development" (p.86). Thus Vygotsky (1978) argues that "learning which is oriented toward developmental levels that have been reached is ineffective from the viewpoint of a child's overall development" (p.89). This type of learning is common in traditional and formal education that follows a curriculum based on the achieved development and individuality. On the other hand, Vygotsky's "zone of proximal development" sheds light on the importance of a social learning environment, as he argues "human learning presupposed a specific social nature and a process by which children grow into the intellectual life of those around them" (p.88). As this dissertation aims to understand information phenomena in informal learning contexts, the social constructivist approach is more useful than the cognitive constructivist approach.

2.1.2 Information behavior and information practices

Research in the field of LIS that explores interactions between human and information has gone through several "turns", such as from a computer-centered approach to a user-centered approach (e.g., Dervin & Nilan, 1986) and from a cognitive constructivist approach to a social constructionist approach (e.g., Savolainen, 1995). Along with these shifts are the changing research foci and terminologies used in

empirical studies to describe these information phenomena. Even though the differences between studies focused on information behavior and information practices are sometimes unclear and difficult (e.g., “The behaviour/practice debate: a discussion prompted by Tom Wilson’s review of Reijo Savolainen’s Everyday information practices: a social phenomenological perspective. Lanham, MD: Scarecrow Press, 2008.",” 2009), research on information practices shift attention from individual information seeking to satisfy some encountered gap in one’s mental model, to encompass other forms of information related actions, for instance, both active and passive information seeking, use, and sharing in everyday life (Savolainen, 2007, 2008) and information creation in online communities (Harlan, Bruce, & Lupton, 2012). These information practices are viewed as an integral part of social practices, which are shaped by immediate situations and sociocultural contexts.

In LIS, researchers have investigated information practices among various professional communities and age groups, such as information practices among physicians in healthcare settings (e.g., Bonner & Lloyd, 2011; Isah & Bystrom, 2016), scholars interacting with books (Anderson, 2007), Japanese tanka gathering (Sakai, Korenaga, & Sakai, 2015), women pregnant with twins (McKenzie, 2003), theater professionals in performing Shakespeare (Olsson, 2010), Ph.D. students in business school (Bøyum & Aabø, 2015), welfare workers at work (French & Williamson, 2016), and young children exploring their interests (Barriage, 2016). These studies point out how information practices are embedded in everyday life, workplace, and learning contexts. Additionally, these findings highlight how information practices are shaped by

one's dynamic interactions with the physical, material, and social contexts. These studies further suggest capturing information actions that are beyond information needs.

2.1.3 Sociocultural approaches to learning

Aligning with the metatheory of social constructivism are the sociocultural approaches to learning, as they commonly refer to the perspectives that are influenced by Vygotsky's (1987) work. These approaches shed light on the situatedness of activities within specific places, the mediating role of physical and material features, the interactions among people that influence learning process and outcomes (Bell et al., 2009; Lloyd, 2012). Particularly, works from Lave (1988) and Lave and Wenger (1991) appear to be useful for understanding situated and routine information practices within a setting.

2.1.3.1 Situated learning

Lave (1988) points out that traditional view on learning-as-transfer is problematic in that it isolates learners from situations and contexts in which learning take place. She critiques the idea that the underlying assumption of the learning-as-transfer model is the uniform of cultures and a privileged view on what is counted as scientific knowledge. She argues:

> Problems of the closed, 'truth or consequences' variety are a specialized cultural product, and indeed, a distorted representation of activity in everyday life, in both sense of the term – that is, they are neither common nor do they capture a good likeness of the dilemma addressed in everyday activity" (p.43).

In her observations of shoppers in supermarkets, she recognizes that there are problems "out there" (Lave, 1988, p.69), however, it's the shopper's choice to recognize the problems or not. Hence, "if a problem must be recognized in order to exist, it is not possible to locate problems exclusively either in settings or in cognitive processing – both

are involved" (p.69). This exemplifies real-life problem-solving as situated in the act of doing that are anchored in the setting.

Working from a sociocultural theoretical perspective of learning, Lave and Wenger (1991) claim that learning is realized through practice and participation within particular communities that develop over time through a process of "legitimate peripheral participation." From this perspective, learning is essentially situated activities, facilitated through social participation and is an integral part of social practice in a social world. This framework directs the investigation towards "what kinds of social engagement provide context for learning to take place" (p.14).

The notion of situated learning does not indicate constraints that learning is isolated to one place and time, or dependent on an immediate social setting, and the notion of community does not imply physically and socially visible boundaries (Lave & Wenger, 1991). Rather, they suggest a relational view about knowing and learning, and about the negotiation of meanings between understanding and experiences in a range of different contexts. As a person moves from peripheral participation to full participation, not only are a domain of knowledge and skills mastered, but the person's broader context in which practices take place also changes. This in turn shapes his/her participation and practices in a particular community.

Further, Lave and Wenger's theory of communities of practice (CoP) provides a lens to understand collaborative information practices. For instance, Talja and Hansen (2006) propose a social practice approach to study collaborative information activities. This approach views information activities, either seeming solitary acts or collaborative acts, as integral dimensions of work practices or social practices, while individuals are

"participants in practice" (p.127). Information seeking is interwoven with other information activities, such as information use and information evaluation, and these all can be seen as aspects of practices at work. Instead of focusing on individual information needs and seeking behavior, Talja and Hansen (2006) suggest a shift of attention to the interplays between people, information technologies, information objects, and artifacts in the process of accomplish some tasks at hand.

Overall, the theory of CoP has implications for this dissertation. It directs attention to dynamic and dialectical relations between "'person', 'activity', 'knowing,' and the 'social world' (Lave & Wenger, 1991, p.122)". It offers guidance on conceptualizing learners as social actors and learning being essentially social. This perspective further guides the conceptualization of a complex and dialectical context (Courtright, 2007) of information practices that this study investigates. Through the lens of Lave and Wenger's CoP, information practices that young people engage with in informal learning environments are seen as an integral part of these young people's social and learning activities.

2.1.3.2 Embodied knowing

When humans and all activities are conceptualized as situated, their experiences are inevitably embodied and constitutive of each other (Lave, 1988; Wenger, 1998). Embodied knowing not only refers to physical and material presence, but also to actions responding to the immediate space (Dourish, 2001) and "the extent to which an agent can alter its environment" (Dawson, 2013, p.217). Especially in the activities of design and creation, Hakkarainen, Paavola, Kangas, and Seitamaa-Hakkarainen (2013) point out the importance of embodied knowing:

> The role of materials and artifacts in the design process is crucial. Designers are "working with things"; they express their ideas in "things themselves" rather than merely words; in a lateral sense, designed artifacts carry and embody knowledge. In order to understand and improve the ideas being developed, they have to be given a material form by means of practical exploration, prototyping, and making (p.65).

In the field of LIS, Anderson (2007) suggests taking this embodied perspective to understand information practices, for it allows theoretical attention to both individual meaning making processes with objects and tools, and the sociocultural and material contexts in which meaning making takes place.

2.1.3.3 Distributed cognition

This dissertation further draws upon the notion of distributed cognition (Hutchins, 1995) to uncover the interactions among individuals, technologies, and materials (Vasiliou, Ioannou, & Zaphiris, 2014). Moving away from the conceptualization of cognition as located within an individual, Lave (1988) claims that "'cognition' observed in everyday practice is distributed - stretched over, not divided among - mind, body, activity and culturally organized settings (which include other actors)" (p.1). Cole and Engestrom (1993) argue that cognition is essentially cultural mediated through tools with which individuals interact. They state that "the ways in which mind is distributed depend crucially on the tools through which one interacts with the world, and these in turn depend on one's goals" (p.13). This theoretical attention to the mediating role of tools and technologies in one's practices in a community is also reflected in Lave and Wenger's (1991) cultural-historical perspective approach in learning, which indicates that tools and artifacts "carry a substantial portion of that practice's heritage" (p. 101). Tools and artifacts should not be viewed at their face value but through the cultural practices and social process of their generation.

Hakkarainen et al. (2013) proposed a "trialogue" collaborative knowledge creation approach that extends the attention from examination of conversations between people to the interaction among people and shared objects. Artifacts and tools are given a central role in mediating collaborative learning processes. From this approach, objects are understood as both "knowledge-laden and physically embodied as digital or other types of artifacts" (p.65). On the other hand, Hakkarainen et al. (2013) indicate that "shared objects…maybe epistemic, not having tangible or material form" (p.59), such as conceptual ideas, hypothesis and plans. This approach directs the theoretical attention to shared objects and the affordance and constrains of them in people's collaborative activities.

2.1.4 Everyday information practices

This dissertation further draws upon Savolainen's (2008) framework of everyday information practices to understand how young people interact with information in the selected informal learning environment (i.e., library makerspace). Savolainen (2008) asserts that "information practices are composed of information actions", and these actions involve seeking, using, and sharing information, which are composed of individuals' "doings and sayings" (p.64). He argues that in most everyday life situations, "People seldom think of collecting, processing, or using information as something separate from the task or problem at hand" (Savolainen, 2008, p.3). Rather, these information actions serve as the tools for people to accomplish their tasks, solve problems, reach their goals, or for the pleasure of doing things. This conceptual attention to the "doings and sayings" gives rise to individuals' "bodily activities" and "mental and discursive activities" in relation to information (p.64).

The underlying assumptions of Savolainen's (2008) everyday information practices and information behavior research are fundamentally different. Savolainen (2008) points out an assumption of information behavior studies is that "information seekers are 'needy' individuals hunting for information from various sources and channels" (p.3). In contrast, Savolainen (2008) proposes a different perspective that does not use "the concept of 'needy' individuals" (p.3); Instead, he argues to view "the phenomena of information seeking, use, and sharing…as socially and culturally sensitive phenomena" (p.4). Rather than assuming information behavior being affected by an uncertainty in one's mental structure, Savolainen (2008) draws upon Schatzki's practice theory and Schutz's work, and argues that information practices are affected by contextual factors such as "the specific goals of various projects" (p.26), "the actors knowledge base" (p.26), "interest at hand" (p.29), "a set of internalized social rules and norms" (p.30), and "affective factors" (p.30). This is further due to the assumption that humans live in an intersubjective life world and individuals' experiences of life world are through situated learning. Thus, studies on information practices investigate the "role of contextual factors that orient people's information seeking, use, and sharing" (Savolainen, 2008, p.4), and "the criteria by which they access (or avoid) information sources or share information with other people in life world contexts" (Savolainen, 2008, p.5).

Savolainen (2008) is focused on three information actions – information seeking, use, and sharing. When people engage in information seeking, information sources are selected based on personal preferred ways, which are affected by one's experience, knowledge base, and other sociocultural and context factors. Sources are also accessed

based on their perceived usefulness. Further, information use is studied at a "macro-level" and by examining "the ways in which people interpret the value of information sources more generally and how they wield information to orient their action" (Savolainen, 2008, p. 149). In other words, information use practices unpack how people evaluate an information source in terms of its perceived authority, credibility, and trustfulness. Savolainen's (2008) everyday information practice framework also sheds light on the "communicative aspects" of information practices - information sharing (p.183). Information sharing is defined as "a set of activities by which information is provided," either to others or from others, by serendipitous encountering or "by proxy" (Savolainen, 2008, p.183).

While Savolainen (2008) is focused on these three information actions in everyday life, this study does not limit the focus to these three actions, because in the context of makerspaces, information actions have emerged more than seeking, use, and sharing information. However, this study chose Savolainen's (2008) framework as the starting point to explore key information practices and direct attention to contextual factors, such as the criteria by which young people select and choose certain information sources, their perceived credibility and authority of information obtained, and motives that trigger collaboration in information activities.

2.1.5 Social practice approach to collaboration

As this dissertation further aims to understand the collaborative dimensions of young people's information practices, Talja and Hansen's (2006) social practice approach to collaborative information activities was adopted. Aligning with the assumptions of the sociocultural perspectives to learning as well as Savolainen's (2008) everyday

information practices framework, Talja and Hansen (2006) argue that collaborative information practices are integral to people's work or mundane practices in everyday life. Thus they cannot be studied as separate. They further indicate that "collaborative information activities are therefore best captured by naturalistic research that pays attention to the dynamic interplay of work practices, information practices, and information technologies in everyday settings" (p.116).

2.1.6 A bricolage approach

As this dissertation aims to gain a holistic picture of young people's information practices that are embedded in their makerspace activities, it draws upon theoretical frameworks both in LIS and learning science, in particular, Savolainan's (2008) everyday life information practices, and a set of sociocultural perspectives. Hence, it is a bricolage approach, "concerned not only with multiple methods of inquiry but with diverse theoretical and philosophical notions of the various elements encountered in the research act (Kincheloe, 2001). This bricolage is feasible because of their compatible underlying assumptions of knowledge as socially constructed and humans as social beings that participate in societies. It does not imply a freedom of choosing theoretical framework, but is concerned with "diverse theoretical and philosophical notions of the various elements encountered in the research act" (Kincheloe, 2001, p.682). In LIS, studies have applied both sociocultural approaches in learning science to LIS studies. For example, Isah and Bystrom (2016) draw upon Engestrom's activity theory and Lave and Wenger's (1991) situated learning theory in understanding physicians' practices in accessing information at work. Overall, a bricolage theoretical approach suggests the interdisciplinary nature of this proposal study (i.e., LIS and learning science), which,

according to Kincheloe (2001), may expand the boundaries of accepted knowledge and thus produce new knowledge.

The sociocultural approaches to learning provide lenses to understand that young people's activities are fundamentally shaped by the availability, arrangement, and nature of the space, material, technological objects, artifacts, and other resources that they encounter at makerspaces (Bell et al., 2009). With Savolainen's (2008) information practices framework, a focused attention will be given to emergent information actions. Together, these lenses can support development of a holistic understanding of young people's information practices as situated and embedded in the contexts of makerspace activities. Key points of these abovementioned conceptual frameworks are summarized in relation to the research questions (RQ) (see Table 1, below). RQs are listed on p. 46.

Theoretical lens	Conceptual contribution	Phenomena of interest in relation to the RQs
Situated learning (Lave & Wenger, 1991)	Situatedness and embeddedness of information practices as part of social practices in a social world.	To address RQ1 – 6, viewing information practices and collaborations as integral parts of young people's social practices and their participations of maker communities
Embodied knowing (Anderson, 2007; Dawson, 2004; Lave, 1988)	Actions and doings in relation to material objects, technologies, tools and artifacts.	To address RQ 2 and 6 regarding information practices and the roles of available materials and technologies
Distributed cognition (Cole & Engestrom, 1993; Hutchins, 1995)	The mediating role of shared objects (including both tangible objects and conceptual artifacts) in social interactions and collaborations.	
Everyday life information practices (Savolainen, 2008)	Information practices are composed of information seeking, use, and sharing,	To address RQ 2, 3 and 4 regarding information actions and their contextual

	giving attention to contextual factors.	factors influencing the actions
Social practice approach to collaboration (Sanna Talja & Hansen, 2006)	Mutual shaping relationships between information practices, collaboration practices, and the tools involved.	To address RQ 5 regarding collaborative information practices

Table 1: Theoretical lenses and conceptual contributions in relation to the RQs

2.2 Existing Research

Section 2.2 first reviews the history and characteristics of makerspaces and current literature on makerspaces in library settings. It further includes a review on informal learning. Following these is a review of the empirical research on young people's information behavior and practice in everyday life and creative works. Existing literature on collaborative information practices is reviewed at the end.

2.2.1 Library makerspace

2.2.1.1 History and characteristics of makerspaces

The maker movement was initially promoted by Make magazine to celebrate grass-roots American culture and do-it-yourself (DIY) projects in 2005. Since 2007, the maker movement and culture have received a lot of interest and support from the government, research institutes, museums, libraries, and schools in the U.S. (Benton, Mullins, Shelley, & Dempsey, 2013; Colegrove, 2013; Flintoff, 2017; Johnson, 2016). More and more libraries, museums, and universities embrace the maker movement and culture to design and create their makerspaces throughout the nation and world (Barniskis, 2016; Benton et al, 2013; Brown & Antink-Meyer, 2017; Slatter, Howard, & Zaana, 2013). Makerspaces also catalyze on the transformation of library missions from spaces that encourage mere information consumption to spaces that encourage information creation, from fostering reading and inquiry skills to fostering knowledge

creation (Flintoff, 2017). Yet, the concepts and goals of makerspaces are not new (Colegrove, 2013). According to Dale Dougherty, the founder of Make Magazine, makerspace encompasses the concepts that "[have] already been happening for hundreds of years – maybe thousands" (as cited in Colegrove, 2013, p.2).

Before the emergence of makerspaces, there have been spaces such as fab labs and hackerspaces. However, makerspaces can be viewed as composed of these other spaces, as the shared goals are all focused on making rather than consuming (Colegrove, 2013). Makerspaces are designed to provide programs and resources that encourage people to learn about STEAM (science, technology, engineering, art, and mathematics) related knowledge, and foster people's creativity and innovation with technologies (Bevan et al., 2015; Bowler & Champagne, 2016; Colegrove, 2013; Flintoff, 2017). In schools, similar spaces such as science labs or art rooms also exist; yet makerspaces differ from them in that the former usually have imposed tasks from educators, while the latter gives students the freedom to set their own plans (Koh, 2015; Yockey & Donovan, 2015).

2.2.1.2 Makerspaces in libraries

Within the past few years in LIS, there have been a growing number of studies exploring makerspace, in academic libraries (e.g., Fourie & Meyer, 2015), or school libraries (e.g., Koh, 2015; Moorefield-Lang, 2015), or public libraries (e.g., Slatter & Howard, 2013). These library makerspaces have been described as providing people meaningful learning experiences and hands-on explorations, fostering entrepreneurship and innovation, developing interests in STEAM, and enabling collaborations among like-minded people (Benton et al., 2013; Bowler, 2014; Sierra, 2017).

LIS researchers have also argued that makerspaces in libraries are not just places for socializing, they are also spaces for information sharing and collaborative learning (Fourie & Meyer, 2015), and informal learning spaces (Abbas & Koh, 2015; Koh & Abbas, 2016). The informal learning aspects are also reflected as people set their own learning agenda based on their curiosity and motivation (Fontichiaro, 2014), seek information from sources more than teachers and textbooks beyond academic requirements (Gustafson, 2013; Koh, 2015), and develop ownership of their own creations (Graves, 2014). These essentially social, self-directed, interest-driven, and free-choice experiences are all characteristics of informal learning, as discussed in learning science (Falk & Dierking, 2000). Further, library makerspaces as informal learning environments are described among practicing librarians and makerspace facilitators. For example, Farkas (2015) states, "the beauty of offering STEM education in the library is that it is a neutral space where students are not being graded for their participation. Libraries are rarely hamstrung by rigid curricula and thus can focus on what most interests children" (P.27). In Landgraf's (2015) interviews with four practitioners from different library makerspaces, the informal nature of learning in makerspaces has also been highlighted.

Existing literature has explored library makerspaces mostly from the perspectives of makerspaces designers, librarians, and researchers. Studies have explored aspects to consider in creating a makerspace in schools (Moorefield-Lang, 2015; Yockey & Donovan, 2015) or in academic libraries (Fourie & Meyer, 2015), desired competences for future makerspace facilitators (Bowler, 2014; Koh & Abbas, 2016), professionals' perceptions of makerspaces (Abbas & Koh, 2016), challenges and benefits of creating

makerspaces (Slatter & Howard, 2013), and issues on makerspaces access (Barniskis, 2016; Willett, 2016). Two empirical studies have focused on the perspective of makers. One is conducted by Koh (2015) to examine the learning process of a group of 19 middle school students at their makerspace, what they have learned, challenges encountered, and their learning needs. Her study applies a set of data collection methods including weekly reflection journals, field observations, and video recorded activities, group and individual interviews, and pre- and post- questionnaires. Koh (2015) finds that middle-school students primarily consult their mentors and peers in a makerspace. Students reported that they have learned how to engage in self-directed learning, solve real-world problems, use a range of different information and technologies to look up information, as well as science and technology related knowledge. The other research is conducted by Bowler and Champagne (2016) to study the types of questions that teens and facilitators ask at three different makerspaces to support their "mindful making," a process of self-reflecting and self-awareness in relation to the makings, materials, and technologies (p.119). They employ methods of observation, focus groups, sketching exercises, and interviews with makerspace facilitators. Bowler and Champagne (2016) identify eight questions that might encourage young makers' deep thinking and learning in their making activities. These eight questions highlight the interplays between emotions, audience, materials, space, time, effort, knowledge base, readiness of failures, and creations.

While interest in makerspaces have been increasing, there is still a lack of understanding of how people actually use and make sense of their makerspace experiences, including their interactions with space, objects, technologies, tools and other resources that are available at makerspaces. Abbas and Koh (2015) describe the need for

research on informal learning environments, in particular, what and how teens learn in informal learning environments in libraries and museums. According to them, empirical findings and evidence that show teens learning through these informal learning spaces will help these informal learning spaces in libraries and museums sustain and develop.

2.2.2 Informal learning

The notion of informal learning stems from Resnick's (1987) seminal paper that explores four contrasts between school and out-of-school learning, including "individual cognition in school versus shared cognition outside" (p.13), "pure mentation in school versus tool manipulation outside" (p.13), "symbol manipulation in school versus contextualized reasoning outside school (p.14) and "generalized learning in school versus situation-specific competencies outside" (p.15). All these four broad contrasts suggest "school is a special place and time for people—discontinuous in some important ways with daily life and work" (p.13). Since then, numerous studies in learning science have investigated informal learning contexts that are extended beyond the school environment.

Informal learning indicates a reconceptualization of learning in informal contexts – learning is essentially social where people engage with others and their culture to make meaning of the world around them (Falk & Dierking, 2000). Further, participation is not compulsory (Bell et al., 2009) and this process is directed by a learner, meaning that they engage in learning about what they are interested in or what piques their interests.

Even though it is not always the case that schools are formal learning while out-of-school settings are informal, researchers have pointed out that informal learning commonly takes place in the following contexts - everyday experiences (e.g., walking in the park), designed settings (e.g., libraries and museums), and programs such as after-

school clubs and virtual spaces (Bell et al, 2009). Makerspace, as a designed setting for informal learning, in discussed in the following section.

A table of comparisons among the notions of informal learning, formal learning and everyday life information seeking (ELIS) is presented in Table 2. It is important to note that the descriptions under each dimension do not represent a full capture of each notion; rather, they highlight the differences among them.

Dimensions of comparison	Informal learning	Formal learning	ELIS
Definition	"Informal environments are generally defined as including learner choice, low consequence assessment, and structures that build on the learners' motivations, culture, and competence" (Bell et al, 2009, p.47).	Formal learning is not necessarily dichotomous to informal learning but can be seen as a continuum; it is mandatory, highly evaluative and curriculum-driven (Bell et al., 2009; Tal & Morag, 2007).	"The acquisition of various informational (both cognitive and expressive) elements which people employ to orient themselves in daily life or to solve problems not directly connected with the performance of occupational tasks (Savolainen, 1995, p.266-267).
Core Assumptions	Learning is essentially social (Vygotsky, 1978), situated (Lave & Wenger, 1991), and distributed (Hutchins, 1995). Mutual constitutive of individual learning and sociocultural influences on learning (Zimmerman, Reeve, & Bell, 2009)	Individual epistemology that individuals are the learning agents and knowledge can be transferred (Suthers, 2006) Social interactions may support learning but are not intrinsic to learning (Suthers, 2006)	Knowledge is socially, culturally and physically constructed (Talja, Tuominen, & Savolainen, 2005) Duality between "way of life" and "mastery of life" (Savolainen, 1995)
Settings	Everyday experiences Virtual spaces	Traditional K-12 classrooms	People's private lives (Agosto &

		Higher education	Hughes-Hassell, 2006) Nonwork-related aspects of everyday life, such as health care (Savolainen, 1995) Beyond school and libraries (Meyers, Fisher, & Marcoux, 2009)
	Designed settings such as museums and libraries in which materials are provided to guide learners' experience (Bell et al, 2009).		
Characteristics	Personal interest and prior experience drive what is learned (Falk & Dierking, 2000) "Tool manipulation", "Contextualized reasoning", "Situation-specific competences" (Resnick, 1987, p.13-15) Designed environments, structured by institutions, yet the interactions with the environment are defined by learners (Bell et al, 2009, p.48)	Individual learning outcomes are measured by pre- and post-tests (Tal & Morag, 2007) "Pure mentation", "Symbol manipulation", "Generalized learning" (Resnick, 1987, p.13-15)	The equally important roles of materials, social, cultural and cognitive capital in seeking and using information (Savolainen, 1995) Information seeking as an inseparable and natural aspect of social practices in everyday life (McKenzie, 2003; Savolainen, 1995).

Table 2: Comparisons among informal learning, formal learning, and ELIS

Based on the above discussion, the notions of informal learning and everyday life information seeking share a great deal of commonalities in terms of core assumptions (i.e., socially and culturally constructed ways of knowing), part of the settings (i.e., everyday life extending over time) and characteristics (i.e., becoming informed as an aspect of social practices that are intertwined with people, materials and culture). However, the differences lie in that the former conceives designed environments, such as

libraries and afterschool programs, as places where social learning takes, whereas the latter tends to look beyond these places (e.g., Meyers, Fisher, & Marcoux, 2009).

2.2.3 Young people's everyday life information seeking

Even though the focus of this dissertation is on information practices, the literature reviewed here includes studies on young people's information behavior and information practice. As pointed out by Savolainen (2007), the lack of consensus on the use of terminologies (information behavior vs. information practice) reveals the challenge of defining "the content and scope of information practice" (p.124). Yet, research on information behavior appears to be informative in developing an understanding of the information phenomena among young people, especially when there is a lack of research on young people's information practices.

Research on young people's information behavior is largely focused on information needs and information seeking, based on an assumption that information seeking is derived from cognitive gaps in one's minds. Examples of this type of study have investigated inner-city teenagers' everyday life information needs (Agosto & Hughes-Hassell, 2006), preteens' everyday life information needs (Meyers, Fisher, & Marcoux, 2009), children's information needs for innovative activities (Small, 2014), and middle school students' information needs and seeking in accomplishing assigned history projects (Beheshti, Cole, Abuhimed, & Lamoureux, 2015). These studies demonstrate that young people have a wide range of information needs, and their information seeking behavior is dependent on the context of their needs.

The research on young people's information seeking shows that they prefer human sources, such as friends, peers, classmates, teachers, and parents (Agosto &

Hughes-Hassell, 2006; Beheshti, Cole, Abuhimed, & Lamoureux, 2015; Meyers et al., 2009; Shenton & Dixon, 2003). Whether or not to access or avoid certain interpersonal sources is influenced by young people's perceived level of trust, prior experience, social relationships, and potential "social costs" of seeking information (Meyers et al., 2009, p.331). This percieved level of trust is connected to human sources' "social roles and social types" (Meyers et al., 2009, p.336), and these social types are categorized based on their convenience, comparable experience, and expertise (Shenton & Dixon, 2003, p. 221).

In addition, factors such as age, maturity, identities, personal background, prior experience, knowledge level, socioeconomic status, and motivation appear to play important roles in young people's information seeking (Agosto & Hughes-Hassell, 2006; Shenton & Dixon, 2003). Some factors that enable information seeking may also be barriers to young people, for instance, perceived level of trust and emotions. For example, Julien (1999) identifies that negative perception of sources, lack of trust in sources, institutional factors such as scheduling, and emotional factors all contribute to barriers in information seeking. Meyers, Fisher and Marcoux (2009) indicate that preteens' information seeking is hindered by parents and other adults' control over media access and expectation of certain behaviors, lack of trust with adults, and fear of "social costs" such as "embarrassment and loss of esteem" in seeking and sharing information (p.319).

While information behavior research focuses on information needs and seeking, studies on information practices shed light on other aspects of information activities, such as information sharing (Meyers et al., 2009), information use (Barriage, 2016), and

information literacy practices (Lloyd & Wilkinson, 2016). Common to these studies is the emphasis on how young people's information practices are naturally embedded in their everyday life and serve as a tool to achieve their social practices (e.g., Agosto, Magee, Dickard, & Forte, 2016; Lloyd & Wilkinson, 2016). Tweens use telephones, emails, and instant massagers to share information with their friends and peers, and use a shared family calendar to help them manage information (Meyers et al., 2009). Barriage (2016) shows that young children use information to create information artifacts and share that information with others.

Research on young people's everyday life information activities also involves activities in out-of-school environments and other informal educational environments. Meyers et al. (2009) find that libraries are viewed as a less common information sharing ground in young people's everyday lives (Meyers et al., 2009). In a recent study, Agosto, Magee, Dickard, and Forte (2016) show that while many young people view libraries as outdated and irrelevant to their everday lives, some of them say that the reason they go to libraries are for social interactions with their friends and peers. In Radford's (2006) report on a large-scale study in New York City that explores fifth and seventh graders' perceptions and experiences of visiting urban libraries, she finds that the most critical factor in their succcesful library visits is the attitudes of librarian and other staff members they encountered.

A review of existing studies on young people's everyday life information behavior/practice shows some common strategies of collecting data, including individual interviews (Agosto, Magee, Dickard, & Forte, 2016; Julien, 1999; Meyers et al., 2009), focus groups (Meyers et al., 2009), surveys (Barriage, 2016; Beheshti, Cole, Abuhimed,

& Lamoureux, 2015; Julien, 1999), and designed activities for data collections, such as drawing an "information horizon map" (Martin, 2012, p.384), and "Tween Day" designed activity (Meyers et al., 2009).

Summary of Section: Young people's information behavior/practice in everyday life. The studies reviewed in this section highlight the social nature of young people's information practices, contextual factors that enable and constraint their information practices, their use of technologies in managing and sharing information, as well as their perceptions of libraries in their everyday lives. However, compared to the studies on information seeking, other aspects of information practices (i.e., information use and sharing) in young people's everyday lives, as recognized in Savolainen (2008), have not received equal attention. In particular, the ways in which young people perceive the credibility and authority of information sources and the motives that enable information sharing remain unclear.

Further, literature on young people's everyday life information practices does not provide enough details regarding their information practices in creative works. Thus, to complement this identified gap in the literature, the following section reviews studies that are focused on young people's information practices in creative activities.

2.2.4 Young people's information practices in creative works

Research on young people's everyday life information seeking is mainly concerned with monitoring their mundane everyday lives and/or coping with life changes such as career decision-making (Todd, 2003). Hence, this body of literature does not address young people's information practices in creative works. However, with the development of Web 2.0 technologies (Dede, 2008), the maker movement and making

culture, and emerging calls for "connected learning" in the 21st century education (Ito et al., 2009; Siemens, 2005), more and more young people engage in do-it-yourself activities and in making their own creations, either in digital (e.g., Koh, 2013) or physical environments.

A small but growing number of studies in LIS have investigated young people's information related activities in the process of creation and innovation in digital environments (e.g., Harlan et al., 2012; Koh, 2013) and physical spaces such as libraries (Small, 2014). Harlan et al. (2012) studies seven teens' (aged 15-18) information practices in their experiences of creating digital contents in online communities. Three key information practices that are involved in their creative works include gathering information, thinking about information, and creating their content. Information is gathered to learn about an online community as well as the ways to participate in such a community, such as the expectations and rules of a community. Thinking practices, indicating the processes of using information and integrating information to their knowledge base. In creating practices, the teens engage in using information regarding tools and ideas to learn and to create. Harlan (2016) further suggests that these abovementioned information practices are building blocks for connected learning, reflecting its six principles: "peer supported, interest driven, academically oriented, production centered, shared purpose, and openly networked" (p.111).

Different from Harlan et al.'s (2012) report on information practices that includes ways to choose and learn about an online community, Koh (2013) focuses on twelve adolescents (aged 12-15) who are creating content in a particular online community – Scratch. According to Koh (2013), the adolescents engage in developing content,

organizing information, and presenting information artifacts. Emergent information practices include "visualizing, remixing, and tinkering" (Koh, 2013, p.1831), which appears to be in accord with the practices of coping, modeling, and composing in Harlan et al.'s (2012) study. Yet, Koh (2013) highlights young people's preference in visual presentations of information for its support in communication. While young people "seamlessly incorporate information in different formats in the digital environment," Koh (2013) indicates that the tasks at hand and their topics affect young people's choices of information format. Additionally, Koh (2013) highlights the emotional aspect involved in information creation – "sense of empowerment" (p.1831), suggesting that young people gain a sense of ownership and agency through their making and creating process that is enabled by digital media and tools in web 2.0 environments.

In exploring the motivations and information needs of young people from grade 4 to 8 in innovative activities, Small (2014) finds that websites, especially the sites found on Google, are ranked as the most useful information source in their creations. While these young participants recognize the importance of inquiring and information seeking in creative works, their skills in evaluating information sources are inadequate and sometimes flawed. Small (2014) thus points out the instructions on inquiring and evaluating information in STEM related creative activities would be beneficial for these young people, and further suggests opportunities for school libraries to take on to foster these skills.

Summary of Section: Young people's information practices in creative works. A relatively small number of studies have focused on young people's information practices in creative works, and within these studies, the focus has been placed on their

engagement with creating artifacts in online environments. Among these studies, semi-structured interviews were mostly used. The findings of these studies highlight young people's information practices as fundamentally shaped by the social context, emotions, and features of available technologies and media.

2.2.5 Collaborative information practices

Collaborative activities occur naturally in everyday life, work settings, and learning environments (Shah, 2014). They are embedded and interwoven with people's everyday life events, work practices, and learning activities (Sanna Talja & Hansen, 2006). These collaborative activities are characterized in several ways - synchronous vs. asynchronous, co-located vs. remote, implicit shared goals vs. explicit goals and different group sizes and dynamics (Capra, Velasco-Martin, & Sams, 2011). In the field of information science and some overlapping fields such as Human-Computer Interaction (HCI), Computer-Supported Cooperative Work (CSCW), and Computer-Supported Collaborative Learning (CSCL), a growing number of studies have investigated the collaborative aspects of information activities with varying scopes and perspectives, for instance, "collaborative information behavior" (e.g., Talja & Hansen, 2006), "collaborative information seeking" (e.g., Foster, 2006; Shah, 2014), "collaborative sensemaking" (Paul & Reddy, 2010), and "collaborative grounding" (Hertzum, 2008).

Reddy, Jansen, and Spence (2010) find differences in individual information practices in medical work, collaborative information activities often start with using information retrieval systems to find information as a starting point for subsequent collaborations. In their earlier study, Reddy and Jansen (2008) reveal some common features of collaborative information search strategies in three different settings -patient

care teams, information technology teams, and student teams. One commonality is that team members tend to search collaboratively for specific information with explicit information needs. Another commonality is in collaborative information seeking where interactions with information systems are not the only source of locating information. They conclude four "triggers" for collaborations, including "complexity of information need, lack of immediately accessible information, lack of domain expertise, and fragmented information resources" (p.78).

Similarly, Paul and Reddy (2010) explore the occasions and characteristics of collaborative sensemaking through investigating ways in which health professionals make sense of information together during a collaborative information seeking activity. According to them, "collaborative sensemaking" refers to the processes of synthesizing and understanding information together, which is another important aspect of collaborative information seeking, similar to how people "collaborate during the seeking, searching, and retrieval of information" (Paul & Reddy, 2010, p. 330). Paul and Reddy (2010) find three reasons that lead to collaborative sensemaking: situations when there is conflicting information in collaborative tasks, unevenly distributed information based on different roles, and inadequate knowledge and skills in certain aspects (Paul & Reddy, 2010). They further characterize collaboration in making sense of fragmented information. Their findings show that medical team members evaluate the relevancy of information related to their shared information needs and decide whether or not to share it with other members. As collaborative sensemaking takes place across time and people, it is beneficial for a team member to know what earlier steps were taken to make sense of a situation. Moreover, team members need to maintain "social awareness, action awareness

and activity awareness" in collaborative sensemaking (Paul & Reddy, 2010, p.328). According to Paul and Reddy, merely knowing who is doing what for the collaborative tasks is insufficient. To make sense of different pieces of information collaboratively, team members need to have a whole picture of the entire activity, including short-term and long-term actions and goals, as well as other sociocultural aspects such as “work practices, cultures, organizational structures, interpersonal relations” (Paul & Reddy, 2010, p.328).

In addition to understanding collaborative information practices, studies have also explored barriers in these practices. Karunakaran and Reddy (2012) capture barriers from the individual, team, technological, and organizational levels from different organizational settings. The findings show that the barriers at the individual level included personal attitudes, perceptions, and cognitions about themselves and others; barriers at the team level arose out of unclear work boundaries and conflicting schedules among team members; technological barriers were often caused by the lack of a particular technology or a function of a technology; and organizational barriers in collaborative information seeking were associated with organizational structure, culture, values and accepted practices.

A relatively small number of studies in LIS have focused on collaborative information practices in collaborative or cooperative learning tasks in formal educational settings. Often, these learning tasks are mandatory, assigned by teachers and/or researchers. Hyldegård (2009) applies Kuhlthau’s (2004) information search process (ISP) model to investigate the differences between group-based information behaviors and individual behaviors among three groups (10 participants) of LIS graduate students

over 14 weeks. She concludes that collaborative and individual information seeking are similar in that they both experienced the six information search stages that are described in Kuhlthau's ISP model. Similar to individual information search process, groups of students report their experiences of exploring information before a focus is developed, then searching relevant information as a focus is formed, documenting information and reducing search activities as they start writing their reports. Yet, Hyldegård (2009) argues that despite these general similarities between individual and collaborative information activities, the differences among the nature of their tasks and group dynamics have been identified. For these students, group work tasks contain both collaborative and individual activities.

In another study, Kim and Lee (2014) investigate information seeking and knowledge construction among graduate students who worked in teams for a research project. They identify several challenges that the students experienced in teamwork. Students find difficulties in finding specific information after dividing the workload. Another issue is information overload as team members keep sharing information throughout their information seeking and search process. Students also report difficulties in selecting, synthesizing, and organizing information throughout the tasks. Compared to individual learning tasks, the social interactions, such as negotiations and communications with other team members, affect one's overall experience in information seeking and search.

Summary of Section: Collaborative information practices. The literature reviewed this section shows that most studies have investigated collaborative information activities at organizations or medical settings. Comparatively, a small number of studies

in LIS have focused on collaborative information seeking and use in learning contexts, and these learning contexts tend to be formal educational environments where young people are given tasks. The findings in these studies show that collaborations are natural integral aspects of social or work practices. The social and contextual factors influence collaborative information activities. Sometimes social factors among group members may become a burden for collaborative information activities.

2.2.6 Summary of the gaps in the literature

The above sections have reviewed the existing literature on the topics of library makerspace, informal learning, young people's information behavior and information practices in everyday life and creative works, and collaborative information practices in general. The findings of these reviewed studies show that:

1) Young people's information practices are part of their social practices in participating in different communities and their social world, thus a narrow focus on what their information needs are and what sources they seek for information is inadequate to capture their practices where information is involved.
2) Studies have examined young people's everyday life information needs and seeking, without giving equal attention to information use and sharing, and other emerging information related actions.
3) Social and contextual factors influence young people's information practices in their everyday lives. Yet, the factors that influence their perceptions of credibility and authority of information have not been fully explored,

especially when they engage in free-choice activities in information-rich contexts (e.g., library makerspaces).

4) Studies have indicated that young people used available technologies and media to share information; yet, the motives that enable them to share have not received much attention.
5) Studies have explored young people's information practice in creations in digital environment. Yet, it remains unknown how they engage with information in environments (e.g., library makerspaces) where they have opportunities for digital and physical creations and how they move between these online and offline spaces fluidly. It is also unclear how technologies and materials within these spaces afford and constraint young people's information practices.
6) Studies have shown that collaborations are deeply embedded in people's information practices and social practices. Compared to the amount of studies in collaborative information activities in organizational or medical settings, little attention has been given to explore the collaborative aspects of young people's information practices in informal learning environments. Especially, little is known about when and in what circumstances to collaborate in young people's information practices in these environments.
7) Moreover, most empirical research reviewed in this section uses qualitative methods such as individual interviews and online surveys. While these methods have advantages in capturing in-depth data, they do not offer researchers an opportunity to actively engage with young participants in the

research process. To conduct research that actively engage young people may require non-conventional and innovative research methods.

Chapter 3 Methodology

3.1 Research questions

Following the above literature review (see Chapter 2), six research questions were developed to understand young people's participations, information practices, and collaborations in library makerspaces:

RQ1. What are the opportunities and desired outcomes, if any, that drive young people to participate in library makerspace activities?

RQ2. In what ways do young people seek, use, and share information to start and accomplish their makings as they participate in makerspace activities?

RQ3. What are the criteria by which they prefer some information sources to others?

RQ4. What are the motives of sharing information as young people participate in their makerspace activities?

RQ5. When and in what circumstances do young people collaborate in their information seeking?

RQ6. How do technologies and materials at makerspace afford and/or constrain young people's information practices?

3.2 Qualitative approach

To address these abovementioned research questions, this dissertation research takes a qualitative methodological approach to understand young people's information practices and collaborations as they participate in makerspace activities. Qualitative approaches are different from quantitative approaches in terms of underlying assumptions of reality, ways of collecting and analyzing data, and nature of findings, even though

"they are not fundamentally opposed" (Connaway & Radford, 2017, p.213). Qualitative approaches are usually characterized as having the strengths of studying natural and ordinary events that naturally take place in real-life settings, using multiple interactive and flexible methods to uncover the questions of how and why regarding the phenomena of interest, and developing a rich and holistic understanding of phenomena (Connaway & Radford, 2017; Creswell, 2003; Miles, Huberman, & Saldaña, 2014). As this dissertation research aims to collect rich and in-depth data from young people to reveal and unpack the complexity of their makerspace experiences and information phenomena during makerspace participations, qualitative methods appear to serve the purposes best.

Qualitative methods have been increasingly used in library studies and this trend is likely to continue (Connaway & Radford, 2017). The frequent use of qualitative methods is also seen in the studies of information practices and collaborative information practices that were reviewed in Chapter 2. Common to these reviewed studies is the use of qualitative methods such as observations (e.g., Sakai et al., 2015), individual interviews (e.g., Harlan, Bruce, & Lupton, 2012), focus groups (e.g., Sundin & Francke, 2009), and questionnaires (e.g., Kim & Lee, 2014). Connaway and Radford (2017) further confirm that "interviews and observations are among the most popular qualitative methods used in LIS research" (p.221).

Savolainen (2008) indicates that it is challenging to study everyday life information practices because of their routine and habitual nature. According to him, researchers might be "belaboring the obvious and describing just the surface of everyday phenomena as they appear" and "imbuing mundane practices with inappropriate complexity and/or significance" (p.5). To capture in-depth data and unpack young

people's perspectives on makerspace experiences, this study adopts a combination of different qualitative methods, including field observation, individual interviews that apply Flanagan's (1954) Critical Incident Technique, photovoice, and focus groups. The following table (Table 3) provides an overview of the goals, strengths, and limitations of each of these four data collection methods.

Data collection methods	Goals	Strengths	Limitations
Field observation	• To build rapport and sustain connections with the participants and the two makerspaces • To triangulate with interview data • To have a better understanding of the participants' self-reports	• Getting a better understanding and "here-and-now experience" of what happens in a naturalistic setting (Lincoln & Guba, 1985, p.273) • Generating questions to be addressed with the participants (Creswell, 2003; Gans, 1999; Kawulich, 2005)	• To what degree to be involved in participants' activities • Bias that researchers bring into observations (Kawulich, 2005)
Individual interview that apply the critical incident technique (Flanagan, 1954)	• To gain an in-depth understanding of young people's perspectives and experiences	• "Focus(ing) on the ways in which people make their experiences and choices accountable to themselves" (Savolainen, 2008, p.5). • Eliciting participants' experiences that are significantly meaningful (Radford, 2006)	• Bias brought by researcher (Connaway & Radford, 2017)
Photovoice	• To capture young people's perspectives	• Probing participants' memories, information, and	• Privacy issues (Julien, Given, & Opryshko, 2013)

	• To help young people talk more about their experiences	feelings that cannot be gained through traditional interviews (Harper, 2010). • Empowering participants as they can decide what photos to take, what meanings that these photos contain (Anderson, 2010) • Generating longer responses (Julien et al., 2013)	• Participants' unfamilarity in taking photos (Woodgate, Zurba, & Tennent, 2017)
Focus groups	• To capture incidents that are not mentioned in the individual interviews • To identify common themes and differences among participants	• Seeking "common features people exhibit when they construct their information practices" (Savolainen, 2008, p.5). • Observing interactions among participants (Morgan, 1996) • Informal environment to elicit more complete and rich data (Connaway & Radford, 2017)	• Bias that is caused by the make-up of participants • Potential withdrawal from discussion (Connaway & Radford, 2017)

Table 3: Goals, strengths, and limitations of the chosen data collection methods

As shown from this Table 3, each data collection method has its strengths and limitations. These methods can complement each other and provide triangulations for data analysis.

3.3 Selection of sites

This study is aimed to understand young people's information practices and collaborations in informal learning environments. The following criteria were considered

in selecting specific library makerspaces as the study sites: 1) Does the library makerspace meet the characteristics of informal learning where young people have the freedom to set their learning agenda and initiate their own interest-driven activity? 2) Does the library makerspace provide a range of different tools and technologies? 3) Does the library makerspace encourage both individual and collaborative activities taking place? 4) Does the library makerspace have a good number of visitors? 5) Does the library makerspace offer a variety of programs?

Based on these criteria and considerations, two library makerspaces in central New Jersey were selected for the pilot studies to assess the validity for this dissertation. Both library makerspaces also agreed to be study sites. These two library makerspaces are described in the following sections.

3.3.1 Site 1: Makerspace in a public library

The first makerspace is in a public library (see Figure 1) in a semi-rural township in New Jersey. The demographic of this township is characterized as young families with school age children and retired adults. This public library has departments for children and teen services, virtual branch, reserve, reference, public relations, interlibrary loan, circulation and bookmobile. The reasons for choosing the makerspace at this public library are listed as follows: 1) it was recommended by the makerspace facilitator at the Piscataway Public Library, which was the first makerspace opened in New Jersey, 2) it is close enough for the researcher to conduct field observations on a daily basis, 3) the library administrator and makerspace facilitators were willing to provide the researcher opportunities to conduct this doctoral study, and 4) the most important reason was that this makerspace is well-developed, vibrant and attracts many local residents.

This library makerspace mainly runs two types of programs. One type is a weekly theme-based program that runs an hour-long on Thursdays. Young people between eight to twelve years old can register for the programs in advance. There are a variety of themes and technologies involved in these programs, such as origami vibrating robots, sushi candles, Arduino training and practice, 3D modeling, pumpkin carving, LED lights, green screen movies, and building circuits.

Based on the makerspace facilitator's introduction, the weekly theme-based program is somewhat structured and instruction-oriented, in which the facilitator guides young people's activities of making. However, it is also informal because young people and their parents have the freedom and choice to sign up for the program on a weekly basis.

This public library makerspace also offers a volunteering program, which is less structured and informal. Young people can sign up for the volunteering program and utilize the resources at the makerspace to work on their own projects or to answer questions when library visitors ask about the 3D printers at the makerspace. Young people in this program are usually teenagers in a nearby high school.

Figure 1: Public library makerspace

3.3.2 Site 2: Makerspace in a middle school library

The second site is a makerspace located in a semi-rural public middle school (see Figure 2). The demographic of this school is 61% White, 24% Hispanic, 8% Black and the rest are Asian and multi-racial. According to the New Jersey Assessment of Skills and Knowledge (NJ ASK) Report for grade 4 to 8 from 2013 to 2014, the school's academic performance is high compared to other schools statewide. However, the school's college and career readiness lags behind compared to other schools in the state. This library makerspace was also recommended by the makerspace facilitator at the Piscataway Public Library and it is conveniently located for the researcher to conduct field observations and data collection. The school principal and librarians were supportive of this doctoral study. Another important reason in selecting this library makerspace was because of its multiple programs.

Based on the librarian's introduction, the programs at this makerspace include: 1) gifted + talented program for 4th/5th graders; 2) library recess/Maker Monday; 3) technology club that offers free choice, mixed age groups from 4th to 8th graders working together; 4) Lego Mindstorms, 5) brick buddies designed for a small group of 4th grade students with special needs and students from general classes, 6) several teacher-driven classes that also use makerspace resources, such as 8th/math - scale model, 5th/language arts - sentence crafting, 7th/poetry, 4th grade – circuits, and 7) NJ Maker Day.

Among all these programs, the technology club appears to be an ideal program for the researcher to further investigate because it allows free-choice and collaborative activities. The club is divided between two days – On Tuesdays it is for lower school (grades 4-5 only) and on Wednesdays it is for upper school (grades 6-8 only).

Figure 2: School library makerspace

3.4 Participants

The dissertation employs a purposive sampling strategy to recruit active adolescents between grades 6th to 10th at the school library makerspace and public library makerspace to elicit an in-depth understanding regarding the research questions. According to Miles, Huberman, and Saldaña (2014), purposive sampling is more appropriate for qualitative research as it allows researchers to pay close attention to one particular context in which samples are recruited. A small incentive (a $10 Barnes & Noble gift card) is offered to each participant.

3.5 Pilot studies

Two completed pilot studies were conducted prior to collecting data for the dissertation research. These two pilot studies are described in the following sections.

3.5.1 Pilot #1

Pilot #1 set out to assess the validity of the two sites, the theoretical framework, and the data collection methods. A total of 62 young people who participated in makerspace activities at the public library and school library were recruited for this pilot study. Participant gender are presented below in Table 4. Data on the participants' grades and ethnicities were not collected in Pilot #1.

Gender	School library makerspace	Public library makerspaces
Female	9 (15%)	15 (24%)
Male	13 (21%)	25 (40%)

Table 4: Participant demographics in Pilot #1

From September to December 2015, qualitative data was collected through video recorded observations, post-activity interviews that were informed by Dervin's Sense-Making theory (see Appendix 2 for interview questions), and Sense-Making surveys. Data was analyzed by the researcher in both a deductive and inductive way (Cheuk & Dervin, 1999) in Nvivo, with the first round of coding based on the key elements of Sense-Making theory – situations, gaps, gap bridging and use/helps, to elicit instances for these categories. Following that coding was the inductive constant comparison technique (Glaser & Strauss, 1967) to further generate emerging sub-categories.

3.5.1.1 Findings of Pilot #1

The findings from pilot #1 provided evidence that the two library makerspaces allowed young people to engage in informal learning experiences, hands-on explorations and experiments in creative works. Young people were allowed to define their own information seeking strategies in pursuing their various interests and needs during creation and production. Findings from the interviews and surveys revealed that challenging situations occurred in the initial designing phase and actual making process. The questions that young people had were centered on what to build in the initial

designing phase, how to build things in the discovery and making phase, and how to improve in their product refining and finishing phase.

This pilot study further describes the participants' information practices of seeking help from iterative trial and error, friends and peers, books and manuals, the makerspace facilitator and their intuition. When the participants were asked where they got help or information for their questions, many of them mentioned that they often engaged in iterative trial and error to find an answer. For example, one participant indicated: "We don't get any help. What we do is just, it's just a simple test, like trial and error." The participants often commented that they sought help from the makerspace facilitators and peers. Compared to the information seeking strategies among the participants at the volunteering programs, the young people at weekly theme-based programs tended to rely on the facilitator for information and answers. This may be due to the designed nature of these two types of programs – the volunteering programs are more towards the informal end of learning while the weekly theme-based programs are more towards the formal and instruction-oriented learning. Additionally, the findings show that informative resources helped the participants understand their troublesome situations and move forward with their makerspace activities.

3.5.1.1 Contributions of Pilot #1 to the dissertation study

Pilot #1 study findings are informative for this dissertation in three aspects. First, this pilot #1 shows that the public library makerspace and the school library makerspace are information-rich informal learning environments. This justifies the validity of using these two library makerspaces as an example of informal learning environment for this dissertation study.

Secondly, pilot #1 reveals the needs of revising the theoretical and methodological framework. Using the Sense-Making surveys with all open-ended questions appears to be inefficient for working with young people. When they were asked to recall the questions and challenges that they had after their makerspace activities, many of them tended to simply note that they did not have any questions and difficulties. Yet, from the researcher's field observations, these young people often asked questions and shouted out the problems they had. Additionally, this focus on young people's individual information needs revealed an inadequacy of using Dervin's (1992) Sense-Making as a theoretical and methodological framework. Other information activities such as information sharing were not captured when the researcher used Dervin's Sense-Making theory. Therefore, the theoretical framework was revised to better capture young people's information practices and the embedded collaborative aspects of these practices at makerspaces.

Thirdly, the weekly theme-based programs at the public library makerspace appear to be inappropriate for this dissertation. The main reason is because it cannot be defined as informal. In these programs, the librarian plays a role of instructor and guides young people's attention to certain technologies and content to use. Therefore, the researcher decided not to recruit young people from the weekly theme-based program at the public library makerspace.

Lastly, pilot #1 showed that adolescents initiate their activities by themselves and mostly engaged in self-directed activities. In comparison, children at the elementary school age indicate that they go to makerspace because they are asked to do. As the goal of this study is to understand information practices in informal learning environments, the

researcher decided to focus on adolescents from grades 6th to 10th for the dissertation study.

3.5.2 Pilot #2

Derived from the contributions of pilot #1, the researcher decided to replace Dervin's Sense-Making (1992) theoretical and methodological framework with a conceptual framework that sheds light on the mundane, situated, embodied, and distributed ways of knowing in everyday life. As a result, sociocultural approaches to learning were employed for this dissertation (see section 2.1.3). Pilot #2 was designed to test this updated conceptual framework and a visual method that may unpack the "hidden" aspects of practices, and evoke young people's reflections that are not captured in traditional verbal-based interviews (Clark-Ibáñez, 2004; Harper, 2010).

The visual method of "video-recorded reenactment" (Pink & Mackley, 2014) was employed to capture what young people normally do at makerspace while the researcher recorded it on a video camera. According to Pink and Mackley (2014), this method offers a new way to capture the participants' "*in situ* encounters with the material, affective, personal and political elements of everyday as lived and experienced" (p.146). They indicated that this video re-enactment method is more than just having the participants remember what they do, it "deal[s] with a performance that bridges the gap between representation and action" – "expressive ways of drawing on embodied resources and ways of knowing that are precisely part of who participants are, psychologically and physiologically" (Pink & Mackley, 2014, p.153).

Four participants at the school library makerspace were recruited for pilot #2. The grade, gender, and ethnicity are presented in Table 5.

6th grade	7th grade	Female	Male	Caucasian	East Asian	Latino
2 (50%)	2 (50%)	2 (50%)	2 (50%)	2 (50%)	1 (25%)	1 (25%)

Table 5: Participant demographics in Pilot #2

The participants were asked to show the researcher around the makerspace and re-enact what and how they usually do in the space, including the materials that they usually use and the areas where they usually go. The researcher held a digital video recorder and followed the participants around in the space. As the participants reenact and tell the researcher about their experiences, the researcher asks questions regarding how they experience the supports and limitations of different materials and tools during their makerspace activities. Detailed questions are in Appendix 3. The duration of this videotaping was approximately 5 to 7 minutes long. Four videos were selected from the upper school technology club to analyze. Videos were first transcribed and uploaded to Nvivo 11. The researcher followed the inductive constant comparison technique (Glaser & Strauss, 1967) in data analysis to generate emerging categories.

3.5.2.1 Findings of Pilot #2

Key information practices identified in pilot #2 show that young people engage in information sharing, ideas generating, help seeking, and information use in the activities of making. The participants engage in sharing information practices through the Lego shelf - an old bookshelf that is deliberately used for displaying Lego creations (see Figure 3). This figure also illustrates that cognition is distributed among Lego creations made by students who use the makerspace at a different time (e.g., lower school technology club and Lego club).

Figure 3: Lego shelf

Further, the participants get ideas and inspirations for makerspace activities from playing and observing, reading, imaginations, and serendipitous encountering. When the participants have problems, they engage in tinkering, and getting help from friends and the librarian. Perceived cognitive authority affects the participants' selection of information sources for help.

These activities highlight the interplay between participants and the materials available at makerspace, the space itself, computers, and their social interactions. The materials at the makerspace afford the participants ways to share their ideas, to play, to be inspired, to tinker, to imagine, and to build their identities. The makerspace itself provides a space for the participants to hang out with their friends, meet new people, and allows equal access to materials and games. With the computers available at makerspace, the participants could code, get ideas serendipitously, use existing knowledge, and design 3D models.

3.5.2.2 Contributions of Pilot #2 to the dissertation study

The findings of Pilot #2 study revealed the usefulness of sociocultural approaches to learning (i.e., situated learning, embodied knowing, and distributed cognition) in exploring the interplay between people, practices, technologies, and materials at the makerspace. Compared to pilot #1, the findings of pilot #2 depict a more holistic picture of young people's information practices and reveal the embeddedness of these information practices in their makerspace activities. Yet it is necessary to incorporate other theories to guide the research to focus on information practices and collaborative information practices. Based on these considerations, the dissertation study employs a bricolage of theories. In addition to the sociocultural approaches to learning, Savolainen's (2008) everyday information practices, and Talja and Hansen's (2008) social approach to collaboration, are applied in the dissertation study.

Additionally, the method of video recorded re-enactment data collection appears to be effective in capturing the locations, materials, technologies, and artifacts that these young people use and the ways in which they use them. However, this method appears to be insufficient in that some young people appear to be nervous when being videotaped by the researcher. Also, merely using this method to collect data is not enough to capture rich and in-depth data regarding their information practices and collaborations in their makerspace activities. Hence, for the dissertation study, methods that can give voice to young people were considered, along with other data collection methods to capture the how and why questions regarding their information practices and collaborations at makerspace.

To summarize, the findings of these two pilot studies justify the revisions to the conceptual and methodological framework and confirm that these two makerspaces are workable for the dissertation research.

3.6 Data collection methods

3.6.1 Participant observation

Participant observation has been often used in qualitative research in LIS, with different degrees of participation, including complete participant, participant as observer, observer as participant, and complete observer (Kawulich, 2005). The strength of participant observation includes building rapport with the participants and their community, helping researchers build a better understanding of what happens in a naturalistic setting and generating questions to be addressed with the participants and increase the validity and quality of data (Gans, 1999; Kawulich, 2005). According to Creswell (2003), active visiting to research sites allows researchers to develop an in-depth and detailed understanding about the people and place of research interest.

In LIS, researchers have used the strategy of field observation to understand a range of information phenomena, for instance, the use of digital services in community-based public libraries (Pettigrew, Durrance, & Unruh, 2002), information behavior in organizations (Solomon, 1997), everyday life information seeking (Markwei & Rasmussen, 2015) and collaborative information seeking (Paul & Reddy, 2010). Observations are necessary because participants may express what they expect to do in interviews, rather than what they actually do (Sakai et al., 2015). Additionally, it might be challenging for participants to tell researchers what they did in practice, so it is helpful to conduct both field observations and interviews (e.g., Reddy, Jansen, & Spence, 2010).

In this study, the researcher takes on the role of observer as participant, aiming to "observe and interact closely enough with members to establish an insider's identity without participating in those activities constituting the core of group membership" (Adler & Adler, 1994, p.380). There are different strategies in conducting observations, such as "descriptive observation," "focused observation," and "selective observation" (Angrosino & Mays dePerez, 2000, p.677). Lincoln and Guba (1985) point out that observations may start with being unstructured and become more focused as researchers gain some understanding of what is being observed. Several strategies to take observation notes, such as "running notes," "field experience logs," "notes of thematic units," "chronologs," "context maps," and "rating scales and checklists" (Lincoln & Guba, 1985, p.265).

Participant observation has its weakness in data collection. One challenge is for the researcher to decide to what degree to be involved in participants' activities, and another challenge is the bias that researchers bring into observations (Kawulich, 2005). To complement the shortcomings of participant observations, individual interviews that use the Critical Incident Technique (Flanagan, 1954), and the photovoice method (Harper, 2010) are included to triangulate the data collected from observations, which are further described in the following sections.

3.6.2 Critical incident technique

The Critical Incident Technique (CIT) has been used in interviews, surveys, and observations to elicit contextual rich information from participants (Flanagan, 1954; Radford, 2006). In LIS, studies using CIT have elicited participants' recent experiences that were significantly meaningful within a particular context, such as public library use

(Radford, 2006). Other LIS studies have used the CIT in their interviews to recall significant incidents of seeking health information (Yi, Stvilia, & Mon, 2012), successful and unsuccessful use of online information (Hughes, 2012), uses of Google in scientists' information seeking behavior (Jamali & Asadi, 2010), and journalists' latest critical incidents in their information finding practices (Jamali & Asadi, 2010).

According to Flanagan (1954), critical incidents are defined as "extreme behavior, either outstandingly effective or ineffective with respect to attaining the general aims of the activity" (p.327). The five main stages involved in using the CIT include "general aims, plans and specifications, collecting the data, analyzing the data, interpreting and reporting" (p.336-345). The stage of determining general aims of this study has been established in the previous chapters, along with the literature reviews conducted to identify what is known and unknown about the topic to be studied (i.e., young people's information practices at makerspace). In the second stage of planning to use the CIT, it is important to consider who the participants are, their age groups, and particular methods of data collection to be used (Radford, 2006). Even though in-person interviews are labor-intensive, they allow researchers to ask follow-up questions for clarifications, and in the CIT questions, one can ask the follow-up question of why that incident stood out as important, successful, or unsuccessful (Radford, 2006).

After the planning stage is the data collection phase, in which participants are asked to report their recent incidents as participants mostly like to recall the details, however, "adequate coverage cannot be obtained if only very recent incidents are included" (Flanagan, 1954, p.340). Davenport (2010) also reports the challenges of

having participants retrospectively recall an incident in their everyday life information seeking.

A strategy to overcome such limitations is to ask participants to describe their experiences in either recent or the past, as shown in Radford (2006, p.49). Flanagan (1954) provides a criterion to evaluate the coverage of incidents, which is to see if participants are able to give full and precise details regarding an incident, and further notes that once the main question is stated, interviewers should avoid asking any leading questions and show their trust in participants as experts. Overall, the CIT questions should be designed with a consideration of how they can provide answers for the study's research questions (Radford, 2006).

Sample size also needs to be considered during this data collection phase. The number of interviews and critical incidents collected vary, from eight participants with a total of 35 critical incidents (e.g., Wong, 2013) to 2416 participants and critical incidents in Radford's (2006) study of grade school children. According to Flanagan (1954), collecting 50 to 100 critical incidents would be a satisfactory starting point for some simple activity, and use further collections of critical incidents to test if new themes emerge. If the newly added incidents only lead to two or three new themes, then according to Flanagan (1954), it would reach an "adequate coverage" (p.343). As many researchers have pointed out, CIT is not used to make generalizations but to have a full coverage of a topic (e.g., Radford, 2006).

Following data collection, the next step is to analyze the data. Flanagan (1954) recommends strategies such as member checking, which has not been employed in many

ELIS studies (Davenport, 2010). Radford (2006) suggests involving more than one researcher in data analysis to enhance reliability of data analysis.

To address the research questions regarding young people's makerspace participations, information practices, and support and constraints of technologies and materials at makerspaces, a total of four pairs of positive and negative critical incident questions were developed to elicit rich and in-depth data from participants. These questions are listed as follows, which are also included in Appendix 4:

- [Positive Critical Incident Question] Tell me about your favorite time in the makerspace. What happened? Why was it your favorite?
- [Negative Critical Incident Question] Tell me about your least favorite time in the makerspace? What happened? Why was it your least favorite?
- [Positive Critical Incident Question] Remember a time, either recently or in the past, when you were able to find information that you were looking for and felt good about it? Tell me about this. Where did you find it?
- What is it about this time that makes you remember it as easy or successful?
- [Negative Critical Incident Question] Remember a time when you had difficulty in finding some information and did not feel good about it? Tell me about it.
- What is it about this time that makes you remember it as hard or unsuccessful?
- [Positive Critical Incident Question] Tell me about a time that you were working/playing/building something with someone else's help in the makerspace and it was fun. What happened? Why was it fun?

- [Negative Critical Incident Question] Tell me about a time that you were working/playing/building something with someone else's help in the makerspace and it was not fun. What happened? Why wasn't it fun?
- [Positive Critical Incident Question] Tell me about a time at makerspace that you used some technologies, tools, or materials that was very helpful for your making/playing/building. What happened? Why was it so helpful?
- [Negative Critical Incident Question] Tell me about a time at makerspace that you used some technologies, tools, or materials but it was not helpful at all for your making/playing/building. What happened? Why wasn't it helpful?

In addition to the individual interviews that apply the CIT, the researcher also applied photovoice as a way to elicit rich data from the participants. The method of using photovoice is described in the subsequent section.

3.6.3 Photovoice

Photovoice as a research method has been long used in ethnographic works since the mid-50s to probe informants' memories, information, and feelings that cannot be gained through traditional interviews (Harper, 2010). However, in LIS, this method has not been widely used, except for a small number of exceptions (Julien et al., 2013; Neurohr & Bailey, 2016).

Yet, these existing studies have highlighted the strengths of the photovoice method. One of the strengths is that the photovoice method gives participants a sense of empowerment as they can decide what photos to take, what meanings these photos contain, and responsibility to collaborate with researchers to achieve research goals to understand participants' perspectives (Anderson, 2010; Julien et al., 2013; Neurohr &

Bailey, 2016). Even with same or mundane objects, different participants may reveal different meanings of them (Neurohr & Bailey, 2016). This method further allows participants who might not be native English speakers to capture and express their understandings and experiences (Lloyd & Wilkinson, 2016). Compared to traditional interviews that do not include the use of photos, the photovoice method also enables participants to generate longer responses, as they might feel more relaxed and comfortable during interviews with the focus being placed on photos rather than themselves (Julien et al., 2013). In addition, the photovoice method has been used to evaluate programs from the perspectives of users, create partnership among community members, and provide feedback to policy makers within that community (Julien et al., 2013; Lloyd & Wilkinson, 2016).

In LIS, researchers have used the photovoice method to capture different aspects of information-related phenomena. For example, in understanding how library patrons perceive of a public library and their uses of library space, Neurohr and Bailey (2016) ask the participants to captures the objects "they used, liked, or that helped them" in an academic library (p.66). In another study that investigates how Native American college students perceive an academic library, Haberl and Wortman (2013) ask the participants to take photos of their most and least favorite places in the library, places in the library where they enjoy spending time, and inspiring places in the library. In Lloyd and Wilkinson's (2016) study, 15 refugee young people are asked to take photos of "types of information and information sources that were important to them and the places where that information was located" (p.304). In addition, the numbers of photos participants are asked to take also vary, for instance, unlimited amount of photos in Haberl and

Wortman's (2013) study, 15 photos at least in Neurohr and Bailey's (2016) study, and 5 photos in Lloyd and Wilkinson's (2016) study.

The photovoice method is usually coupled with a few pre- and post-meetings with the participants. Before participants start taking photos, it is important to have training and workshops regarding the usage of digital cameras and ethical issues involved in taking photos (Julien et al., 2013; Lloyd & Wilkinson, 2016). After participants complete the tasks of taking photo, interviews are conducted, either in the form of individual interviews (Haberl & Wortman, 2013; Neurohr & Bailey, 2016), or group interviews (Julien et al., 2013; Lloyd & Wilkinson, 2016). Short interviews with participants before discussing photos allow researchers to obtain some contextual information, which may help the researchers develop a better understanding of the participants and their photos (Neurohr & Bailey, 2016). Further, group interviews are often coupled with the photovoice method. Group interview is an effective way to enable the interactions among the participants, and allow them to identify common themes among all the photos shared by different participants(Julien et al., 2013; Lloyd & Wilkinson, 2016). Some other designs of using photovoice include having multiple meetings with the same participants, and ask them to delete one photo and rank their top photos, along with their explanations (Neurohr & Bailey, 2016).

The ways of analyzing photos are not always explicitly described in existing literature. Yet, some studies ask the participants to identify common themes and/or differences during focus group interviews, as a strategy to analyze photos and enhance the validity of findings (Julien et al., 2013; Lloyd & Wilkinson, 2016). Neurohr and Bailey (2016) compare photos across cases and utilized the concept of "pursuing

members' meanings" in data analysis to ensure the voices from the participants, instead of the researchers (p.61).

3.6.4 Focus groups

The research method of focus group has been employed in qualitative studies since the mid-1980s (Morgan, 1996). It can be used with a combination of other methods, including both qualitative and quantitative methods (Connaway & Radford, 2017; Morgan, 1996). Particularly in the field of LIS, focus group interviews have been used in academic, public and school library settings to explore a range of topics such as young people's attitudes and needs of library services (Connaway & Radford, 2017).

The focus group research has several advantages in collecting data. It is a technique that allows researchers to actively create an environment for participants' interaction (Morgan, 1996) and gives researchers an opportunity to observe the interactions among participants when discussing a given topic (Connaway & Radford, 2017). According to Connaway and Radford (2017), the lack of formalness in focus group may elicit more complete and rich data from participants.

On the other hand, limitations of focus groups include bias that stems from factors such as the composition of participants and the skills of the moderator (Connaway & Radford, 2017). Without careful moderation, some participants may feel unwilling to share and withdraw from group discussion.

In addition, location for holding focus groups should be selected in an open, quiet and friendly environment that encourages participants to discuss (Litosseliti, 2003). The length for a focus group should be one or two hours (Connaway & Radford, 2017).

3.7 Data collection procedures

Participant recruitment. At the beginning of December 2016, active adolescents participating in the makerspaces at both the public library and school library were purposefully recruited by the researcher. The researcher asked the makerspace facilitator to help recruit participants. Consent forms for young people and their parents were handed out by the researcher. The voluntary nature of their participation and confidentiality of their responses were emphasized and explained by the researcher at the research sites as well. To compensate for the participants' contribution and effort to this study, a $10 Barnes & Noble gift card was provided. The total number of participants was twenty-one, with ten from the school library makerspace and eleven from the public library makerspace. The researcher did not conduct additional rounds of data collection as theoretical saturation was reached by current collected data.

First meetings and interviews. The first meeting with the participants was conducted from the beginning of January 2017. In this initial meeting, the researcher collected adolescents' and parental consent forms. Once the researcher had the participants' signed consent forms and signed parental consent forms, the researcher conducted interviews with them. The individual interview schedule is included in Appendix 4. After the interview questions, the participants were asked to take photos based on the list of photo statements, which is included in Appendix 5. The usage of digital cameras or the researcher's cellphone camera was briefly illustrated, as the tweens and teens indicated that they were familiar with taking photos using digital cameras or cellphones. Ethical considerations when taking photos was the main topic of this initial meeting. The participants were reminded that people who were not participating in this study should not be captured without their permission (Julien et al., 2013).

Second meetings and focus groups. Four one-hour long focus groups with two at each research site were carried out after the researcher completed all twenty-one (100%) individual interviews and collected the photos from the participants. At the public library makerspace, the first focus group had five (24%) participants, and the second focus group had four (19%) participants. At the school library makerspace, the first focus group had five (24%) participants, and the second focus group had five (24%) participants. At the beginning of each focus group, the participants were reminded of the ground rules, such as taking turns to talk. The participants took turns to present their photos, described what each photo means, and why they took them. After one participant finished talking, the researcher asked follow-up questions for clarifications and other participants also expressed their comments, indicating similar and/or different experiences. At the end of focus group, the researcher let the participants have an open discussion on any of the photos the participants want to further discuss. The focus groups were audiotaped and transcribed verbatim by the researcher.

Field observation. Field observations were conducted between the weeks of conducting interviews and the weeks for focus groups. The researcher chose to apply the "focused observation" strategy, with a focus on the interplays of people, information related activities, technologies, and materials at makerspaces. More specifically, the researcher observed the participants' actions, such as joking with friends, asking questions, giving helps, problem solving, and sharing ideas, the use of technologies (e.g., computers and 3D printers) and materials (e.g., Legos and artifacts). During the field observations, the researcher used paper and pen to take notes with timestamps.

3.8 Ethical considerations

This study largely involves young people, thus ethical considerations are critical. Before carrying out any form of data collection, the researcher gave young people and their parents paper-based consent forms to sign. Only after acquiring the agreements from both the young people and their parents, the researcher started collecting data from them. A safe rule to follow, according to Corbin and Strauss (2008), is that "if you don't think you would like it, then the participants probably wouldn't like it either" (p.29). As shown from the pilot studies, some young people might feel nervous answering interview questions. The solution to reduce their levels of anxiety is to remind them that this is not a test and there are no right or wrong answers, and their participation is absolutely voluntary. The researcher reminded the participants if they wanted to stop at any step during the data collection, there was no penalty. All twenty-one participants were able to complete the interview questions without withdrawing. In addition, throughout the data collection and analysis, participants' privacy and confidentiality were protected by assigning pseudonyms (Corbin & Strauss, 2008).

3.9 Data analysis process

Data collection was conducted from January 2017 to May 2017 at the two selected research sites, one school library makerspace (SLM) and the other public library makerspace (PLM). Data sources include a total of fifteen field observation notes (nine from the SLM and six from the PLM), a total of 777 minutes of recorded interviews with an average of 37 minutes per individual interview, four focus groups that enriched with a total of 161 photos (71 photos from the SLM, and 90 photos from the PLM) taken the data collection of photo-elicitations. Examples for field observations and photos from the

photovoice method are provided in Appendix 6 and 7. The transcripts, field notes, and photos were imported to Nvivo 11 - qualitative data analysis software.

Data analysis was carried out at the end of data collection. However, while collecting data on a weekly basis, the researcher reflected on the experiences reported by the participants and identified salient and unexpected aspects of their makerspace participation, which were used to suggest questions that the researcher would ask in subsequent interviews and focus groups. The researcher transcribed the audio records of the twenty-one individual interviews and four focus groups and imported all the transcripts to NVivo for data analysis. As Charmaz (2006) states, data analysis that follows basic grounded theory guidelines in qualitative research pays close attention to "participants' meanings" (p.5) and "seeing the world through their eyes and understanding the logic of their experience" (p.54). The researcher strived to elicit and understand the meanings of the participants' self-reports in the interviews and focus groups from their perspectives.

The data analysis started with an initial round of open coding. During this first round of coding, the researcher followed the practice that Charmaz (2006) suggests, staying open and close to the data. As Charmaz (2006) points out, "it is *our* view: we choose the words that constitute our codes…nonetheless, the process is interactive…we try to understand participants' views and actions from their perspectives" (p.47). Thus, the researcher paid careful attention to understand what the participants said in the interviews and focus groups, and what was not said in their self-reports. In understanding what was left out in their self-reports, data from ongoing observations became especially helpful. For instance, when Mitch talked about his favorite time at the school library

makerspace, indicating that "got to play games and Ms. William was really nice about that." What left out in his account was that in the previous two semesters, the makerspace facilitator was very strict about what they could do at the makerspace. Playing games on computers was not allowed at that time.

In addition, in naming codes, the researcher was careful not to force any preconceptions and assumptions into the coding process. As Charmaz (2006) denotes, "preconceived theoretical concepts may provide starting points for looking at your data but they do not offer automatic codes for analyzing these data" (p.68). Naming the codes using gerunds helped the researcher stay away from adopting existing theories and stay close to the processes and actions in participants' self-reports. When analyzing the field observation notes, the researcher followed the principle of coding incident by incident, because the texts on these field notes were written by the researcher (Charmaz, 2006). During this initial coding phase, the researcher also had regular meetings with her adviser to check the fitness of the initial codes.

From the beginning of initial coding, the researcher also engaged in memo writing in Nvivo. An example of memo is included in Appendix 8. These memos captured the researcher's reflections on the connections, similarities, and differences between codes to codes, possible theoretical categories, and (conflictive) thoughts on the codes. *In Vivo* codes that used the participants' terms and "juicy quotes" were also highlighted and collected for further thoughts and analysis. An example of "juicy quotes" is included in Appendix 9. As data coding evolved, the memos started to reflect on some theoretical notions (Glaser & Strauss, 1967; Miles et al., 2014).

After the initial round of coding, some codes became more frequent and salient in the data, which led the researcher to conduct rounds of focused coding. Charmaz (2006) states that focused coding is an iterative, non-linear process. Miles, Huberman and Saldaña (2014) also suggest that researchers need to be flexible and ready to reconfigure existing codes when data shapes up. With each emergent focused code, the researcher closely read through the coded data and all other data to make sure the focused code could describe the data and identify other data that was not previously coded under a certain focused code. As a set of focused coding emerged, the researcher also developed axial coding (Charmaz, 2006), grouping codes as child-codes of a category that had potential to address the research questions. For example, codes for different ways of becoming informed in makerspace participation were grouped under the category of seeking information, as they showed different dimensions of seeking information. An example of the coding scheme is included in Appendix 10.

3.10 Trustworthiness

To ensure the trustworthiness of the data analysis in this dissertation, the researcher employs steps that run -through different aspects of the data collection and analysis. Lincoln and Guba (1985) suggest five activities that help naturalist inquires meet the criteria of trustworthiness. The first suggestion from Lincoln and Guba (1985) is to carry out "activities that make it more likely that credible findings and interpretations will be produced (prolonged engagement, persistent observation, and triangulation)" (p.301). These three activities are all seen this dissertation at different stages of data collection and analysis. Each of these activities are described as follows.

Lincoln and Guba (1985) point out "prolonged engagement" helps researcher to "detect and take account of distortions that might otherwise creep into the data" (p.302). Similarly, Miles et al. (2014) suggest spending as much time as possible at research sites to help avoid biases that are cause by the presence of researchers. Following these suggestions, the researcher spent approximately three semesters at both research sites since September 2015, sometimes only to visit and other times observing informally without any data collection. After obtaining the IRB approvals, the researcher conducted two pilot studies at these two research sites from September 2015 to December 2015, and March 2016 to May 2016. By the time the researcher recruited participants for the main study of this dissertation from January 2017 to May 2017, the researcher had built rapport and trust with many of the participants who had been involved in makerspace activities for a few semesters.

The trustworthiness of this study's data analysis comes from the strategy of triangulation in data sources (Creswell, 2003; Miles, Huberman, & Saldaña, 2014). According to Miles, Huberman and Saldaña (2014), triangulation helps researchers to "get corroboration from three different sources". Dezin (1978) indicates that triangulation can be achieved through the use of multiple "sources, methods, investigators, and theories" (as cited in Lincoln and Guba, 1985, p.305). Triangulation of different sources is the most common strategy (Lincoln & Guba, 1985). The researcher was able to triangulate the findings across the data collected from interviews, field observations, and focus groups that incorporated photovoice. When the findings were confirmed through the triangulation of other sources, they are reported as well in Chapter 4 Findings. For

example, in section 4.3.1.3, the finding on the practice of searching online is confirmed through triangulation of interview data, observations, and focus groups.

Chapter 4 Findings

This chapter reports the findings of the six research questions. All names reported here are pseudonyms, including twenty-one young participants, the librarians, and other educators who were mentioned during the data collection. Acronyms SLM (school library makerspace) and PLM (public library makerspace) are included after each participant's pseudonym name to indicate which makerspace the participant is involved in.

4.1 Description of participants

A total of twenty-one young people from both SLM and PLM were recruited for this dissertation. The grade, gender, and ethnicity are presented below.

Library makerspace	6th grade	7th grade	8th grade	10th grade	11th grade
SLM	4 (19%)	4 (19%)	2 (10%)	0	0
PLM	0	0	0	1 (5%)	10 (48%)

Table 6: Participant's grade by library makerspace

Table 6, above, lists the number of participants in each grade at the two library makerspaces. This data was collected in the individual interviews when the researcher asked the participants to introduce themselves.

Library makerspace	Female	Male
SLM	3 (14%)	7 (33%)
PLM	0	11 (52%)

Table 7: Participant's gender by library makerspace

Table 7, above, lists the number of participants for each gender at the two library makerspaces. All eleven participants from the public library makerspace are male, and only three of the ten participants from the school library makerspace are female. It was not the researcher intention to recruit only male adolescents; rather the researcher aimed to recruit active makerspace participants to elicit rich data. While at the SLM, there appears to be a balanced mix of both genders participating in makerspace activities, only

three female adolescents agreed to participate in this dissertation. At the PLM, when the researcher first started recruiting participants, only groups of male adolescents were active makerspace users.

Library makerspace	Caucasian	East Asian	Latino	Middle Eastern	South Asian
SLM	5 (24%)	1 (5%)	3 (14%)	1 (5%)	0
PLM	1 (5%)	1 (5%)	0	0	9 (43%)

Table 8: Participant's ethnicity by library makerspace
* The participants' ethnicities were identified by the researcher's observation.

Table 8, above, lists the participants' ethnicities that were identified by the researcher's observation.

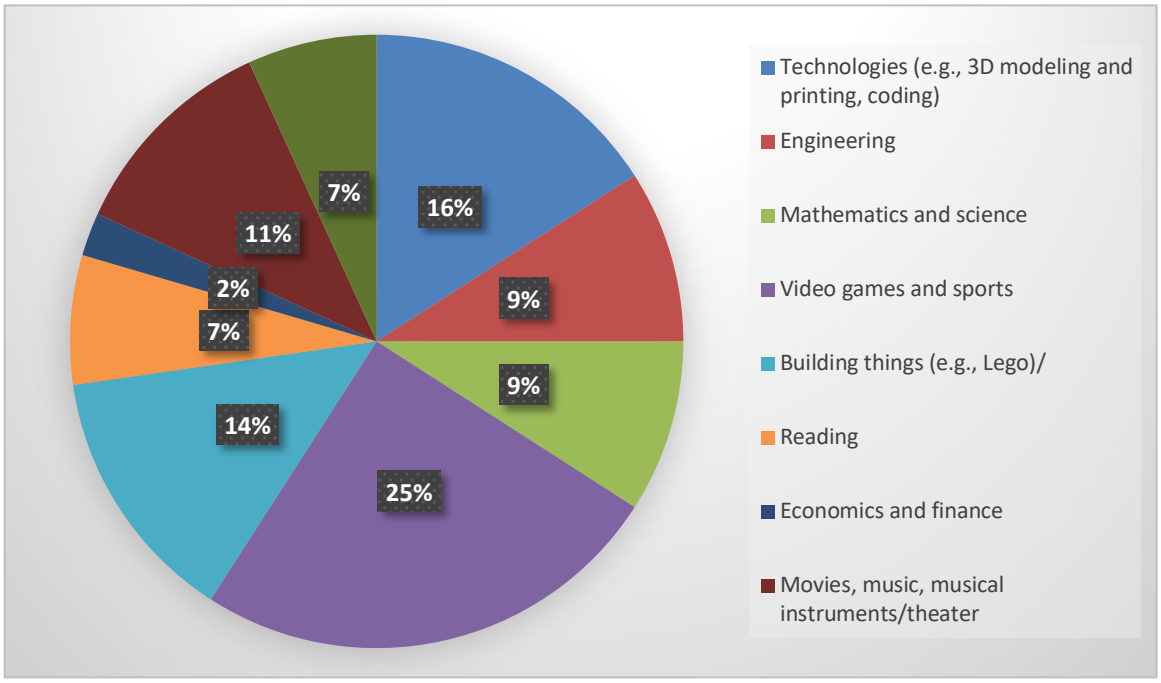


Figure 4: Participants' personal interests

Figure 4, above, shows the distribution of the participants' personal interests. This data was collected in the individual interviews when the researcher asked the participants to introduce themselves.

4.2 Opportunities and desired outcomes of makerspace participation

Section 4.2 addresses findings related to RQ 1: what are the opportunities and desired outcomes, if at all, that drive young people to participate in library makerspace activities? Data analysis shows that from the perspective of young people, the opportunities and desired outcomes of makerspace participation are centered on four major themes, in order of frequency of mentions by the participants: make, learn, social, and interests.

Each of these four major themes are discussed in sections 4.2.1 to 4.2.4, structured to first address the makerspace opportunities and the desired outcomes. As some of these twenty-one participants are driven to participate in makerspace activities for more than one perceived opportunity, the table below (Table 9) presents a distribution of identified opportunities among all the participants.

Participants	To make	To learn	To be social	To pursue interest
Katie (SLM)		X	X	X
Max (SLM)		X	X	X
Anna (SLM)	X	X	X	X
Ian (SLM)	X	X	X	X
Alan (SLM)	X	X	X	X
Mike (SLM)	X			X
Alice (SLM)	X	X	X	X
Daniel (SLM)	X		X	X
Mitch (SLM)	X	X	X	X
Alex (SLM)			X	X
Ryan (PLM)	X	X	X	X
Nathan (PLM)	X	X	X	X
Sam (PLM)			X	X
Kaden (PLM)	X	X	X	
Noel (PLM)	X	X	X	X
Neil (PLM)	X	X	X	X
Kal (PLM)	X	X	X	X
Ken (PLM)	X	X	X	X
Nick (PLM)	X	X	X	X
Adam (PLM)	X	X	X	
Travis (PLM)	X	X	X	X
Total	17	17	20	20

Table 9: Opportunities that drive the participants to use makerspaces
*Participant names are pseudonyms.

4.2.1 Make

The major theme *Make* describes the opportunity and desired outcomes pertaining to creating, (de)constructing, and building something—either tangible or digital—with the use of technologies, materials, and tools at the makerspaces. This major theme *Make* is the most frequently mentioned by the participants among all four themes. There are sub-themes under the *Make* major theme:

a) Opportunity: To make,

b) Desired outcome: Enjoyment, and

c) Desired outcome: Construction.

These sub-themes, along with important categories within them are discussed below in order of frequency, illustrated with quotations.

4.2.1.1 Opportunity: To make

This sub-theme, opportunity to make, refers to a hands-on opportunity where young people can freely create and build products, especially in tangible forms. Eighteen (86%) participants [eight (38%) from the SLM and ten (48%) from the PLM] report that they choose to participate in makerspace activities for the opportunity to make. They perceive the makerspace to be a place where they can create and build something of their own choice using a myriad of technologies, materials, and tools that are available at the makerspaces. For example, Mike (SLM) stated: “I guess the biggest reason is because I

want to create stuff using technology." [1]Alice (SLM) stated: "I like using my hands, and the 3D printer was really cool, there is like make designing something to fit like what you, if have envisioned in your mind and being able to have it and hold it." The opportunity to make something at the makerspaces is further characterized by the freedom and resourcefulness of the makerspaces. The participants also express their dislikes when this opportunity of making is interrupted.

4.2.1.1.1 Freedom to make

This category, freedom to make, is defined as the participants valuing the freedom, choices, and independence in making something at the makerspaces. Twelve (57%) participants [five (24%) from the SLM and seven (33%) from the PLM] indicate the makerspace is a permissive environment where they have the opportunity to make something of their own choice. Such makings range from low-tech to high-tech involvement, and have different purposes of productions. For example, Nathan (PLM) indicated: "Makerspace is a place where you could, you could create anything you want to, you could use the 3D printer to make your own design or find a design on your own and print it out, makerspace is where, basically it's for creativity and building." Mike (SLM) noted: "Here we are kind of more independent...have the independence and the ability of create our own design." Similarly, Daniel (SLM) stated: "You can literally just

[1] All the quotations are verbatim, and the grammatical mistakes have not been corrected by the researcher.

make anything you want as long as the place has the material… If you want, you can code, and we can design things for the 3D printer... it's more freely, we don't have a set guideline to do, we just do whatever."

The freedom in making at makerspace further shows its unique opportunity that formal school education does not offer. For example, Adam (PLM) indicated: "It's just your building, like you're doing what you want with it…With how many ideas we come up with, we can do 10 times more than what would they allow in an actual school class." Mike (SLM) stated:

> In a classroom…we have to follow the exact same things and do the exact same thing, and not have the independence and the ability of create our own design…over there, you might not be interested in a topic or you might not want to do it…then the students to join the makerspace, they have the ability to do whatever they want to do, and kind of work their way, so yeah over here, you don't follow certain steps, you get to create your own steps.

Similarly, Nick (PLM) indicated:

> Our school robotics operates under VEX. I just find VEX to be limiting and you can't really do what engineering really is…We can't really go on our own and do our own thing. We have to follow these rules and guidelines, only use these components. It's just very restricting…makerspace is building things on your own… makerspace is just trying to tackle things on your own. If there's a problem, you fix it. If you want something, you make it instead of going out and buying it. Basically DIY in the entire hacker community, that's all makerspace.

4.2.1.1.2 Resourcefulness

This category, resourcefulness, is defined as the participants wanting to make something at makerspace because of the availability of technologies, materials, tools, and funding for maker projects (Unique at the PLM). Nine (43%) participants [four (19%) from the SLM and five (24%) from the PLM] indicate that the makerspace provides them a resourceful space for them to make something that formal learning environments and home do not offer. For instance, Mike (SLM) indicated: "I have Legos at home, but I

can't, I can't 3D print something." Ryan (PLM) stated that: "Makerspace is like the hub of creativity so there is plenty of tools that one can use inside the makerspace, such as like I said before, the 3D printers, the 3D scanners, there is also new technologies that you can download on your phone and use in the makerspace." Travis (PLM) further noted:

> For our high school, there's not certain classes where you can build drones and other stuff, things you want to build. But here it allows you to do that…The library's able to fund most of our projects, even if they go over $500. A lot of, there's a lot of stuff you can do with a lot of money and space.

Nick (PLM) echoed:

> At the library here I can do things that I couldn't do at home. I can work on bigger projects here, like a drone. A drone is a pretty expensive project. At home I generally do more things that are more low budget and my parents are willing to pay for all the time. Over here it's more like, I can take more risks and do more.

4.2.1.1.3 Disruption to make

This category, disruption to make, is defined as participants feeling frustrated when the opportunity of making is disrupted. Five (24%) participants [two (10%) from the SLM and three (14%) from the PLM] emphasize that the opportunity to make and create something actively is important. For example, Alex (SLM) pointed out his least favorite time at the makerspace was when the opportunity to make was disrupted, as he indicates: "Like in the first day, a lot of talking, not really doing anything… there was nothing to do but I did understand everything." Kal (PLM) indicated: "That process [making budget sheet] normally takes a really long time. We are not really doing anything active. That's why it's my least favorite part." Nathan (PLM) stated:

> My least favorite time was the gap between our two projects was a huge gap, like we took like constant breaks that we don't get anything done, like we just go there and like there is no productive work being done, and then it's sort of a bumper because we were planning on doing things, and we just keep on pushing it back.

Overall, data analysis shows that the opportunity to make something attracts young people to engage in makerspace activities, which complements the opportunities the traditional classrooms provide. This opportunity to make something entails freedom in young people's creations in terms of choices to make and abundant resources to use, which further account for an inclusive makerspace culture. Not only do makerspaces provide young people the access to technological and financial resources, it is also a permissive environment in which young people decide what to do with these resources. For young people, it is desirable to have a space where they can freely express their imagination and ideas without having to follow rigid instructions, and without worrying about the consequences of following their own desires.

Statement of finding from section 4.2.1.1. to 4.2.1.1.3: Young people are drawn to the makerspace because of the opportunity of having freedom to make something with the availability of technological and financial resources. When the opportunity to make is interrupted, young people feel frustrated.

4.2.1.2 Desired outcome: Enjoyment

This sub-theme, enjoyment, is defined as the participants' pleasant affective outcome that they gain from making something at makerspace. All twenty-one (100%) participants [ten (48%) from the SLM and eleven (52%) from the PLM] indicate that their makings, doings, and creations at the makerspaces lead to some sort of personal enjoyment and excitement. When the participants describe their makerspace productions, a typical term that they used was "fun" or "cool". Alan (SLM) commented: "I was using the 3D printer to make a keychain…at the end it was really fun." Mike (SLM) further

highlighted that having fun as an outcome of making his own creations that downloading a 3D model online to print cannot achieve:

> When downloading something and have it printed out, it's not as fun as designing and taking the credit for it…the only thing you can do is to say I printed this, not I designed this, I created this…it's much fun and it's much better to say I designed this, I created this, and look at this, this is my doing…I created this myself, I worked for two hours to build it and when I printed it, it's so fun, it's amazing, and now, isn't it amazing?

Noel (PLM) stated: "My favorite time was when the catapult thing, when we actually did it, that was like the fun part, cause we finally got to see what it came out to look like." Kal (PLM) also commented on his enjoyment through makerspace participation:

> Whenever I do something, especially something in terms that's like considered work, I wouldn't do work that I don't enjoy doing naturally. So when I come here, I actually enjoy working on projects, and therefore, it's not actually work for me. It's just experimenting and having fun at the same time you're achieving success in innovation and sort of improving yourself.

Excitement is especially evident as an outcome when the participants experience problems in the process of making and put a lot of effort in to problem solving. Mike (SLM) stated: "I spent many hours working on this and I'm literally excited so when I came into the library I saw it finished, I was very excited to get it off...like getting a birthday present." Sam (PLM) commented: "It's satisfying to see something you have been working on for a while comes to life and actually works." Ryan (PLM) stated:

> We worked on the project for so long… so that was finally like the first time it worked, so it's just a great experience to see like wow our work finally paid off, just finally see the success, just to see like oh we put all those hard work and they finally paid off like our success is actually worth something.

Ken (PKM) also commented on how all the group members were excited about making the trebuchet successfully: "Everyone else was also happy and all my friends

around me. I just remember all their emotions, like everyone's cheering because it actually worked and we didn't know if it was going to work or not."

4.2.1.3 Desired outcome: Construction of products

This sub-theme, construction of products, is defined as the participants indicating the outcomes from creating and building something using technologies, materials, and tools. Twenty-one (100%) participants [ten (48%) from the SLM and eleven (52%) from the PLM] report an outcome of makerspace participation is constructing for tangible and digital products. Below, Table 10 illustrates a detailed list of the production outcomes. It shows that the majority of makerspace participation outcomes are tangible products rather than digital products. Even though 3D objects involve digital creations before printing out, the participants do not stop from just 3D modeling on computers; instead, having a physical 3D printout is the desired outcome.

Participant	**Tangible productions**					**Digital productions**
	3D modeling and printing	Lego/ Lego Pneumatics /K'Nex	Snap Circuits/ Makey Makey/ littleBits	Deconstruction	Various technologies, tools and materials	code.org/scratch.mit.edu
Katie (SLM)			"cool doorbell" (Snap Circuits)			"a smiley face with glasses" (code.org)
Max (SLM)	"little stick figure"		"a piano out of tinfoil and popsicles" (Makey Makey)			
Anna (SLM)	"a little house", "pencil box"	"a candy machine that took coins" using Lego;				

		"robot crane" using; (Lego Pneumatic)				
Ian (SLM)	"some stuff that I actually get to use"	"robots", "spaceship", "a mask" (Lego)				
Alan (SLM)	"a collage of continental place", "a keychain"	"a ship" (Lego) "a tower", "a car" (K'Nex)				"a pun game" (Scratch)
Mike (SLM)	"Burj Al Arab"					
Alice (SLM)	"chains", "costume piece", "something for my friend's birthday", "an old kind of airplane as a necklace"		"circuits" (Snap Circuits)			
Daniel (SLM)		"Japanese café" (Lego)	"a machine" (littleBits)	"memory chip"		"three snowmen that kept on getting smaller and smaller" (code.org)
Mitch (SLM)		"really big structure" (Lego)		"all the components"		"making my own game" (Scratch)
Alex (SLM)		"a giant Lego", "random things", "a mini spaceship" (Lego)		"tech parts"		
Ryan (PLM)	"a battle tank with the gun", "a catapult"					
Nathan (PLM)					"trebuchet" "drone"	

Sam (PLM)	"a small trebuchet"				"trebuchet"	
Kaden (PLM)					"trebuchet"	
Noel (PLM)	"something that could be useful"					
Neil (PLM)	"a clip for my bag"					
Kal (PLM)	"a tank…trenches that they used in World War I and II" "a 3D custom logo"					
Ken (PLM)					"robot", "trebuchet", "weather balloon"	
Nick (PLM)					"drone"	
Adam (PLM)					"drone"	
Travis (PLM)					"drone"	

Table 10: Products that the participants made

These makerspace productions outcomes are further characterized for two main purposes - for practical purpose and for play. Sixteen (76%) participants [five (24%) from the SLM and eleven (52%) from the PLM] show that their products are for useful and practical purposes. For example, Neil (PLM) recalled his experience of making an everyday object – a clip for his bag: "I use the 3D printer for my own purposes...It was kind of like a clip for my bag because the one on my bag had broken, so I 3D printed my own and put it on my bag and it was operational." Similarly, Alice (SLM) noted her creation for an everyday object – a phone case: "I was trying to make something useful, I was trying to make something that I could use every day so it was like phone case or something like that." Ryan (PLM) noted his desired outcome of making for his school

project: “I was able to design and create a tank to print for the project, and the teacher loved it… it allowed me to get a better grade.” Travis (PLM) showed how his group made a frame that helped them building a drone: “We don’t have to buy supplies from a source and that take time away from actually building anything. Here it’d usually take like, what’s it? Five hours, maybe, to build a part. And then we’re automatically right away we’re able to implement it.” Mike (SLM) indicated:

> I’m trying to convince my dad to buy a 3D printer, so everything that I 3D prints, I come back home and I show to him to make sure that I am able to convince him a little bit, maybe in the future, he’s still a no, but I think he is getting closer… cause I want to be able to make these things at home whenever I want during the summer.

Fifteen (71%) participants [ten (48%) from the SLM and five (24%) from the PLM] report that their outcomes of construction are for play and do not necessarily have any functional purposes. For example, Anna (SLM) noted that she made “a candy machine that took coins” and with her friends, “we’ve made like a little house, like about that tall…it was a little square house with a roof and a door that kind of stuff.” Max (SLM) remarked: “I’m making a piano out of tinfoil and popsicles.” Ken (PLM) indicated that with his team members, they built “a weather balloon.” Neil (PLM) indicated: “I can take things that are in my mind and put them into 3D object that I can hold and play around with.” Daniel (SLM) stated: “we were taking apart the computers…and we kept on asking to take home the memory chip, the memory drive, and she [Ms. William] finally said yes…it’s the coolest little thing and we got to take it home with us.”

Statement of finding from section 4.2.1.2 to 4.2.1.3: Desired outcomes of young people’s makerspace participation include making tangible products that are of practical

purposes and entertainment purposes, and gaining positive feelings such as enjoyment and excitement from hands-on creations and productions.

4.2.2 Learn

The major theme *Learn* describes the opportunity and desired outcomes pertaining to constructing new understanding and skills through makerspace participations. Data analysis shows that young people perceive the opportunity to learn, especially pertaining to technologies, at an informal learning place like makerspace. There are sub-themes under the *Learn* major theme:

a) Opportunity: To learn,
b) Desired outcome: Science, technology, engineering, art/architect, and mathematics (STEAM) knowledge,
c) Desired outcome: Real-life skills, and
d) Desired outcome: Career readiness.

These sub-themes, along with important categories within them are discussed below in order of frequency, illustrated with quotations.

4.2.2.1 Opportunity: To learn

This sub-theme, to learn, contains statements that refer to the participants seeing that they can get to know (more) about technologies. Fourteen (67%) participants [five (24%) from SLM and nine (43%) from the PLM] report that they perceive that the makerspace offers them an opportunity to learn about existing and emerging technologies, which motivates them to participate. Ian (SLM) indicated: “There’s so much things about tech that some people don’t even know, so that’s why so many people come to the makerspace to learn about it. I come to the makerspace to learn more about it

too." Ryan (PLM) commented: "I just really enjoy coming here, I feel like it's a great opportunity to increase my intelligence… learning new technologies, and just, it's great, a great opportunity to have." Likewise, Neil (PLM) indicated: "That was my motive in going there for the first time, learning other things when it comes to technology."

Three (14%) of these fourteen (67%) participants further indicate that the opportunity to learn about technologies at makerspace also means that they have choices to decide what to learn and the extent to which they are involved in learning. Neil (PLM) indicated: "Some people want to learn how a 3D printer works, and some people want even more than that. For those who want even more than that, it's great that the makerspace provides these options to learn more." Having choices in young people's learning activities also marks the difference between the makerspace from a formal classroom, as indicated by Nathan (PLM):

> Well for school it's boring, it's a forced thing, you are learning about the stuff that you don't want to learn about sometimes...school is a lot more pressure, you have to get grades, you have tests, you have to study, and pretty much school like it defines your future, like you need to get into a good college, all that, pressure on you, but makerspace is a place where the knowledge you get is all on you, you decide whether to use or not, and it's something you want to learn yourself, instead of being forced to do something.

In addition, Nick (PLM) commented:

> In our school it's very basic. It doesn't go into depth with electronics. It sticks to the basics, like what's this component? What does it do? As opposed to actually designing circuits and building your own. You don't do any of that in our school. It's just the basic overview subject of it…I'm usually explaining to the kids how things work. That's the reason that many kids joined this club. They want to learn about real electronics.

These accounts show that young people are motivated to learn something of their own interests and goals when they have choices. Compared to what young people can do

in environments where they have to follow rules, library makerspace provides them the opportunity to engage in free-choice learning.

Statement of finding: This study finds that young people are driven to participate in makerspace activities for the opportunity to engage in free-choice learning.

4.2.2.2 Desired outcome: STEAM knowledge

This sub-theme, STEAM knowledge, is defined as an outcome of makerspace participation in which young people consider themselves gaining new understandings pertaining to STEAM. Twenty-one (100%) participants [ten (48%) from the SLM and eleven (52%) from the PLM] report that they have developed an understanding of STEAM through participation at the makerspaces.

Technologies. Among these five domains, fifteen (71%) participants [seven (33%) from the SLM and eight (38%) from the PLM] identify that they learn technology-related knowledge, especially on 3D modeling/printing and coding at makerspace. For example, Alice (SLM) recounted:

> I didn't, I knew the 3D printer was here…I thought that it was just like something like the school can say oh we have a 3D printer…so she [the librarian] was showing the other kids how to make a chain, and I was like it was just a simple chain, it couldn't move, it was just like a block…and I said oh can you make something move and she said I'm not teaching that, I don't know how to do that, but if you want, you can figure it out, so I figure it out (laughter), and I actually printed out a couple of trials, and they all turned out pretty well, but I, like each time I got to make the chain better and better, and so I had set goal…so everybody in the play that I'm in is gonna wear, hopefully, wear a costume piece made from the 3D printer…so I'm going to make amount of codes for certain characters in the show…I'm almost done…and now I'm making something for my friend's birthday.

This account captures Alice's (SLM) transformation in makerspace participation within four months. She started off not knowing that she could use the 3D printer at all, and ended up being capable of making 3D designs for her friend's birthday, and costumes

for her school play. Similar participation progressions are evident in others' self-reports. For instance, after personally taking apart an old laptop, Alex (SLM) commented: "I finally understood how to work with the computers." Anna (SLM) recounted: "I didn't know coding that much before I came here…so code is the main thing I have learned here." Kal (PLM) indicated: "When I first started here at makerspace, I wasn't completely sure what 3D printing was. Now I know what 3D printing is."

Mathematics and Science. Knowledge of mathematics and science is another outcome of participation that is reported by seven (33%) participants [two (10%) from the SLM and five (24%) from the PLM]. For example, Nick (PLM) stated: "I've learned a lot about electronics, just by doing it instead of reading about it. That's how I've learned it." Kaden (PLM) indicated: "Like when we are going to build this space, the drone that is going to space, now that we are learning physics, we would be understand it better and we could just put it into physics and put physics into this, so like understanding why it's going off and what heat can do this and that."

Engineering. Four (19%) participants [four (19%) from the PLM] report that they learn engineering-related knowledge from makerspace participation. For instance, Ryan (PLM) commented: "I also believe that my intelligence level in areas such as computers and graphic design and mechanical engineering improve because all that stuff is included at the makerspace."

Arts and Architects. Two (10%) participants [both (10%) from the SLM] indicate that they learn about art and architectural design as a learning outcome. Alan (SLM) noted: "It kinda helps me in art class. It kinda helps me draw new things that I

have never drawn before." Mitch (SLM) remarked: "Like playing the Legos helps us know architects and stuff."

Overall, the participants report that they learn a great deal of STEAM related knowledge and experience, which further contributes to their building of identities as a STEAM person. For example, Kal (PLM) states:

> Just getting more involved with makerspace helps me identify as a STEM person because you get to learn more about it. Whenever somebody asks you, "Hey, what do you learn at Studio M?" I'm able to tell them everything that I learned. If I never did it, if they asked me, "Why do you classify as a STEM person?" I'd just be like, "I don't know. I like math?" You get the difference?

4.2.2.3 Desired outcome: Real-life skills

This sub-theme, real-life skills, is defined as a desired outcome of makerspace participation in which young people gain experiences and capabilities in real-world situations. Seven (33%) participants [three (14%) from the SLM and four (19%) from the PLM] indicate that it is a desired outcome of makerspace participation where they can apply what they have learned from school and makerspace to real-world contexts. For instance, Kaden (PLM) indicated: "It [makerspace] is not going to help you as much in any specific subject, but more like life skills." Mitch (SLM) remarked: "Working like playing here allows you to learn about tech stuff and then apply it to real world." Kal (PLM) recounted: "You actually learn about real life experiences…you get to actually apply the knowledge that you learn from school." Nathan (PLM) provided two examples where he and his friend Sam applied the skills learned in the makerspace to build something at their homes, as he indicates:

> It was a little difficult like having to learn how to drill stuff, and chop woods, and stuff like that, but in that process, we were able to learn and become more efficient at that sort of work, so it helps us a lot…I give you an example, after Sam was able to make the trebuchet, he made a bookshelf all by himself… it

> applies like into your own ways… I was helping my parents to put some cabinets back together.

4.2.2.4 Desired outcome: Career readiness

This sub-theme, career readiness, is defined as an increased sense of preparation for possible future careers through makerspace participation. Five (24%) participants [two (10%) from the SLM and three (14%) from the PLM] report that that they feel prepared for future careers and foresee a connection between makerspace and their future careers of interest. For example, when responding to the researcher's question on the goal of makerspace participation, Mitch (SLM) stated: "I probably will get a job in computer or engineering or tech design or graphic or video games stuff like that." Max (SLM) recounted: "It is basically like it connects to the future maybe like in a career you need to do those stuff to yourself and then basically looking forward to a career in technology." Noel (PLM) denoted: "I just wanted to get like activity or something that helps me, so that [makerspace] helps me basically my college and career."

Statement of finding from section 4.2.2.2. to 4.2.2.4: Desired outcomes of makerspace participation include constructing new or in-depth understanding in STEAM, developing skills that are grounded in real-life situations, and gaining a sense of career readiness.

4.2.3 Social

The major theme *Social* describes the opportunity and desired outcomes regarding interactions and involvement with other people at the makerspaces. There are sub-themes under the *Social* major theme:

a) Opportunity: To be social,

b) Desired outcome: Enjoyment,

c) Desired outcome: Teamwork, and

d) Desired outcome: Friendships.

These sub-themes, along with important categories within them are discussed below in order of frequency, illustrated with quotations.

4.2.3.1 Opportunity: To be social

This category, to be social, is defined as the opportunity for young people to spend time together with their friends and peers. Thirteen (62%) participants [six (29%) from the SLM and seven (33%) from the PLM] report that they choose to participate in makerspace activities because they want to spend time working or playing with their friends and peers, and makerspaces provide them a convenient venue for social interaction. For example, when responding to the researcher's question on what drove them to participate in makerspace, Ian (SLM) indicated: "First of all it was because my friends are here, this is one of the places that I can talk to them." Alice (SLM) stated: "My friends are mostly why I joined the makerspace. I really like my two friends here." Similarly, Sam (PLM) commented: "Just like hanging out with my friends and stuff so the [makerspace] is a way we get to communicate or we don't have to somewhere to meet up, we just meet up at the library." Ken (PLM) noted: "Just because all my friends do it too, so it's like you hang out with them at the same time."

Statement of finding: This study finds that young people choose to participate in makerspace activities for the opportunity to hang out with friends and peers and makerspace provide them a convenient venue for such social interactions.

4.2.3.2 Desired outcome: Enjoyment

This sub-theme, enjoyment, is defined as a desired positive affective outcome where young people experience pleasure through hanging out with their friends and peers. Eighteen (86%) participants [eight (38%) from the SLM and ten (48%) from the PLM] report that having fun is desirable when hanging out and working together with their friends and peers. For the participants, it is important that they get to both hang out *and* work together with others at the same time to achieve enjoyment and fun, as indicated by Nathan (PLM): "Working with my friends obviously makes it more fun." Having fun is a typical term that the participants use when they describe their experiences that involve other people. Adam (PLM) stated: "It's just fun to hang out and talk and actually make stuff." Ken (PLM) noted: "It's just a fun experience because we're hanging out with friends. At the same time we're working on a project." Ryan (PLM) stated: "It's fun for me because I'm friends with him, so it's great to interact with someone that I already know and to be able to spend more time and work with him on something that we both are very passionate about."

Further, for Anna (SLM) and Ian (SLM), the outcome of makerspace participation was the most enjoyable time at school. Anna (SLM) denoted: "I mean usually it's always fun, I love coming here like Wednesday is the highlight of my week and the makerspace that I got to hang out with my friends and work on the computers." Ian (SLM) indicated:

> Basically these good times actually prove that I actually got to hang out with my friends, I actually had a good time at the makerspace, I actually had the best time, like actually in school, like during the school building, and that would be actually the best time, cause like I actually got to hang out with my friends, I actually got to do things that I actually love but I can't do it at home.

Even when the participants encounter problems and barriers in their makings, having fun remains as a desirable outcome. Adam (PLM) recalled a time when his other

group members "did the wrong thing" and they had to "redo the whole thing". However, he indicated: “It was good because we all got talking, it was fun, we were making jokes like, ‘aw look at this’. It was just, I guess it was just like light-hearted poking at each other and made the day a little better instead of like ugh we have to do this all over again.”

4.2.3.3 Desired outcome: Teamwork

This sub-theme, teamwork, is defined as a desired outcome that young people identify when they gain experience of working with others effectively and fairly. Twelve (57%) participants [four (19%) from the SLM and eight (38%) from the PLM] indicate that they gain valuable experience of working with other people effectively and fairly in accomplishing common goals at makerspace. For example, Kaden (PLM) stated: “Teamwork is gonna be a huge thing in life, so it just helps us learn teamwork… we do learn more teamwork-based stuff.” Desired teamwork experience is further reflected in two aspects: gaining leadership and fair play.

Leadershi Leadership is conceptualized here as a desired skill to motivate and work with others in reaching a common goal in makerspace activities. Ten (48%) participants [three (14%) from the SLM and seven (33%) from the PLM] indicate that they expect to gain leadership and improve leadership skills through makerspace participation. For instance, Ken (PLM) stated: “By participating in makerspace activities, I hope to like gain a leadership role... I want to learn how to be a better leader and how to like delegate tasks to people and how to get them to do something. That’s what I want to gain from makerspace.” Nick (PLM) also pointed out that gaining leadership is important for him, as he indicates: “This [makerspace] is more institutionalized so I can get

leadership, stuff like that, as opposed to just being a hacker on my own." This statement shows that makerspace provides young people a structure for a visible recognition by others.

Among these ten (48%) participants, four (19%) of them [two (10%) from the SLM and one (5%) from the PLM] indicate that they practice leadership through negotiating with their friends and peers about the roles that they take on for a shared project. These participants report that they take on leadership roles spontaneously without the librarians assigning them any divided workload and role. For example, Anna (SLM) stated:

> We built this robot crane as a group of three, me, Mara, and I think someone else, and you know, we each had a job, one found the part, and the other one kinda helped both of us… I mean we are all good friends, so one person just said 'oh I will find the parts', and the other just said 'oh I'll help you both', that kinda.

Similarly, Adam (PLM) stated:

> When we noticed that this wasn't working correctly, so he [another team member] was like 'okay I'll look it up and you keep trying'. So I kept trying, he looked it up, then we looked at the pictures again. It was like a process of like 'okay you do this, I'll do this' and then we just came together, we're like 'okay this is wrong' and we kind of just team-worked it out.

Fair play. Fair play is conceptualized here as everyone contributing equally in accomplishing shared goals in makerspace activities. Seven (33%) participants [seven (33%) from the PLM] indicate that it is desirable that everyone in the team could take a fair workload. Kaden (PLM) noted: "We shouldn't put hard things on people just cause we don't like them or not, so just like split equally to instead." Nick (PLM) indicated that his project of building a drone could not be done without other peers' fair contribution, as he commented:

> Some of the soldering work and some of the assembly work can't be done with one person and I need help doing it. That why, just having people, more hands doing helps accelerate it. They've all done that. They've all been there, just spread the work out evenly and take some of the burden off my shoulders. They've definitely all done that.

In addition, Ken (PLM) indicated it was important to make sure that every team member could contribute fairly when considering what team project they wanted to do, as he recalled:

> There's one kid who did and he probably could have created a drone, but it was just one kid who would have had to dominate, just lead the whole group… it wouldn't have been fun for all of us, so we didn't do that. We ended up doing a weather balloon, because it's something that we can all do… so basically it involves a lot more kids and so that's the reason we chose it.

These accounts show that fair play is the other aspect of desired teamwork outcome at makerspace.

4.2.3.4 Desired outcome: Friendships

This sub-theme, friendships, is defined as newly established relationships with others or strengthened relationships with existing friends. Ten (48%) participants [six (29%) from the SLM and four (19%) from the PLM] indicate that they want to make new friends, to know their acquaintances better, and to sustain existing long-time friendship throughout the makerspace participation. Ian (SLM) responded: "I actually made a new friend… apparently now my good friend." Similarly, Kaden (PLM) noted that he got to know his peers better through makerspace participation: "Like the first day I only knew half of people, I knew everybody here but some of them are just like a name to name basis, so since we have to be with each other for a good amount, we just, like it just got a bit closer."

Two (10%) of these ten (48%) participants [one (5%) from the SLM and one (5%) from the PLM] describe their makerspace outcome as sustaining a long-time partnership with their friends. Anna (SLM) indicated: "Mara and I go to the mini-mart and get a snack, and we come here, grab the computer or whatever Ms. William assigned us and then you just have fun doing it...I have been doing it for the longest time, me and Mara have been doing it since like the 4th grade." Similarly, Adam (PLM) indicated his partnership with his friend Nick over years on maker projects. He commented: "I knew him from like seventh grade when I moved here", and "with Nick, we used to just do stuff. Like he maybe had a few projects, and I'd just help him out with one or two things." Their partnership of making projects together has carried over to the library makerspace.

Statement of finding from section 4.2.3.2 to 4.2.3.4: Desired outcomes of makerspace participation include having fun and enjoyment though social interactions, gaining teamwork experiences, and building new relationships with others or sustaining long-time friendships.

4.2.4 Interests

The major theme *Interests* describes the opportunity and desired outcomes at makerspace that pertain to young people's engagement with individual curiosity and attention. There are sub-themes under the *Interests* major theme:

a) Opportunity: To pursue interests, and

b) Desired outcome: Interests triggered.

These sub-themes, along with important categories within them are discussed below in order of frequency, illustrated with quotations.

4.2.4.1 Opportunity: To pursue interests

This sub-theme, to pursue interests, is defined as an opportunity of makerspace that young people perceive where they can engage their curiosity. Seven (33%) participants [ten (48%) from the SLM and seven (33%) from the PLM] report that they choose to participate in makerspace activities because they see the opportunity to engage with some of their personal interests. These personal interests include technologies, engineering, mathematics, science, building/taking apart things, video games and sports, music and theater, economics and finance, reading, and general club activities (see Figure 4, p.73).

For instance, Travis (PLM) noted the reason for him to go to makerspace: "We just like engineering in general, so we like building stuff. That's why." Noel (PLM) indicated: "Since this is related to technology stuff and engineering related, I'm interested." Similarly, Max (SLM) indicated: "I was pretty interested in technology and I just wanted to see what the deal was." Further, Anna (SLM) noted:

> I love everything engineering, and I actually applied to an engineering high school…I really want to do engineering stuff as I grow up so that's like my number one thing…When I was little, my parents bought me, you know, the starter set of Legos and stuff like that. I just love building with them and then once I got older, I started building like working like a candy machine that took coins and all that stuff. And I love working with my hands and thinking like that so, yeah.

Nick (PLM) indicated that his strong interests in engineering could not be met at school, so he chose the library makerspace to sustain and develop his interests, as he stated:

> I really like electronics. It's my hobby. I build stuff at home. I've been making things since I was a little kid. When I started off as a little kid, I used to play with Legos a lot. From there, it could be when I was around 12, it became electronics, and I've been doing that ever since.

Daniel (SLM) stated: “Cause last year the computer class we went on the coding website and I was really interested in it and I wanted to see more about it.” These accounts show that the makerspace is inclusive in terms of meeting young people’s diverse levels of interests.

Statement of finding: This study finds that young people choose to participate in makerspace activities for the opportunity to engage with diverse personal interests, which center on some key areas listed in Figure 4 (see p.73).

4.2.4.2 Desired outcome: Interests triggered

This sub-theme, interests triggered, is defined as new curiosity on something that young people never experienced before but have become aware and now pay attention. Eleven (52%) participants [six (29%) from the SLM and five (24%) from the PLM] report that they have new interests triggered through makerspace participation. Often these new interests are generated when the participants interact with something that they have never done before. For example, Alex (SLM) indicated: "I really like experiencing this kind of stuff which I have never experienced before." Max (SLM) stated: “I thought it was pretty interesting when I first learned about it.” Mitch (SLM) indicated his activity of taking apart an old laptop “sticks to my brain because it’s really really cool and interesting, something that I have never actually did before.”

Other interests that are triggered through makerspace participation include 3D printing, makings and building things, coding, and science. Six (29%) participants [five (24%) from the SLM and one (5%) from the PLM] report their emergent interests on 3D modeling after makerspace participation. Max (SLM) indicated: “Like when the first time, when I was making something, I realized all the cool stuff, you could zoom in zoom

out, you can change the angles of a shape… I think 3D printing is kinda cool." Ian (SLM) commented: "the teacher, she asked me if I wanted to do 3D printing, so I got interested in that."

Nathan (PLM) commented: "Well my initial reason for joining was I needed volunteer hours, and then after that I started enjoying the area, like I found interested in making things and the whole creative outlet, it's just interesting." Katie (SLM) noted: "When I first learned how to code, I thought it was the coolest thing ever, because I literally never seen anything like it, so I thought it was super cool, and I would probably do it more often now that I know about it and practice to get better." Ryan (PLM) indicated: "I also feel that my interest in science increases."

The participants' accounts show that these newly triggered interests further encourage the participants to engage in makerspace activities. However, one participant showed that his initial interest waned, as Sam (PLM) indicated:

> See, at first I found the 3D printer is really cool, I still find it cool but I have used it so much to this point that there isn't something I really want to print anymore unless it's towards projects or some stuff, but I know a lot of people go and print stuff, so I just go there to try to see if anyone needs help and volunteer, and then most of the time I go to makerspace now is to do BETA with all the clubs, so that's it… I just like hanging out with my friends and stuff so the club is a way we get to communicate or we don't have to somewhere to meet up, we just meet up at the library, work together and hang out.

This example shows that when interests are triggered but not sustained successfully, other opportunities such as the opportunity to make and to hang out with friends become the motivations.

Statement of finding: This study finds that through makerspace participation, young people develop new interests on STEAM related areas. Yet, not all emergent

interests are necessarily sustained through participation, in which young people are motivated to participate for other opportunities such as to hang out with friends.

4.2.5 Summary of RQ1

This study finds that:

Make:

a. Young people are drawn to the makerspace because of the opportunity of having freedom to make something with the availability of technological and financial resources. When the opportunity to make is interrupted, young people feel frustrated.
b. Desired outcomes of young people's makerspace participation include making tangible products that are of practical purposes and entertainment purposes, and gaining positive feelings such as enjoyment and excitement from hands-on creations and productions.

Learn

c. Young people are driven to participate in makerspace activities for the opportunity to engage in free-choice learning.
d. Desired outcomes of makerspace participation include constructing new or in-depth understanding in STEAM, developing skills that are grounded in real-life situations, and gaining a sense of career readiness.

Social

e. Young people choose makerspace as a convenient venue to hang out with friends and peers.

f. Desired outcomes of makerspace participation include having fun and enjoyment though social interactions, gaining teamwork experiences, and building new relationships with others or sustaining long-time friendships.

Interests

g. Young people choose to participate in makerspace activities for the opportunity to engage with diverse personal interests.

h. A desired outcome of makerspace participation is to develop new interests on STEAM related areas.

4.3 Seeking, using, and sharing information in makerspace activities

Section 4.3 addresses three research questions:

RQ2: in what ways do young people seek, use, and share information to start and accomplish their makings as they participate in makerspace activities?

RQ3: What are the criteria by which they prefer some information sources to others?

RQ6: How do space, technologies, tools, objects, and artifacts at makerspace support and/or constrain young people's individual and collaborative information practices?

Data analysis shows that young people's information practices of seeking, using, and sharing at the makerspaces are largely social oriented and embedded in the activities of making, learning, hanging out, and pursuing interests. The following sections are

structured to first describe the participants' practices of information seeking, then information sharing, and lastly using information.

4.3.1 Seeking information

This major theme, seeking information, is defined as the participants' active actions of looking for an answer or help in order to accomplish their tasks at hand. Data analysis shows that young people's practice of seeking information in makerspace participation is composed of using self as a site of information (section 4.3.1.1), asking (section 4.3.1.2), searching (section 4.3.1.3), and learning (section 4.3.1.4). The table below provides an overview of the practices of information seeking and use. The following subsections describe each of these practices.

Seeking information practices		Uses	Outcome/Criteria
Self	• Tinkering	• To make/To solve problems	• Construction of products/Satisfaction
	• Sensing	• To make/To know/To solve problem	• Construction of products/designing/understanding
	• Imagining and improvising	• To create	• Construction of products/Having fun
Asking	• Asking librarians	• To get help • To get instruction • To get permission • To get material	• Perceived expertise • Perceived authority • Friendly relationship • Perceived resourcefulness
	• Asking friends	• To get help • To engage in group activity	• Perceived expertise • Proximity • Perceived authority
	• Asking other human sources – computer teacher, parents, online experts	• To make/To solve problems	• Perceived expertise
Searching	• Looking up electronic information from the Internet	• To figure out how to make something	• Perceived authority • Firsthand experience • Collective view

		• To find supplies within the budget • To design for 3d productions • To answer general questions • To get project ideas • To engage in scientific inquiry
Learning	• Online tutorials • Print-based manuals • Maker Magazines • Lego books	• To code and program • To make physical objects

Table 11: Practices of information seeking and use

4.3.1.1 Self

The sub-theme, self, is defined as the participants' practices of seeking information from their own selves—drawing upon own knowledge and experience, senses, and imaginative and improvisational ideas.

4.3.1.1.1 Tinkering

This category, tinkering, contains statements that pertain to the participants figuring out what to do and how to do things through trial and error by themselves. Tinkering is a practice of information seeking within oneself, to figure out the questions and problems that they encounter in his or her making activities. This practice of becoming informed at the makerspaces characterizes an essential culture among the maker communities—do it yourself through persistent efforts and trial and error. Ten (48%) participants [seven (33%) from the SLM and three (14%()) from the PLM]

indicate their practice of tinkering through trial and error as a way to figure out and understand their tasks at hand. This practice of experimenting is further confirmed in the focus group at the PLM. For example, Alan (SLM) stated: "I always try to figure it out myself and not use other information to do it." Anna (SLM) commented: "just keep trying and then if I can't get it like the 10th time, then I might ask for help but I'm kinda person that likes to figure things out by myself." Kal (PLM) indicated: "You might as well experiment if you're not completely sure. Try it out on your own and then if it still doesn't work out, then now you know it doesn't work out. Try to move on to another option or another route on fixing a problem." Nick (PLM) stated:

> From the start I really didn't know anything about electronics. It was just learning through trial and error. Certain things wouldn't work. I've blown up many circuits. I've burnt a lot of stuff. Eventually you figure out what to do and what not to do. After that, to supplement that, you can read stuff online, like this is what this is and learn like that. It's mostly trial and error to start with.

Nick's self-report further demonstrates that the way of knowing at the makerspace is different from how young people learn in traditional formal classrooms. This difference in the ways of knowing is also indicated by Daniel (SLM): "in a classroom you have a person to tell you what to do but in here it's like you get to figure out, you get to figure out for yourself." Likewise, Ken (PLM) commented:

> learning in a classroom, a lot of it is theoretical… but we won't always in experiments. Once in a while we'll do an experiment in class, but we can't always model what we learn in class… But like being able to do in makerspace is what we learn, we apply. It's hands on and so we don't get that in the classroom studying all the time.

In addition, two (10%) participants (both from the SLM) indicate that experimenting as a way of knowing is more rewarding and leads to a sense of accomplishment. For instance, Anna (SLM) indicated: "It's just more satisfying once I

get it that you know you figure it out and you didn't need any help from anyone." Alan (SLM) also commented: "I want to show everybody that I can do it by myself and not need any hel"

4.3.1.1.2 Sensing

This category, sensing, is defined as the participants actively becoming to know using parts of their body—such as visual perception and licking—in their activities of making, doing, learning, and problem solving. Eleven (52%) participants [four (19%) from the SLM and seven (33%) from the PLM] report this way of knowing through sensory information in their acts of making at the makerspaces.

Data analysis shows that keen observation becomes a valuable information source to design and create information artifacts (e.g., 3D model and Lego creations). This practice of using vision also reveals the artistic aspect of their information practices. For example, Katie (SLM) stated that she was able to design a 3-dimentional smiley face through a keen observation: "I pretty much just dug through my brain to find the right amount of pixels to move, or like how many degrees to turn, or like where to go on the screen...I would consider searching inside me." Daniel (SLM) indicated: "When you make something in the makerspace, you can actually see what you put in together and you can see it all come together than just like 'oh, what's this gonna be.'"

In addition, the participants utilize keen observation to construct a deeper understandings of relevant scientific knowledge embedded in their makings and doings. For example, Nick (PLM) indicated:

> I've learned a lot about electronics, just by doing it instead of reading about it. Doing it, because see, electronics is a thing where if you read about it, it's hard to figure out. It's more really just concepts. When you see the circuit working, the

> way it works and the way different components work, it's easier to then formulate using those components and design new circuits, stuff like that. Electronics is a place where programming and hardware, they come together. You have to actually see it work to understand what's happening. Learning electronics in a classroom would be difficult.

Nick's report illustrates that learning about electronics is better through keen observations on how circuits work, rather than reading about the concepts of it. Sensory information such as licking with your tongue to determine voltage is also described as informative in solving problems during makerspace activities. Nick (PLM) recalled a time when the battery was shorted as he was building a drone at the makerspace:

> Over here when it went wrong, there was no way for me to know what exactly went wrong ... I tried testing the battery with different things. I tried licking it, because when you lick a battery, you can tell if there is voltage or not ... I got used to determining different voltages by tongue, so I can just tell. I can tell what nine volts is, and what five volts is. It's about how much it zaps my tongue.

4.3.1.1.3 Imagining and improvising

This category, imagining and improvising, contains statements that pertain to the participants using newly emergent and creative ideas as a legitimate source of information to create and make things at the makerspace, such as Lego creations and 3D modelling. Eight participants (seven from the SLM and one from the PLM) indicate that they draw upon these imaginative and transient ideas, which is further captured in one field observation and one focus group at the SLM. For instance, Alex (SLM) indicated: "You have to think and make, use your imagination, don't be copying other people's stuff, just use your imagination." Ian (SLM) identified himself as someone with "a huge imagination in the head like I can't even explain it ... like sometimes I think of lizard in a human body." For Ian, when he looked for ideas to create for the 3D modeling, he sought ideas in his head, as he commented: "For 3D printing, I just draw whatever I can think

of." Similarly, Alan (SLM) indicated: "I learned to use my imagination to make new things that I have never been able to do before. I built a tower out of K'Nex." In the focus group, Mitch (SLM) stated:

> I try like making stuff and before I make, I was just trying to make like this carpet and then it just, I just got some ideas and it turned into like this giant symbol art and I got like this good idea. So sometimes when you're doing things, when you're doing something, something like an idea might pop up unexpectedly and then you could turn that into something good.

These examples show that young people value their own imaginative and improvisational ideas as a source of information to help them create and make things at the makerspace. Furthermore, while using imagination for creations appears to be an individual activity, the participants invite other friends and peers to join the act of making and have fun together, which contributes to the opportunities and desired outcomes of makerspace participation - enjoyment of making (section 4.2.1.2) and hanging out (4.2.3.2). For example, Alan (SLM) stated: "I got to use imagination with other people to make something and use it to do something fun that we would all like." In the focus group, Alex (SLM) indicated: "Me and all my friends are able to come here and talk and let our imagination go and just build whatever we like."

Statement of finding from section 4.3.1.1.1 to 4.3.1.1.3: This study finds that tinkering, sensing, and imagining and improvising are ways of knowing in the activities of designing, making, learning, and problem solving in makerspaces. What is counted as information to the makerspaces participants is not always external resources or information sources in tangible forms.

4.3.1.1.3.1 Affordance of 3D printing and Legos

This sub-category, affordance of 3D printing and Legos, is defined as 3D printing technologies and Legos enabling the participants to transform their imaginative and improvisational ideas to physical objects. Seven (33%) participants [four (19%) from the SLM and three (14%) from the PLM] point to the supporting role of 3D printing and Legos in the practice of imagination and improvising. For example, Alan (SLM) indicated: "it [3D printer] allows me to use imagination in technology form, it makes me build whatever I want using technology to print it and make whatever I want." Neil (PLM) stated: "I can take things that are in my mind and put them into 3D object that I can hold and play around with." Max (SLM) noted: "Legos are basically fun, you get to build whatever you want it of colorful box, so it is basically fun you can make your own structures."

4.3.1.1.3.2 Constraints of 3D printing

This sub-category, constraint of 3D printing, is defined as the participants recognizing the limitations of using 3D printers. Seven (33%) participants [four (19%) from the SLM and three (14%) from the PLM] indicate their frustrations when they have to wait for hours to print out a 3D creation. For example, Ian (SLM) indicated: "It takes about 2 hours to 3D print so you gotta wait a long long time and that was actually hard because I didn't know what to do all the time while I was waiting." Mike (SLM) stated: "I've been waiting for it for a really long time... I waited a couple of days." Mitch (SLM) indicated: "I mean the 3D printer takes forever to do, I mean it's cool in all but it takes forever and you can only make certain things in certain size."

Four participants (two from the SLM and two from the PLM) point out the limitation of the sizes for their 3D creations. Kal (PLM) indicated: "When I printed it out,

it either didn't work out because it was too weak to hold everything together or it was too flimsy or too small. The printer here, the 3D printer is only limited to build something very small. You can't really build anything too big."

Statement of finding from section 4.3.1.1.3.1 to 4.3.1.1.3.2: This study finds that the technologies available at the makerspaces, especially 3D printing and Legos, support young people's practice of imagining and improvising in their creative activities. Yet, 3D printers constrain young people's information creation in terms of time and size. These findings address in pertain to part of RQ6.

4.3.1.1.4 Stock of knowledge and experience

As mentioned in the previous sections, the practice of using self as a way of knowing at the makerspaces shows that for these participants, what is recognized as information in their activities of makings and doings is not always in explicit and external forms. Participant's existing knowledge and past experience play a valuable role in their practice to become informed. Eighteen (86%) participants [nine (43%) from the SLM and nine (43%) from the PLM] indicate that they are informed by their stock of knowledge and past experiences in makerspace activities. This section reports the components that make up their stock of knowledge and experience, which is social in nature and accumulated by the participants engaged in a range of social activities. These social activities are further divided into three categories, including:

1. Social life composed of social relationships with family members and friends.
2. School life including engaging in formal classroom learning and other informal learning activities, such as school clubs.

3. Community life, such as participating in creative activities at libraries and community-based maker events.

4.3.1.1.4.1 Social life

This sub-category, social life, is defined as the participants' interactions with other people such as parents and friends in their everyday life contributing to their stock of knowledge, which helps them use self as a site for information at the makerspaces. Six participants (29%) [three (14%) from the SLM and three (14%) from the PLM] show that their past experiences of observing how other people do things with tools, and how they solve technology-related problems is informative. These experiences help them know how to do and make products at makerspaces. It shows that knowing how to do something and how to tackle problems at makerspace is not an isolated action but a practice of long-time participation in social activities.

For example, Alice (SLM) indicated that her way of problem solving at the makerspace was largely shaped by what she saw of other people (i.e., friends and parents) tackling computer related problems:

> I have one friend who is like a computer like, he could he has access to so many different things in school, like so seeing him kinda like do that, and also my mom is a web designer, so I have some knowledge, like what little knowledge I had came in useful, because I knew how to, just kinda problem solve in a basic way, and find solutions of how to fix problems, so that came in very helpful when with this.

In another example, Alex (SLM) indicated how reflecting on how his step-father used tools in building things helped him figure out how to take apart the old laptop:

> so I went back and started thinking about the time that I used the computer… how to take apart the computer, but I didn't know how to take those pieces out carefully, sometimes they are stuck, cause I have seen my step dad work at a

> farm, so he builds stuff, and I already know that he has tools, so he can build, he built his own cage for the dogs, and I really like how he built those stuff.

At the PLM, Adam noted his experience of helping his dad prepared him to participate in the activities of making at the makerspace: "just sometimes with my dad, I'll just help him build stuff. That's where more of the hands-on knowledge came from and all that stuff. Yeah, it's kind of me."

These accounts show that for the participants, information is not necessarily in external tangible form; reflection on past experience and knowledge of what they see from members of their social lives are counted as information as they experiment and tinker at the makerspaces.

4.3.1.1.4.2 School life

This sub-category, school life, is defined as the participants' experiences and knowledge learned in formal classrooms contributing to their stock of knowledge, which helps them use self as a site for information at the makerspaces. Four (19%) participants [two (10%) from the SLM and two (10%) from the PLM] note the similarity between the ways of knowing in science class and makerspaces – experimenting by oneself. For example, Daniel (SLM) indicated: "like in science class with labs like you are researching and figuring things out together, instead of having the teacher tell you." Allice (SLM) stated: "whenever we do things like this, not like exactly of this, because this is pretty cool, but things like this in class is always a lot of fun, so I figured it would probably be the same here." Kal (PLM) noted: "You get to actually apply the knowledge that you learn from school, but then in school, you never get to apply anything." Mitch (SLM) indicated:

> Sometimes math and reading obviously, uh, but yeah language skills help you reading and writing stuff like writing codes, and math can help you with the coding, and science sometimes teaches you how to take things apart but yeah it does actually work...Everything is kinda intertwined.

These accounts show that for the participants, experiences from formal classes contribute to their stock of knowledge, which allows them to use their self as a site of information in the informal learning environment. This finding further suggests that the boundary between formal and informal learning is blurry and that they may influence one another.

4.3.1.1.4.3 Community life

This sub-category, community life, is defined as how participants' past activities of making and building contribute to their stock of knowledge, which helps them use themselves as a site for information at the makerspace. Nine (43%) participants [five (24%) from the SLM and four (19%) from the PLM] indicate that such experiences play an informative role in their makerspace participations. These experiences became valuable in knowing how to make something and the norm of tinkering at the makerspaces. For example, Travis (PLM) indicated:

> When I was younger I used to like flying remote control helicopters so one time I go on those sites and just try to find a helicopter I'd like to buy me for my birthday…I'm able to take stuff I learned in my childhood and implement it right now. Stuff I didn't know I would use until right now.

In another example, Ian (SLM) indicated: "everything here I already knew about, because back then I used to watch some videos and how-to guides and they actually had everything at the makerspace except for littleBits, so I actually knew all about it." In addition, Ian (SLM) had been actively participating in the community-based maker event,

as he stated: “there is something special for it, it’s called Maker’s Day, and I actually have been to all of them so far.” For Ian, when he had questions, he drew upon his own rich knowledge and experience, instead of seeking external information sources, as he indicated: “I just try to solve it myself, push my brain to actually solve it.”

The norm of tinkering in the community of makers has also been learned from the participants’ previous experiences of makings, which contributes to the practice of using their self as information at the makerspaces. For example, Nick (PLM) indicated: “When I think of an idea, no matter how crazy it is at home, I’ll just figure out a way and make it happen. Like the brain-controlled car, I just thought, ‘Hey, this might be possible. Let me just build it for the hell of it.’”

These abovementioned three sections show the practice of using self as a site for information is shaped by young people’s participation as a member in their social world, school life, and the community of makers. This finding further indicates that young people are not empty vacuums when they start their makerspace activities. Rather, their valuable knowledge and experiences contribute to their way of knowing through experimenting, sensing, and imagining and improvising.

Statement of finding for section 4.3.1.1.4.1 to 4.3.1.1.4.3: This study finds that young people’s stock of knowledge is composed of their ongoing participation in social life, school life, and community life.

4.3.1.2 Asking

This section describes the findings on the most common practice of seeking information among the participants—asking human sources questions for information in makerspace activities. The involvement of interactions with other people is embedded

and intertwined with the participants' activities of making, learning, hanging out, and pursing interests. Human sources that the participants ask include the librarians, friends and peers, and others, such as computer teacher, parents, and expert makers from online maker communities.

The central role of asking in the participants' makerspace participation indicates the essentially social nature of their information seeking. This finding further shows that the makerspace embodies a rich culture of asking, in which young people can freely generate questions and engage in inquiring. In addition, information is also embedded in distributed expertise for the participants, which is not confined to the immediate physical space, but distributed across different spaces, including the makerspace, home, and online space.

This section is structured in two levels. The first level examines the different human sources, including asking the librarians (section 4.3.1.2.1), friends and peers (section 4.3.1.2.2), and other human sources (section 4.3.1.2.3). The second level is based on the types of questions asked for each type of human sources, and the reasons for using these sources.

4.3.1.2.1 Asking librarians

The category, asking librarians, is defined as the participants formulating questions and eliciting information from the librarians. All of the participants at both makerspaces report that when they have questions, they ask the librarians, which naturally and commonly occur in various stages of their makerspace participations. Data analysis shows that the questions the participants ask the librarians include four categories: help-seeking questions, instruction-seeking questions, permission-seeking

questions, and materials-locating questions. In addition, data analysis shows the reasons for asking the librarians include the perceived authority, perceived expertise, friendly relationship, and perceived resourcefulness.

4.3.1.2.1.1 Help-seeking questions

This sub-category, help-seeking questions, refers to the needs of knowing how to do and make something using the technologies and makerspace toolkits at the makerspaces. Eight (38%) participants [five (24%) from the SLM and three (14%) from the PLM] report that they ask the librarian questions when they encounter problems in makerspace activities, especially when their friends and peers could not answer these questions. For example, Nathan (PLM) stated, "If nobody knows how to do anything, we talk to Simon about it." Adam (PLM) noted: "We all messed up… We had to undo it, that's when I had to go ask Simon to help out…" Kaden (PLM) further noted that the questions for the librarians should be challenging ones instead of simple questions, as he indicated: "If it's a basic question, I will feel embarrassed sometimes to ask Simon how to do this, cause like we come here a lot so we should know some of these stuff…but when I take a hard question…we don't have to be scared to ask him anything."

4.3.1.2.1.2 Instruction-seeking questions

This sub-category, instruction-seeking questions, is defined as the participants wanting to learn about some new technologies and toolkits in the makerspaces. This type of questions is not about a problematic situation in their makings, but a moment to be exposed to something new. For example, Neil (PLM) indicated: "I had no idea how to run a 3D printer, I didn't know what kind of software you'd use or anything like that, but

Simon kind of ran me through it in the beginning." Sam (PLM) stated: "We just wanted to see what is the difference between the new one [3D printer] and the old one [3D printer], so those were the main questions…and we just ask Simon." Ian (SLM) stated: "I didn't actually know how to use that [Sphero] at the time so I had to ask [the librarian] how to use it."

4.3.1.2.1.3 Permission-seeking questions

This sub-category, permission-seeking questions, contains the statements that pertain to the participants getting permissions to do certain makerspace tasks. Five (24%) participants (all from the PLM) indicate such kind of questions for the librarian, which is mostly about the budget for makerspace projects. For example, Sam (PLM) indicated: "We gave the library and asked them how much the new project was going to cost and everything." Nick's (PLM) self-report also showed that his question for the librarian was a request for permission to take the library material back home: "I couldn't figure out the problem here. I went up to Simon and I asked him, 'What should we do?' He let me take everything home, which is where our work is."

4.3.1.2.1.4 Material-locating questions

This sub-category, material-locating questions, is defined as the participant looking for certain materials for their makerspace activities. Four (19%) participants [two (10%) from the SLM and two (10%) from the PLM] report that they ask this type of questions. For example, Max (SLM) stated: "We can't find the light on the board, we had to ask Ms. William get the red LED from her tote, and that didn't work either." Ryan (PLM) recalled: "so for the catapult, there was this one part that we couldn't find it at

all…we all searched, tried searching for it…so we were like oh Simon, where would we find this."

Statement of finding for section 4.3.1.2.1.1 to section 4.3.1.2.1.4: Data analysis indicates that young people value the librarians as a source of information and they naturally and frequently ask the librarians questions. The types of questions for the librarians include help-seeking, instruction-seeking questions, permission-seeking questions, and material—locating questions.

4.3.1.2.1.5 Perceived authority

This sub-category, perceived authority, is defined as the participants viewing the librarians at both makerspaces as someone being in charge. Eleven (52%) participants [three (14%) from the SLM and eight (38%) from the PLM] report that this is why they choose to ask the librarians. For example, Sam (PLM) referred to the librarian as "the head of the makers" when the researcher asked him why he chose Simon to ask. Kal (PLM) indicated: "We were supervised by Simon." Ian (SLM) stated: "This year I ask Ms. William… because they are the ones that operate the makerspace, they are the ones who are like the teachers of the makerspace. It's like a full-on class, they are like teachers, everyone would always ask a teacher what to do, so I ask them." Travis (PLM) further considered the librarian as the authority because the funding for their makerspace project was provided by the library, as he denoted: "He is the one who fund our ... he is the one who gets us the money we need to fund our supplies and everything so he's our number one...you know how someone may invest in a stock? He invests in us so we usually go to him for advice on anything." These accounts show that authority is perceived through the makerspace roles.

4.3.1.2.1.6 Perceived expertise

This sub-category, perceived expertise, is defined as the participants asking the librarians questions for their academic training and professional experience. Six (29%) participants [two (10%) from the SLM and four (19%) from the PLM] indicate that they choose to ask the librarians questions for their expertise. For example, Sam (PLM) indicated: "he [the librarian] knows almost everything about it." Ryan (PLM) noted: "we saw that of course Simon has a degree in engineering I think, so we were like oh Simon, where would we find this, and then he found it for us." Alan (SLM) identified that the librarian was his "first person" to ask, as he explained: "because she has been helping everyone through the day and I thought she would be able to help me."

4.3.1.2.1.7 Friendly relationship

This sub-category, friendly relationship, contains statements that describe the participants as viewing the librarians as someone easygoing or with whom they have established friendships before participating in makerspace activities. Six (29%) participants [one (5%) from the SLM and five (24%) from the PLM] indicate that they feel they can ask questions easily and openly from the librarians because of their relationships. For example, Neil (PLM) made a comparative comment on the difference between asking his class teacher and asking the librarian: "It is more formal with my teacher, where I ask a very structured question. Here it is more, not necessarily informal, but it's more open." Kaden (PLM) indicated how he felt he could ask the librarian questions easily:

> Simon [the librarian] is a very friendly person, so we don't have to be scared to ask him anything…when you are more comfortable, then you would be more

> friendly and just be more...you would ask each other stuff easily cause you are just more comfortable with each other.

This friendly relationship with the librarians is also built upon a level of mutual trust from the librarians. For instance, Alice (SLM) indicated: "Ms. William is very helpful, if you have any question she would help you out...she has faith in us that will figure out." Nathan (PLM) recounted the experience of asking the librarian: "You consult with Simon…he knows that we know what we are doing, so he is like let you guys go and we just start our project do whatever we need to do."

These examples show that even though the librarians are in authoritative positions within the formal structures, the relationships with them are unlike the traditional top-down relationship between teachers and students in formal learning environments.

4.3.1.2.1.8 Perceived resourcefulness

This sub-category, perceived resourcefulness, is defined as the participants asking the librarians for their broad network of information sources. Six (29%) participants [three (14%) from the SLM and three (14%) from the PLM] value the librarian as a stepping-stone to connect them to a broader network of information sources that might not immediately be available for them. The librarians' extended network of information sources includes human sources such as other teachers, peers, and experienced makers, and formal instructional sources such as maker related magazines, and online resources. For example, in Kaden's (PLM) self-report, the librarian was valued as "our only human source...cause he would talk to other people who have done this before...they are feeding him information." Anna (SLM) recalled: "[the librarian] had to get the computer teacher Ms. Wager to come to help us." The observation on March 29, 2017 captured how Alan

(SLM) initially sought information from the librarian but then the librarian referred him to his peer, who had encountered the same problem and solved it already.

Statement of finding for section 4.3.1.2.1.5 to section 4.3.1.2.1.8: This study finds that young people often generate questions and ask the librarians for information and help during their makerspace participations. They value the librarians as a source of information for their perceived authority, resourcefulness, expertise, and friendly relationshi

4.3.1.2.2 Asking friends and peers

This category, asking friends and peers, is defined as the participants making sense of their makerspace activities through asking questions and getting answers from other young people at the makerspaces. Similar to the practice of asking the librarians questions, asking friends and peers is also a very common practice of information seeking at the makerspaces. The practice of asking occurs naturally and spontaneously, and it is deeply embedded in the participants' social activities with their friends and peers. Data analysis shows that the types of questions for friends and peers are help-seeking and group activity related.

4.3.1.2.2.1 Help-seeking questions

Similar to the sub-category related to questions for librarians, this sub-category, help-seeking questions, refers to the needs of knowing how to do and make something using the technologies and makerspace toolkits at the makerspaces. Twelve (57%) participants [eight (38%) from the SLM and four (19%) from the PLM] report the experience of asking their friends and peers for help, which is captured in six observation

notes as well. For example, Mitch (SLM) stated, “I was just wondering how to take certain things apart, I did ask someone how I would be able to take something apart, but I really couldn’t, but eventually I figured that out with the help of Katie.” Daniel (SLM) recalled a time when he got helped after asking a question to the peers nearby:

> I remember saying ‘ok I finally got it open, how do I get it out without breaking it?’ so then someone else he was like ‘oh I already did this, let me show you’, and then he tipped out the edges and put it out perfectly…I just said in the group and then someone else came and responded it.

The observation note of the school library makerspace on March 29, 2017 documented that the makerspace was loud and the participants were talking to each other while they took the old laptops apart. Alex shouted out to all the participants: “what is the picture of motherboard? Is it the motherboard?” while he showed the group a piece of object that was taken out from the computer. Then Ian answered: “No, that’s DIMM B [dual in-line memory module]).”

For this type of question focused on how to do something, the participants emphasize that it is important to have someone demonstrate how to do it, rather than doing it for them. For example, Alex (SLM) stated: “I might ask them, could you show me, and sometimes they say let me do it, but I have to say just show me…I really wanna know, I want to see it, cause then they are already done for me.”

Three (14%) participants [one (5%) from the SLM and two (10%) from the PLM] further report their questions are to elicit others’ opinions and advice to help their making tasks at hands. For example, Adam (PLM) stated: “We’ll ask Nick if it’s an alright like if it’s a good website. He’ll just say yeah or point us in a different direction and then we’ll either work from there.” Alice (SLM) indicated: “It was circuits. I just asked for help…I went and asked around, and this person gave me some advice.”

Three (14%) participants from the SLM report that they ask their friends and peers for help when they play games together. For instance, Katie stated: “We were also playing this other game…when I asked my friend Mitch to help me get pass this tough obstacle in a game that we were playing, and he told me how to do it and I got passed it.”

While there is a culture of asking at the makerspace, two (10%) participants [one (5%) from the SLM and one (5%) from the PLM] show somewhat different attitudes towards what questions are legitimate to ask. For instance, Alice (SLM) noted, “There is not really any stupid questions, you know that’s like an old thing, but uh if it is a simple question then it will be quick and easy.” Noel (PLM) indicated: “Sometimes I feel kind of weird to ask them. It’s kind of like a stupid question, like ‘Why am I asking this?’ But then sometimes this is a solid question to ask someone that could be really helpful building it.”

4.3.1.2.2.2 Group activity questions

For group activity related questions, five (24%) participants [one (5%) from the SLM and four (19%) from the PLM] report that they have questions on the short-term objectives for their group projects, questions about what to make as a group, questions eliciting opinions from other group members, and questions that actually serve as the purpose of assigning tasks to other group members. For instance, Kal (PLM) indicated: “We’ll either ask one of the group leaders … what we need to do for the day.” Anna (SLM) stated: “We were trying to figure out what to make and I think someone said let’s make a little house.” Noel (PLM) recalled his questions for his friends and peers: “‘Do you have any suggestions,’ or ‘What are we doing,’ ‘Is this the right thing?’ As a group, I just ask everybody.” Noel (PLM) indicated: “I never find that frustrating, if somebody

else asks me for hel I usually find it. If I don't, I'll just tell someone else, like, 'Here, I'm working on this, helping him out. Do you know what to do?'"

Statement of finding for section 4.3.1.2.2.1 to section 4.3.1.2.2.2: Data analysis indicates that asking friends and peers is a practice of information seeking embedded in the young people's social and making practices in the makerspaces. Types of questions for friends and peers are mainly about seeking help on how to do something and negotiating group-related activities.

4.3.1.2.2.3 Perceived expertise

This sub-category, perceived expertise, is defined as the participants asking other young people as they are seen as more knowledgeable and experienced in certain areas. Eight (38%) participants [two (10%) from the SLM and six (29%) from the PLM] indicate that this is why they ask their friends or peers questions. For example, Adam (PLM) indicated: "Nick is like really smart. He knows what he's doing." Travis (PLM) agreed:

> Nick, he's been doing this for a long time in his life ... because he had former expertise from taking a robotics class we take in high school ... that's not my level of expertise in terms of engineering, I don't have that much experience with electrical systems, but Nick has that experience, he was able to teach me.

Kaden (PLM) also denoted: "Some of us know more than others, like I think Ken and Sam know how to switch the colors, and we don't ... it's not easy to do, so we never bothered learning ... they could just show us when we want." Similarly, Alice (SLM) identified her friends as experts on 3D modeling: "They are a little more experienced than me ... I know that's like a useful tool to use, like I can if I have a question ... hey do you

have any idea for airplane...it was good to have that kind of insight into something that could work." Nathan (PLM) indicated:

> It just depends on who knows how to do something, so someone knows how to code, we ask the person who knows how to code, if someone knows how to put something together and build something, and then we ask that person for help, but it all depends on who has the most expertise and something. I know for example, Kal is really smart and he is good with coding and everything, and we know that, cause we are all close friends in the group, so we know who knows, we know who is good at what, and who is bad at whatever.

These accounts show that the participants made decisions on who to ask for help based on their perceived expertise.

4.3.1.2.2.4 Proximity and convenience

This sub-category, proximity and convenience, is defined as the participants asking their human sources questions depending who is physically close by. Five (24%) participants [four (19%) from the SLM and one (5%) from the PLM] indicate that they ask someone nearby who is available and accessible, which is further captured in seven observation notes (five from the SLM and two from the PLM). For example, Mitch (SLM) indicated: "I usually ask who is around me." Anna (SLM) stated: "When needed help, you know, you can lean over and say this is how you do it." Noel (PLM) commented: "They're right there, sometimes when you get lazy and you're like, 'can you just give me the answer?'"

These accounts show that the makerspaces provide a permissive environment that allows the participants to freely walk around, which creates opportunities to be physically close to other people and ask questions. It further shows that when the participants walk around looking for answers, they assume that everyone can be a resource for them. This characteristic of makerspace also marks its difference from formal classroom, as

indicated Mike (SLM): “in a classroom, you are in a less flexible environment, here you can move the chairs around if you wanna do something.”

4.3.1.2.2.5 Perceived authority

This sub-category, perceived authority, is defined as the participants viewing the group leaders as people who are in charge. Two (10%) participants at the PLM indicate that when they have questions, they ask their team leaders, because they are perceived as authorities. For example, Kal noted: “Most of the time, we’ll either ask one of the group leaders like Ryan, Ken, or Sam what we need to do for the day.” The observation note on March 10th, 2017 further confirmed that the participants chose information sources based on their roles in social groups. In this observation, when the researcher asked a few participants who were in the makerspace what they were working on right now, Kaden stated that their leader was not here yet, so they didn’t really know what to do.

Statement of finding for section 4.3.1.2.2.3 to section 4.3.1.2.2.5: This study finds that young people choose to ask their friends and peers because of their perceived expertise, authority, and proximity to them.

4.3.1.2.3 Asking other human sources

This category, asking other human sources, is defined as the participants asking human sources other than the librarians, friends, and peers, who are immediately available in the physical space of the makerspaces. These other human sources are characterized as someone with expertise, and the questions directed to them are help-seeking in nature.

4.3.1.2.3.1 Computer teacher

Unique among the participants at the school library makerspace, this category contains statements that refer to the participants asking for information from the computer teacher, Ms. Wager. The observation notes capture that Ms. Wager routinely walks through the makerspace as she leaves her homeroom, and sometimes she stops at the makerspace and talks to the librarian Ms. William and/or the participants about their makerspace activities. Among all the ten (48%) participants at the school library makerspace, three (14%) participants indicated that they ask Ms. Wager for help because of her expertise and skills in 3D modeling and design. For example, Anna (SLM) indicated: "Ms. Wager helped us another week, like tried to help us and we got it that time, she's like an expert that knows all this kind of things." Alice (SLM) recalled: "My computer teacher helped me out a little bit, she showed me a design of someone else's like expert like chain."

4.3.1.2.3.2 Parents

Unique among the participants at the public library makerspace is asking parents for hel Noel (PLM) indicated how he and his group members asked his parents for help due to their perceived expertise in engineering:

> Because some of our parents are in engineering side and they know those parts and materials, so they can help us out...They asked my parents, "Do you know anything about his?" And they were like, "If you go on this one website," he told me, I forgot, "If you go there, you can find it."

However, this is not a common practice, which is might be partly due to the relationship between young people and their parents. Noel (PLM) continued to recall his experience of asking his parents questions:

> The annoying part, I guess, was when my parents kept on asking me "Why do you need this? Why do you need that?" It just took a long time explaining, "I'm doing

> this for this." They're like, "I don't know you do that." I'm like, "Yeah, I told you I go to this place." Just talking with them…They know I come here for a reason, volunteering or makerspace, or something like that, but they don't know what project I'm working on, so they're like, "Why do you need this particular product? What are you doing?" So then I'll explain that the whole thing, what I'm doing, how it started off, who's involved in it. It takes time, and it just gets not frustrating but kind of when can this be over, can I go back.

Noel's account shows his frustration when his parents asked him questions about the makerspace project that he and his friends worked on.

4.3.1.2.3.3 Expert makers in virtual communities

In addition to the computer teacher and parents, the participants also ask expert makers in online maker communities. For example, Nick (PLM) indicated:

> I've had a lot of situations where I've had to email experts. There are many community places, like element14 and instructibles, where you can directly talk with experts on the subject and they can help you out … You just have to make an account and then you can talk to anybody else. You can write about your problem, and then other people will write in solutions.

Further, Nick's account shows that the connectivity of information technology affords the participants to engage with a broader maker and hobby community on the Internet and seek information from external experts that they could not otherwise meet at the makerspaces.

Thus far, the participants show that perceived expertise plays an important role in choosing interpersonal sources to ask. Such expertise is distributed among varied human sources, including the librarians, the computer teacher, friends, parents, and experts from online specialized communities.

Statement of finding: Data analysis indicates that young people identify other human sources because of their perceived expertise and ask for help regarding their

makerspace activities. It also shows how the connectivity of information technology affords young people the opportunity to engage with expert makers in virtual communities (RQ6).

4.3.1.3 Searching

This sub-theme, searching, is defined as the participants looking up electronic information from the Internet, predominantly through the commercial search engines like Google. Twenty-one (100%) participants [ten (48%) from the SLM and eleven (52%) from the PLM] indicate that they "look stuff up" (Noel, PLM) in their makerspace activities, which is further confirmed in eight observation notes (six from the SLM and two from the PLM) and all four focus groups. Data analysis shows that the participants' practice of searching online is to serve the following purposes in their makerspace activities:

1. to figure out how to make something
2. to find supplies within the budget
3. to design for 3D productions
4. to answer general questions
5. to get project ideas
6. to engage in scientific inquiry

4.3.1.3.1 To figure out the how-to

This category, to figure out the how-to questions, is defined as the participants looking up information online to figure out the ways to do or make something for their makerspace projects. Eleven (52%) participants [four (19%) from the SLM and seven (33%) from the PLM] report this practice of searching online for hel For example,

Nathan (PLM) stated: "We need to code something, and we don't know how to, we usually just look it up online and find a good source." Adam (PLM) indicated: "we had to look it up online to see how someone else did it." Yet, not every time there is how-to information available on the Internet, as Kaden (PLM) recounted how he had troubles finding online information about the new printer:

> When we get the new printer cause it was still like, it was new and the software for it was pretty new, so it wasn't really specific on how to work it … the rest was up to us, and we were trying to fix how to like, we were trying to figure out a bunch of stuff, so we went searching online but there was nothing online as well.

Four (19%) participants [one (5%) from the SLM and three (14%) from the PLM] and one observation note from the PLM further indicate that searching for information in a visual format is preferred in their practice of figuring out the how-to questions. For instance, Kaden (PLM) noted: "You could watch tutorials on how to build...YouTube for the final product, videos and tutorials." Sam (PLM) indicated: "it was better visual videos on YouTube." The observation on February 24th, 2017 captured a conversation between Ken and Sam at the public library makerspace when Ken was looking for a particular type of class (i.e. a concept of object-oriented programming) for his program on the Finch Robot:

> Ken: dude, where is this class?
> Sam: I don't know.
> Ken: Ok YouTube. There is a thing called YouTube.
> Sam: The Internet here is slow.
> Ken: Ok I'm going to do it at home. I'm going to take a picture of this.

These examples also highlight the affordance of websites like YouTube in the participants' practice of searching for information to learn about the process of making. Yet, as shown in the conversation between Ken and Sam, their practice of searching

visual information is constrained by the slow Internet at the library. However, they are proactive in figuring out a solution in that situation.

In addition, visual information is used in an innovative way to figure out problems in the participants' activities, as indicated by Adam (PLM) when he and his friends tried to read some instructions in Chinese: "Because we use Google translate a lot and it has like a picture mode, so you can just take a picture and translate it. We just use that." This example shows that searching visual information is not merely about retrieving information in visual format, but also inputting search queries in visual format.

4.3.1.3.2 To find supplies

This category, to find supplies, is defined as the participants' practice of searching online for the makerspace project materials and supplies. Five (24%) participants (all from the PLM) and one observation indicate such practice when they need to find parts that are within a certain budget given by the public library. But at the same time, the parts need to meet the requirement of the participants' projects. For instance, Noel (PLM) indicated: "it was on the website, online, we were searching for a particular piece that has a certain amount of battery or life to it." Ryan (PLM) stated: "we just google what we need to find … we research parts and we find the best price at the quickest speed." Kal (PLM) noted: "When we tried to find that one part, it was mostly Google searching for that one part."

The practice of searching online to find parts for their makerspace projects is time consuming and sometimes frustrating. For example, Nathan (PLM) indicated:

> We were trying to find parts for the trebuchet but we couldn't find these couple screws, they were like we couldn't find them anywhere, we looked Amazon, eBay, Home Depot, Lowes, it was pretty much not existing, and then at some

> point we found it and it was such a relief for everybody, we were like ok we could finally get this project started, we have been pushing it back for such a long time, just to find this one little part … it was painful for everybody, everybody was like oh where is this small part, we can't find it anywhere.

Nathan's account shows the trouble in finding a small part for their trebuchet project due to the unavailability in many stores. In another example, Noel (PLM) recalled the challenge in finding a certain kind of battery within their budget:

> we were searching for a particular piece that has a certain amount of battery or life to it…we looked for like five minutes, we were like ok this seemed nice this seemed nice, but it's like not enough for, too costly, and then we kind of like gave up on that, alright, we can't find it and we don't know what to do, then we were like after 10 minutes, we got this, we needed come back, so like we kind of gave up in the middle, but then we got it back…it was the last piece to the planning, so like this one piece we had to finish it, if there was one piece left to a puzzle, you want to finish it right?

4.3.1.3.3 To design

This category, to design, is defined as the participants searching online information, particularly visual information, to help with their 3D design. Three (14%) participants [two (10%) from the SLM and one (5%) from the PLM] indicate that they search visual information as part of the design practice. For example, Alice (SLM) indicated how she utilized visual information to design her 3D model: "I just googled a picture of old plane, and I found this, and it kinda helped me because it showed all the individual parts kinda highlighted in different colors, so you can really pick out like what are the different pieces." Similarly, Mike (SLM) commented on how helpful it was to use pictures for creating a 3D model of Burj Al Arab:

> I looked on Wikipedia ... they also have pictures of showing the structure ... Google also is very useful ... and they will give you a couple of pictures that are correct and a couple pictures that are incorrect ... it's a great thing that Google has Google images because without that and many other websites, I would not be able to find a good picture of anything I wanted to create or build.

Searching visual information for designs is also a practice that involves the participants' continuous effort, working with their hands and minds over a period of time. For example, Alice (SLM) recalled:

> I have been looking for a couple of days now … I searched retro plane Tinkercad, plane Tinkercad, I looked at my phone whenever I don't have a computer, just a lot of going through people's profiles and stuff on Tinkercad. Here, when you search airplane Tinkercad, people's designs came up, but you have to click through every single one of the designs to see them so that's kinda what I have to do.

Alice's account shows that she was deeply engaged in the practice of searching for her 3D modeling of a retro plane. Similarly, Mike's (SLM) experience of searching visual information is also characterized as putting extra effort, as he stated:

> I wanted it to be the exact, correct size, so I had to search for or I had to go on, I think, a lot, I went on a lot of websites so that I can get correct, the exact form of the structure, and kept on looking...I looked through as many things as I could until I can get the correct structure and the correct shape...after half hour of searching for my own stuff, I only found two pictures that were actually good but it did not give me enough information, I was getting frustrated...I just left and sat down on the couch for some time, then I came back u..and I continued searching.

Additionally, Neil (PLM) indicated his extended effort in searching an appropriate design: "It's a cartoon character. I couldn't find one on the site that I typically go on, so I started to browse the internet for a good half an hour so I could find a good enough STL file that I knew would satisfy the customer without being too intricate for me."

4.3.1.3.4 To answer general questions

This category, to answer general questions, is defined as the participants searching online for a quick and simple answer, which is mostly about the "what" questions. Three (14%) participants [two (10%) from the SLM and one (5%) from the

PLM] and three observations (all from the SLM) indicate this practice at the makerspaces. For example, Nick (PLM) indicated: “The internet has a lot. Usually the first place I go is the internet, obviously… Because most problems are general. Most of electronics problems are problems that other people have faced. If you just google it, those people have already talked.” Similarly, Alice (SLM) indicated: “I’ll use Google, maybe go on like Yahoo Answers because it’s a good website for…like small questions, but if it’s something where like complex where I know Google won’t handle it kind of, maybe I’ll try once or twice, but I won’t really spend much time with that.” This account also shows that young people are aware of the affordances and constraints of social Q &A website and search engine.

4.3.1.3.5 To get project ideas

This category, to get project ideas, is defined as the participants searching online for inspirations of what they can do and make at the makerspace. Two (10%) participants (both from the PLM) report this practice of searching online for project ideas. For instance, Kaden (PLM) stated: “for next project, we could just, we can search the fun about it and we can see like a final product, so there is like the computers themselves just give us a lot of information.” Similarly, Ryan (PLM) recalled how his group searched online for ideas for their second project:

> we just google what we need to find…after we finished our previous project, we were looking at good tools to find, uh, not good tools, good projects to start, and we all, someone found a space expiration drone, not a drone, a balloon that platform we could send back up to the space and take photos of the space, of earth, so we all voted on that, and we found it.

4.3.1.3.6 To engage in scientific inquiry

This category, to engage in scientific inquiry, is defined as the participants reading peer-reviewed journal articles for their makerspace projects. This practice is unique to this group of young people who work on building a drone at the public library makerspace. Two (10%) participants, Adam and Nick, both from the PLM, indicate that they search online through Google Scholar for scientific papers, as indicated by the following conversations at the focus group:

> Adam: And then with Google Scholar, you can look up actual papers written on the drones and how they work and stuff. So-
>
> Researcher: Did you actually look up any documents from Google Scholar?
>
> Nick: Yeah. We've had to for this. When we started moving into the water research part, you can't be like, reading dotcoms or random blogs that people put u It has to be peer reviewed studies. That show conductivity values because it depends on what people are drinking and what water is drinkable, and what water isn't. So you can't just trust some blog. What makes you survive and what kills you. It has to be a peer reviewed study where the scientists have determined that a specific value of conductivity is drinkable as opposed to not drinkable. There has to be lab testing behind it. It can't just be some guy on twitter.

Statement of finding from section 4.3.1.3.1 to 4.3.1.3.6: This study finds that young people engage in the practice of searching online to figure out how to make something, to find particular parts within a budget, to design something, to answer general questions, to get project ideas, and to retrieve formally published scientific articles. In particular, finding parts within a budget is sometimes time consuming and makes the participants feel frustrated. Information in visual format is especially helpful in figuring out the how-to questions and 3D design activities, pointing out the affordances of websites such as YouTube and Google Images in young people's makerspace participation. The finding on the affordance of visual information answers RQ 6.

4.3.1.3.7 Criteria for using online sources

This category, criteria for using online sources, is defined as the participants evaluating what electronic information to use for their makerspace activities. These identified criteria show that the participants are aware of the online participatory culture and social-political events going on in their lives. This section answers RQ3: what are the criteria by which young people prefer some information sources to others?

4.3.1.3.7.1 Awareness of the mixed quality of information

This sub-category, awareness of the mixed quality of information, contains statements that pertain to participants explicitly stating that some information sources on the Internet are not credible and of poor quality. Ten (48%) participants [three (14%) from the SLM and seven (33%) from the PLM] indicate such an awareness in the individual interviews. For example, Max (SLM) stated: "Google ...will give you a couple of pictures that are correct and a couple pictures that are incorrect." Kal (PLM) noted: "While searching for it, we realized that some of the information published online may not be completely true and might not be completely reliable." Nick (PLM) further indicated: "with electronics you have to be careful. Not every company's truthful. They sell a lot of fake stuff." In addition, Mike (SLM) denoted that the fake news crisis during the 2016 U.S. presidential election made him to be more aware of fake information on the Internet:

> It's just like the fake news crises, you have to get it from a reliable source, unlike getting from a source that you have never heard of...the news channels... they try to advise the US population about the rise of fake news, and why it's important to stay in reality and not with fake news companies...unlike Facebook which is kind of most at times unreliable... it's kinda a place where you post a selfie.

In the focus group at the school library makerspace, the participants also have a discussion questioning the credibility and trustworthiness of Internet sources. For

example, Anna stated: "Well maybe a lot of credible sources like were given false information."

On the other hand, two participants indicate that they do not consider the quality of information. For example, in the observation on March 1st, 2017, the researcher noticed that Alex (SLM) was actively engaged in searching information online for his game creation. So the researcher asked him how he decided which search result to consider, and he responded: "Go with my gut and choose whatever I like." Adam (PLM) recalled a problematic situation when he and his group members just selected the first link on the search result page:

> We just generally search Google and see what pops up as the first link…Like we thought we did enough research but we kind of ...we picked the first one. We didn't do as much research as we should've but and we didn't really ask anyone because we were just like it's a battery. It usually should be pretty good. But it wasn't, it wasn't what it turned out to be… we didn't perfectly look at everything through. We kind of skipped some parts…we just, we didn't think about it. Like we should've done a tiny bit more.

Adam's account shows that they were troubled by the mixed quality of information on a simple Google search; however, his group now realize that the top ranked result does not necessarily mean credible sources. Data analysis further shows that evaluating electronic information sources on the Internet has not been taught extensively at school, from the perspective of some participants. For example, Kaden (PLM) remarked: "not really unless you take a computer class...like some of us did but I didn't." Alice (SLM) noted: "in school they kinda teach us more on information and facts, what is a good website, and what is a bad website."

Even though only ten participants explicitly indicated their awareness and concerns of the mixed quality of information on the Internet, all the participants show

that they have some criteria to guide their use of information. These criteria, including perceived authority, firsthand experience, and collective wisdom are further described in the following sections.

4.3.1.3.7.2 Perceived authority for online information

Ten (48%) participants [two (10%) from the SLM and eight (38%) from the PLM] indicated that when they used online information, they considered if a source was from well-recognized companies, organizations, URLs, and authors of a source. For instance, Ken (PLM) indicated: “we can also tell based off the company. So, like if a known company, like a well-known company giving information on how to build something...that would help a lot more.” Mike (SLM) commented: “Smithsonian, that’s really good...one of America’s biggest museums...I’ve been to their museums, and they have good sources, it’s good source, so I use Smithsonian a lot when I read about stuff because I know it’s a reliable source.” Ryan (PLM) stated: “when I find information, it has to be from a reputable site...so like the site domain would be like dot edu, or if it’s a government website.” Further, Ryan indicated: “we check author, and we check the publisher.”

4.3.1.3.7.3 Firsthand experience

Ten (48%) participants [three (14%) from the SLM and seven (33%) from the PLM] indicated that they valued their past experiences of using different websites or compared the information source against their own stock of knowledge. For example, Noel (PLM) explained how he and his teammates decided on what information sources to use: “because sometimes we know it, we ordered stuff through it from the last project

also, we ordered, and it came like as a good quality, so those could be trustable." Katie (SLM) stated: "I'm sure like some parts of it that I know, so I would see if the part that I know is false information, and if it's right then I would know most likely right information."

4.3.1.3.7.4 Collective view

This sub-category indicates that eight (38%) participants [two (10%) from the SLM and six (29%) from the PLM] choose to use some information sources based on what other people with similar interests and tasks at hand have said collectively. Such a collective view is distributed in the customer reviews and forums for specific interests and topics, affecting the participants' choices in information use during their makerspace participations. At the public library makerspace, four (19%) participants indicate that the customer reviews play a role when they look up information for what materials to purchase for the makerspace activities. Nathan noted: "we make sure that the customer reviews or whatever are like good, cause if they are not good...then we are not going to buy it." Similarly, Sam (PLM) stated: "Amazon also has reviews on the bottom, on the bottom they have reviews if the product is good or not, so usually we try to go of those."

Meanwhile, three (14%) participants indicate that the collective wisdom on online forums is the reason for why they use that information source. For example, Nick (PLM) commented: "these forums are just reputable, and you just know that so many people will contribute to any issue that's on there." In comparison, Alice (SLM) decided not to use an idea for a 3D design based on others' negative reviews: "I was trying to make something that I could use everyday...I just came up with negative reviews like you know this design doesn't work, things like that, so I ended up not making it."

Furthermore, the participants decide to use an information source only when they find multiple sources either from human sources or online sources to reach a consensus. For example, Kal (PLM) indicated how he decided to use an information source that was approved by others collectively:

> Although one source might say so and so, I wouldn't rely on just that one source. I would have to rely on multiple sources. Once you have those multiple sources, I'm sure that it would be reliable because multiple people are saying it. Even then, it might not be completely true... It's just the amount of people who are confident in stating, "This is how you build this and this." The more people that say that, the more I feel confident on that certain amount of information. They're talking about the same topic...Let's say 10 builders say the same exact step on the process of how to build a trebuchet, then you know that's how to build a trebuchet. Then if this one guy says, "Oh, yeah. Forget what those other guys are saying. This is how you would do it," but then he's the only guy that's saying that, you might not be sure if he's right because he's the only one who goes that route.

Kal's account shows that his reliance on collective view when deciding which source to use. Similarly, Anna commented that she chose information sources when sources from the librarian and the Internet aligned to each other: "If I look up what color piece do I need and one website says red piece and one website says blue piece then I'll ask Ms. William, and then sometimes she is the tie-breaker, or maybe she will say green and then I keep looking until I find another one that says either red or blue or green." Anna's account shows that she is seeking authoritative opinion when a decision is unclear.

Statement of finding for section 4.3.1.3.7.1 to 4.3.1.3.7.4: Data analysis shows that young people have various levels of awareness regarding the quality of information on the Internet. Common criteria they apply to use certain sources include their perceived authority of the sources, their own firsthand experience, and a collective view on a certain source.

4.3.1.3.8 Affordances of ICTs in information searching and use

The abovementioned sections (4.3.1.3.1 to 4.3.1.3.7) show that the Internet and computers afford young people to search and use electronic information for various purposes. The participants are aware of the affordances for searching information, especially when no one is available or able to answer their questions. For example, Anna (SLM) indicated: "You can look a lot of things up like on Google if you need help when the teacher is not available." Kaden (PLM) stated: "you could just search our questions when nobody knows."

The importance of having the Internet and computers is also addressed by the participants. For example, Mike (SLM) indicated how "the Chromebook or any computer really" is helpful in his 3D design: "If that did not exist, or it was not there, it was not a resource for me, it would be kind of impossible for me to design it." Ken (PLM) stated:

> We used the computer to do research on how to build a trebuchet. We did use a computer to find the parts, find the costs, find how to build it, find information on it and so the computers played a crucial role in the building of the trebuchet… we could access the Internet so it's just a big source of information for us to use.

These accounts show that from the perspective of the participants, the Internet and computers consolidate all of the information in one place.

4.3.1.3.9 Constraints of ICTs in information searching

While the information technologies afford the participants to connect to online resources easily, this connectivity also brings constraints for their information searching. Fourteen (67%) participants [four (19%) from the SLM and ten (48%) from the PLM] report the constraints that they experience. In particular, the instant connectivity to the vast amount of online information becomes a challenge for the participants to effectively

find relevant information for their questions and to evaluate the quality of information in facing the fake news crisis and a mixed quality of user-generated information from online participatory communities in the Web 2.0 era. The expectation of instant connectivity of information technologies is also high among the participants, leading them to feel constrained when the Wi-Fi is weak at the makerspaces.

The constant and instant connection to the Internet through information technologies available at the makerspaces makes it challenging to find relevant information that would satisfy a situational inquiry emerging from the participants' activities. For example, Kaden (PLM) stated:

> Technology can't do everything, you can't always depend on it, it's like for some basic questions that we had, and I know we had questions that we couldn't find online so we just had to figure it out ourselves, cause there was like, we just had really basic, dumb questions that no one really asks online I guess… like where do we put these, like when we have two materials, where do we put them, and we didn't notice in the instructions or the video where to put them.

In Kaden's self-reports, the "dumb questions" are situational inquiries, which are not sufficiently afforded by the information technologies such as commercial search engines. Similarly, Neil (PLM) indicated the challenge in looking up information on how to turn on a 3D printer:

> One day I forgot how to turn on the new printer. This was the week after I learned how to manage it and I didn't remember how to turn it on, so I went online and I began to look for it, for ways to turn it on. I found nothing, which I found very peculiar because turning on a 3D printer is not necessarily supposed to be difficult nor hard to find online. I was just annoyed that I was unable to find a source to tell me how to turn on the printer.

Yet, this constraint might turn to an opportunity for young people to use prior knowledge and experience and/or be creative and find alternative solutions for those emergent situations, as Kaden (PLM) further indicated: "We just figured out by

ourselves" when he and his group members failed to find relevant information for their encountered situations.

The connectivity of information technology is also perceived as a constraint due to the prevalence of fake news during the 2016 Presidential Election in the U.S. and unreliable sources that Internet users generate in today's online participatory culture. For example, Kaden (PLM) stated: "If anyone can edit the page, then people could change it or mess with people… if you could edit it, then you know it's not, you should not exactly trust it." Kal (PLM) commented: "It was hard because while searching for it, we realized that some of the information published online may not be completely true and might not be completely reliable." Nick (PLM) noted:

> When you're trying to find the best deal, a lot of these parts come from shady places. With electronics, fakes are a big deal. Some boards, the brand name can easily be faked. Parts sometimes don't work when they're shipped. With electronics you have to be careful. Not every company's truthful. They sell a lot of fake stuff.

These abovementioned accounts show how fake information on the Internet is problematic. Further, the expectation of instant connection to the Internet is high among the participants. When the Wi-Fi signal is weak, the participants experience frustration and view it as a constraint of information technology. Ken (PLM) stated:

> I use a computer, the Internet is so slow, it gets annoying because the library has pretty bad Internet…it's just very slow and so when we're trying to load something it will fail a couple of times. The page will time out. We had to keep refreshing a couple of times until it loads and sometimes the Internet just didn't work at all, which gets pretty frustrating.

Statement of finding from section 4.3.1.3.7 to 4.3.1.3.8: This study finds that the availability and instant connection to the Internet through computers afford the participants' information searching practices. Yet, on the other hand, the information

technologies constrain young people to find relevant and credible information and become frustrated when the Internet speed does not meet their expectations.

4.3.1.4 Learning

This sub-theme, learning, is defined as the participants engaging with formal instructional information sources. These formal instructional sources include online tutorials that are provided by the programming and 3D modeling websites, instructions and manuals, books and magazines, software companies, and Google Classroom resources provided by the librarian. Data analysis shows that seeking information from these formal instructional sources is an integral part of their learning practice at the makerspaces. A total of thirteen (62%) participants [seven (33%) from the SLM and six (29%) from the PLM] indicate their experiences of learning from formal instructional sources, which is further supported in three observations (one from the SLM and two from the PLM) and one focus group at the PLM.

4.3.1.4.1 Purposes of seeking formal instructional sources

Data analysis shows that the participants seek formal instructional sources for different purposes, such as for coding and programming on computers, and for making physical objects. Ten (48%) participants [seven (33%) from the SLM and three (14%) from the PLM] and three observations (one from the SLM and two from the PLM) show that the participants use the instructional tutorials particularly for coding and programming on websites such as code.org, scratch.mit.edu, and tinkercad.com. For instance, Max (SLM) took a picture of the 3D modeling website as “the most helpful stuff in the makerspace”, and he stated, “The 3D printing course online gives you directions and shows you where to put everything. It gives you tutorials, lessons, it’s

pretty helpful...it shows you the instructions of what you are supposed to do." In addition, four (19%) participants [one (5%) from the SLM and four (19%) from the PLM] indicate that they use the formal instructional sources to help them make tangible creations. For instance, Nathan (PLM) stated: "as we were making it, the guidance itself said that we needed that screw for the work."

Data analysis further shows that formal instructional tutorials and instructions are valued because of their prescribed sequence of concrete steps and for visual guidance. On the other hand, while the participants use these formal instructional sources, they experience constraints as well. The following two sections describe the affordances and constraints of these formal instructional sources in the participants' learning practice.

4.3.1.4.2 Affordance of formal instructional sources

This category, affordance of formal instructional sources, is defined as the participants' seeking and using instructional sources because of the designed steps and procedures of doing certain activities that the formal instructional sources provide. Nine (43%) participants [seven (33%) from the SLM and two (10%) from the PLM] indicate that the prescriptions of online tutorials and printed instructions afford them to learn about the construction of productions. For example, Katie (SLM) recalled her experience:

> I would simply look information online, like how to code this certain design, or like how to complete this level on this coding, cause on code.org, there are these levels that you have to do before you can actually make what you want, … I walked myself through then maybe I will find it…because it is appropriate, and it starts from the basics and like it's not completely advanced that you will get confused.

Two (10%) participants (both from the SLM) and one observation at the PLM show that they seek and use formal instructional sources for its visual guidance. For

example, Katie (SLM) indicated: “Here was the instruction book with the Snap Circuits like that help you figure out where to place the right pieces and stuff.” The observation on March 24th, 2017 captured that Nick, Adam, and Travis all watched the video tutorial together.

4.3.1.4.3 Constraints of formal instructional sources

While the formal instructional sources afford the participants’ practices to make and learn, they also experience the constraints of these sources. This category, constraints of formal instructional sources, is defined as the challenges that were brought by the prescribed online lessons of a coding website, instructional booklets that come with the makerspace toolkits, and Lego books. The limitations that are pointed out by eleven (52%) participants [five (24%) from the SLM and six (29%) from the PLM] include the lack of flexibility of these sources, being too vague or too specific, and time-consuming.

Sometimes the prescriptions that come with the computational technologies such as the online learning platforms are limiting the participants’ participation. For example, Daniel (SLM) indicated how he felt he could not be creative with the coding website code.org:

> I feel like code.org…it’s a lot more of a set, like do what you have to do than creativeness...it’s definitely the lesson, just like after a lesson, a really long lesson, then you get to make your own thing…Coding is kinda boring...cause it’s just you put in the commands and you like see if you put in right or not, so it’s not like you get to make your own thing, that’s like cause you can at some places uh the coding, but most of it is like a set thing you do.

Further, some computational prescriptions prevent the participants from moving to the next level if they could not finish the steps based on the prescribed order. For example, Daniel (SLM) noted when he had a challenge trying to figure out how to make

three snowmen that kept on getting smaller and smaller, he could not choose to move on to the next lesson because the coding website locked the next level: “You can skip but it doesn’t let you register as you finished it...I don’t think you are allowed to move on to the next section if you don’t do the entire section.”

The prescriptions in tangible materials are also perceived as a constraint due to their vagueness. For example, Kal (PLM) recalled: “There’s one instruction that told us, ‘Place the blah blah blah material on this part,’ but then we’re just like, what is this material?” Mitch (SLM) noted in the focus group: “Lego books, they just show you ideas for it, they don’t actually show you how to build it. Maybe they should show you how to actually build it.” Adam (PLM) remarked:

> It wasn’t that clear. I mean, we made a few mistakes just looking at the instructions so then at that point once we made our third mistake and we had to restart three times, we were like "okay let’s look this up", we looked at the instructions. We looked 10 times carefully, we redid it and then we finally put it together.

Adam’s account shows that the challenge of vagueness of instructions. In another example, Daniel (SLM) noted: “there was like nothing that really shows you what to do on it, which is understandable for some Legos cause like it’s just building, but like on a computer that can show you and it doesn’t, it’s like really weird and annoying.”

In addition, Sam (PLM) indicated that the instruction for their upcoming project was too specific for them to actually carry out within a limited budget: “so for our project cause our guide being specific for it...they want a really expensive camera, which is not in our budget, so we try to work around.” Nathan (PLM) recalled: “as we were making it, the guidance itself said that we needed that screw for the work...it just says they are all easily findable but apparently not.”

Furthermore, Mitch (SLM) pointed out how time-consuming it is to look for information from online 3D tutorials: “Going to the tutorials for the 3D printer...took forever and I was wondering how much time it was going to take and I never did actually figure that out, it took two hour-meetings and it’s just, was not happy at all.” Neil (PLM) stated: “a long-term study of 3D modeling due to time, time constriction.”

However, with other information practices such as using self as a site for information, asking, and online searching at the makerspaces, the participants do not strictly follow the instructions for their makerspace activities. For example, Max (SLM) indicated: “it was kinda hard for us without one [the Makey Makey instruction]”, yet he commented “basically there was an instruction in the box, but basically we had to try doing it ourselves.” In addition, Daniel (SLM) noted: “you could make, follow what the box has and say ok here is what you do bla bla bla, or you could do your own thing with it and make something entirely new.” In the focus group, Anna (SLM) commented:

> Can I just say, for you guys said that it’s not helpful because it doesn’t show you how to build it, but like I kind of disagree with that because it gives you inspiration for something and even if you want to build something exactly like that, like just following directions doesn’t use your mind as much as like building it from scratch and figuring out how to do it.

Mike (SLM) echoed:

> Because people explain step-by-step procedures they don’t get a chance to think about it themselves or use their imagination, it’s actually wearing down peoples’ creativity. So, Lego books can sometimes be useful to the mind to bring up creativity and ideas. But I agree with the disagreement, so it’s both good yet also bad. So it’s okay.

Statement of finding from section 4.3.1.4.1 to 4.3.1.4.3: This study finds that young people seek formal instructional sources to learn about computational coding and programming, and to learn about how to make physical objects at the makerspaces. The

prescribed sequence of concrete steps of online tutorials and instructions afford young people to progress at appropriate levels. On the other hand, the constraints of online tutorials and instructions such as a lack of flexibility, being too vague or too specific, and time-consuming are also evident from young people's perspectives.

4.3.2 Sharing information

This major theme, sharing information, is defined as the socially oriented practice of exchanging ideas with other people in the makerspace. Data analysis shows that information sharing is a common practice in the activities of making, learning, and hanging out at the makerspaces. The participants' practice of information sharing at makerspace appears to have three modes: encountering information, giving information, and "pooling ideas" without specific directions of giving or receiving information with others. The following table gives an overview of the practices of sharing information. Each of these modes is described in the following sections.

Sub-themes	Categories	Types of information	Outcome
Encountering information	By librarians	• Help-giving • Information about what to do • Introductions of something new	• Get helped • Complete badges • Learning
	By friends and peers	• Help-giving • Idea-sharing • Task-delegating	• Get helped • Get inspired • Collaboration
	By IT professionals	• IT related jobs	• Resistance
Giving information	To give help	• Self-recognized expertise and skill	• Gratification
	To share own work	• Tangible objects that embody creativities and expertise	• Visibility, identity, and recognition
"Pooling ideas"	Multi-directional information sharing	• Ideas	• Shared group awareness

			• Collective decision

Table 12: Practices of information sharing and use

4.3.2.1 Encountering information

This sub-theme, encountering information, is defined as participants engaging with information shared by others without the participants purposefully seeking and searching. Seventeen (71%) participants [ten (48%) from the SLM and seven (33%) from the PLM] report their experiences encountering information serendipitously without active seeking, which is also captured in five observation notes. Data analysis shows that the participants encounter information such as guidance and directions from the librarians, friends and peers, and invited IT professionals. Yet, while the participants mostly accept the encountered information from the librarians and peers, they show an attitude of rejection to the information shared by the invited information technology professionals, which may partially be due to the type of information being shared.

4.3.2.1.1 By librarians

This category, by librarians, is defined as the participants being given information from the librarians without their active seeking. Thirteen participants (eight from the SLM and five from the PLM) indicate their experience of engaging with information shared by the librarians. The types of information shared by the librarians without the participants actively seeking include:

1. help-giving,
2. information about what to do, and
3. introductions of 3D printer, coding websites, and books for maker projects.

Eight (38%) participants [three (14%) from the SLM and five (24%) from the PLM] and three observation notes from the SLM show that the information shared by the librarians is characterized as helpful guidance. For example, Max (SLM) stated: "Ms. William actually gave us some clues, so she told us to follow those directions if we got a little confused." Kaden (PLM) indicated: "He was the one that said oh you could actually do this, basically told us that we don't have to worry too much about being perfect for the materials." Mitch (SLM) commented: "Ms. William displayed a lot of pictures on it that helped me to do things that I wouldn't normally be able to do just using my own brain." Adam (PLM) described his first day at the makerspace when the librarian was providing him ideas for makerspace project: "The first time Simon was actually helping us, he was telling us stuff like I've seen people do this...So we sat with Simon, we looked it up and then Simon is like oh yeah, there's this website, let's look on this. It was just like he was kind of leading us through." This type of helpful guidance also shows that even the makerspaces are informal learning environments, the librarians deliberately scaffold the participants' learning through making.

Five (24%) participants [four (19%) from the SLM and one (5%) from the PLM] and two observation notes show the information shared by librarians is about giving directions on what to do. For example, Anna (SLM) indicated: "Ms. William said the badges on the computer that you have to complete and there is an app on your phone that you can download It's called Tynker ap" Alice (SLM) stated: "She told me to download the Tickle app because here you have to work towards your goals. She gives you a Google spreadsheet and you have to complete different goals, so I had to download a Tickle ap It was a weird name."

Five (24%) participants [four (19%) from the SLM and one (5%) from the PLM] and two observation notes show that the information shared by the librarians is about introducing something new, such as 3D printer, websites, and books. This category further shows the affordance of these physical objects in the makerspaces for information sharing. For instance, Kaden (PLM) pointed out that the 3D objects premade by the librarian inspired him: "These are demos that show us that we can make that." Alice (SLM) remarked how she realized the rules of using the 3D printer through information shared by the librarian:

> I used to do Sphero a lot and then she brought up, Ms. William, told us, was telling us about the 3D printer, and I didn't, I knew the 3D printer was here, but I never really knew like kids could use it, like even if you are not in tech club, if you know how to do it, you know how to make something, you can do it, use 3D printer.

4.3.2.1.2 By friends and peers

This category, by friends and peers, is defined as the participants encountering information shared by other young people at the makerspaces without their active seeking. Eleven (52%) participants [seven (33%) from the SLM and four (19%) from the PLM] report their experience of encountering information from friends and peers, which is further confirmed in one observation note and one focus grou Data analysis shows that the types of information the participants encounter are characterized as:

1. help-giving,
2. idea-sharing, and
3. task-delegating.

Seven (33%) participants [five (24%) from the SLM and two (10%) from the PLM] report that they encounter information that is about others offering help without

their active seeking. For instance, Ian (SLM) indicated: “someone came over and apparently now my good friend, they actually helped me find some piece for the spaceshi” Alan (SLM) stated: “I started building it by myself and I thought it would take a long time, so I just kept building. And then my friend saw it and wanted to help out.” Ken (PLM) indicated: “None of us were able to tie a knot except this one kid, so when we were all failing, he came over and he’s like, "Okay, let me tie it." And then he tied the knot and then we were able to [inaudible 00:00:25] stuff and actually launch it.”

Five (24%) participants [three (14%) from the SLM and two (10%) from the PLM] indicate that the information that they encounter is about ideas for makerspace activities and Lego creations. For example, Daniel (SLM) noted: “It’s definitely better in a group environment when building things cause you can work off other people’s ideas…like ‘oh, I want to do that too.’” Ian (SLM) commented during the focus group: “So the most helpful thing was the Lego shelf because I actually get to, like every time I see someone else’s creation, it actually gives me an idea on what to build next.” Adam (PLM) indicated:

> Usually we just sit in a circle with the laptop, Nick, he’ll be like thinking of tons of things... he’ll have like random tabs open with other stuff he’s thinking of working on, then he’ll be like "Look at that stuff." We’ll be like "Okay. That seems like a good idea." And then it just goes on from there.... And if Nick knows a better site, he’ll tell us about it.

Three (14%) participants (all from the PLM) indicate that the information that is provided by their group leaders without active seeking is directional and task-oriented. For example, Travis (PLM) stated: “Usually Nick he will give us directions to, because he has the most expertise, so he’ll give us direction on what these guys specifically they need to do and what we need to do.”

4.3.2.1.3 By IT professionals

This category, by IT professionals, is defined as the participants encountering information shared by the IT professionals who are invited by the librarian at the beginning of the semester. The observation note shows that the librarian invited student parents who work in the IT field to give a talk about their job, hoping to stimulate the makerspace participants' interests in STEM related careers. However, two (10%) participants express their resistance to such shared information:

For example, Mike (SLM) recalled:

> sometimes it's actually the interviews that come here... the other people who like tell us their jobs at here, because there is actually nothing to do there, because they actually most of the time you just sit there and listen to what they do to during the job...it's not really fun...I can hear what they did during like college or during their life, it's like a timeline that I can hear, but they usually just talk about their lives, not really asking what we would be thinking about ours. They just talk about theirs.

Mike's account shows his rejection to the information shared by the invited IT professionals. Similarly, Alex (SLM) commented: "there was a lot of talking here, like in the first day, a lot of talking...I got a little bored because there was nothing to do but I did understand everything."

Statement of finding from section 4.3.2.1.1 to 4.3.2.1.3: This study finds that young people encounter information from the librarians, friends and peers, and invited IT professionals. Types of information shared by the librarians include helpful guidance, directions of what to do, and introductions of technologies and materials. Types of information shared by friends and peers include help-giving, idea-sharing, and task-delegating. While the IT professionals share information about IT related careers, the

participants show a resistance to it. Further, physical objects afford information encountering in the makerspaces, which answers RQ 6.

4.3.2.2 Giving information

This sub-theme, giving information, is defined as the participants' sharing and offering information to others. A total of twenty (95%) participants [nine (43%) from the SLM and eleven (52%) from the PLM] report their experiences of giving information to others in makerspace participations. For instance, Katie (SLM) recalled: "one of my friends had no idea what it was, so I explained to him what you can do, what it's about, and what other activity you can do." Data analysis further shows two main motivations to give information during their activities. One motivation is to give information for the gratification of helping others. The other motivation is about the visibility of themselves and seeking recognitions from others.

4.3.2.2.1 Helping

This category, helping, is defined as the participants giving information because they want to assist and support others in help-seeking situations. Eighteen (86%) participants [nine (43%) from the SLM and nine (43%) from the PLM] report that they give information when someone else asks for hel For example, Alex (SLM) indicated: "If they need something or ask me something, I will be glad enough to help them, I would show them which one is better, which one is good to use and which one not to use." Ian (SLM) commented that as he participated in the makerspace regularly, "it gets me advantage to help more new kids in the makerspace."

The mindset of helping others is particularly evident among the participants at the public library makerspace, as six (29%) participants indicate that part of the motivation to

go to makerspace is to volunteer and help others from their local communities. For example, Ryan (PLM) noted, “By volunteering I help a lot of people in the community, especially the elder people who like, love to see new technologies.” Ken (PLM) commented: “If they want help with something, they come to us, the volunteers and we help them out with whatever they need.” These accounts also show that the participants are aware of their own expertise and skills. Participating in the makerspace activities allows them to recognize their own progress and development.

Nine (43%) participants [four (19%) from the SLM and five (24%) from the PLM] further indicate that when they share information to help others, they are ultimately driven by the gratification of helping others. For example, Daniel (SLM) expressed his excitement of seeing his peers figuring out the problems with his help: “Just exciting to see how they were like oh! There were more here?!” Alice (SLM) echoed: “Just helping my fellow classmate and making his idea work with what he wanted was good.” Mitch (SLM) stated: “I feel good about helping my friends.” Neil (PLM) noted: “I also got to help the new kid learn something that I never knew before and he was very, very fascinated. I enjoyed it.”

4.3.2.2.2 Recognition

This category, recognition, is defined as the participants sharing information that embody their accomplishments through makerspace participation. Four (19%) participants [two (10%) from the SLM and two (10%) from the PLM] indicate that they want to display and share their creations with other people, such as their peers, local community members, a larger maker community, and the public. For instance, Alan (SLM) stated: “When I do Lego, me and one another friend try and build something big

and put on the shelf so everyone can see it." Kal (PLM) also indicated such a goal: "You can create new technology and then display it to others and share it with others." Travis (PLM) noted that he wanted to share the creations with a broader maker community: "This is so we can present it at events like Maker Fest. We can present to show the public what we do here."

Further, it appears that through sharing their ideas, knowledge, and makerspace creations, the participants establish a sense of identities, defining who they are, especially who they are as makers. For example, Alex (SLM) indicated his identity as a "model": "I like to share my ideas or my creations… cause I feel like I'm the model so I'm giving, I feel like I'm helping people and letting them learn, helping them understand what to build." Nick (PLM) indicated that at the local Maker Fest, "I also got to explain what I'd been doing to so many people, so many parents especially who would ask me, 'How do I get my kid interested in this,' and stuff like that. It was cool to talk with all those people." Through sharing stories about himself, Nick (PLM) identified himself as an expert among his peers, as he continued: "I consider myself an electronics person, electronics hobbyist." Mitch (SLM) recounted his sense of being a leader through information sharing: "I feel like sometimes they need and I think they like my help, they would come to me for information… I think it's because they think I'm kinda the leader and I'm kinda smart, so."

Statement of finding from 4.3.2.2.1 to 4.3.2.2.2: This study finds that a motivation for young people to share information is to help others, especially for the sense of gratification from giving hel Another motivation to share information is to create a sense of self and identity in the community of makers.

4.3.2.3 "Pooling ideas"

This sub-theme, "pooling ideas", is defined as the participants equally and simultaneously contributed information pertaining to a shared task, without having a particular direction of whom this information is shared to. Nine (43%) participants [two (10%) from the SLM and seven (33%) from the PLM] indicate this norm of information sharing at the makerspace. For example, Anna (SLM) commented: "We got to bounce around ideas and that kind of stuff and we all chip in and you get the final product that you know you all made it together so that's pretty fun." Daniel's (SLM) commented: "we have to share things, and like share ideas, and like put things together as a group, so mimicking our community." Adam (PLM) denoted how his group members shared ideas with each other:

> We were all like sitting in a circle just like talking about stuff and ideas, like if we could, what would we build if we had like things. And we all just came up with crazy ideas and that was pretty fun, just sitting around and talking to people and like having fun. It was pretty cool...so we could see where some people in the group were more skilled and more people were thinking of that way.

Data analysis further shows that a main motivation for the participants to share ideas is to figure out what to do and make a collective decision as a grou For example, Adam (PLM) stated: "Sometimes we would also try brainstorming ideas...sometimes we'll get ideas just from talking about stuff...everyone was pitching it where they've probably seen it, where they've seen like it's a good website to search on." Ken (PLM) agreed: "A lot of people throw out an idea, 'Oh, let's do this, let's do that'...We discuss it as a grou.. we pool ideas if we want to start a new project and then we'll eliminate them as a grou" Similarly, Kal (PLM) noted: "We always come together as a group to make

quick decisions on what we want to do... We will either take a vote or we'll just argue or discuss more on what we should do."

However, two of them point out the negative feelings they experience with dealing with the pool of information that is contributed by their teammates. For example, Ryan (PLM) reported the challenges of reaching a consensus among the teammates:

> Since there is a lot of opinions in the makerspace, when first finding a project, different team members would think of a project, so everyone would have one or two ideas, and when we presented to the group, obviously some would be rejected, and some people won't feel as happy as others, so there is a lot of disagreements at that point, but we overcame it.

Statement of finding: This study finds that makerspace has a culture of sharing, in which the practice of pooling ideas is naturally embedded as part of their makerspace participation. Young people pool ideas together to make a collective decision when they try to figure out what to do as a grou

4.3.2.4 Affordance of ICTs in information sharing

This sub-theme, affordance of ICTs in information sharing, is defined as the supporting role of computers, laptops, and cloud-based collaborative technologies, such as Google Drive in information sharing. Nine (43%) participants [five (24%) from the SLM and two (10%) from the PLM] indicate the affordance of ICTs in their information sharing, which is further triangulated in one field observation on March 10, 2016, and one focus group at the school library makerspace. For example, Katie (SLM) indicated in the focus group: "Pretty much the Chromebook because you're able to share docs with your friends and stuff based on their school email." Max (SLM) showed his picture of a Chromebook as the stuff that helped with information sharing and collaborations: "It supports a lot of problem solving and teamwork and work together." Mitch (SLM)

indicated that the Chromebook afforded him to share information: “it does help you share information because you can email them, you can do like in-game chat or something or you can talk to them” Ryan (PLM) indicated: “Stuff that I used to share information with others is the Mac because I use Google Docs, and the other Mac is my next choice because I use it to collaborate since Google Docs has the option to collaborate with others as well.” Adam (PLM) described how the connectivity of laptop helped with the interpersonal ideas sharing among his group members:

> Usually we just sit in a circle with the lapto Nick, he’ll have like random tabs open with other stuff he’s thinking of working on. Then he’ll be like look at that stuff. We’ll be like okay, that seems like a good idea. And then it just goes on from there, whatever we feel like is a good idea.

In addition, the visualization of computers affords and mediates the participants to share information. For example, Anna (SLM) indicated that “the school’s computer” helped her share information and collaborate with others because of its visualization: “I use this a lot to share information and collaborate with other people…cause it’s more visual, if someone is help you just show them the computer and they get to see how it works.”

Statement of finding: This study finds that connectivity and visualization of ICTs afford young people to share information.

4.4 Collaborative information seeking

In answering RQ4 (When and in what circumstances do young people collaborate in their information seeking?), four major themes emerge regarding the situations when young people switch from individual information seeking to collaborative information seeking. Table 13 provides an overview of these identified situations.

Data analysis also shows that when the participants engage in collaborative information seeking, they utilize diverse sources.

Major themes	Stages in activities	Types of information	Collaborative seeking practices
Finding parts and materials for group projects	Beginning	Factual information	Collaborative Searching Collaborative Asking
Solving problem collaboratively	Actual making	How-to questions	Collaborative searching Collaborative asking Collaborative learning Collaborative experimenting
Figuring out the how-to questions	Beginning	How-to questions	Collaborative searching
Generating group projects ideas	Beginning or Finishing	Factual information	Collaborative searching

Table 13: Collaborative information practices

4.4.1 Finding parts and materials

This category, finding parts and materials, is defined as the participants working together to look for information about materials and tools for their shared makerspace activities. Eleven (52%) participants [four (19%) from the SLM and seven (33%) from the PLM] report their collaborative effort in seeking parts and materials for their makings. Data analysis shows that this situation of finding parts and materials occurs at the beginning phase of their projects. In particular, for the participants at the PLM, finding cost-efficient supplies appear to be vital because they are responsible for proposing the budget needed for their potential project and ask for the public library's approval before they could actually purchase them for their projects. Under this circumstance, the participants make collaborative effort in finding the most cost-efficient materials and tools. For instance, Kal (PLM) noted: "We have to plan out which materials we need, find the most cost-effective materials, which means normally finding the

cheapest, yet functioning materials." The practices involved in seeking information on parts and materials include collaborative searching and collaborative asking, each of which is described in the following sections.

Seven (33%) participants (all from the PLM) indicate that they search online together when they look for the parts and materials needed for their shared project. Questions involved in this collaborative searching pertain to prices and the functions of them. For instance, Noel (PLM) recounted his group's experience of collaborative searching for parts:

> We made a budget, so everybody was online working like ok this is your product and like this is the price…we were searching for a particular piece that has a certain amount of battery or life to it…Each one was assigned ... There's a big list of parts, and then the top part is like, "Okay, you do the top five," then the next five, and the next five. If you can't find any, just leave it and go to the next one. We'll try to figure it out.

Similarly, Kaden (PLM) indicated: "we would look for materials...we had a budget and we needed to find the materials...if we find something good, we both go like both computers and find that website." These collaborative efforts in finding supplies that would meet the library's budget are something that these young people rarely experience before in school, as Noel (PLM) further stated: "At the school, you don't really need to worry about the budget or the purchase. It is given to you, 'these are the pieces, you solve it.' Here, you find the pieces and solve it."

In addition, six (29%) participants [four (19%) from the SLM and two (10%) from the PLM] indicate that they engage in collaborative asking when they were in the situation of finding parts and materials for their creations. For instance, Anna (SLM) indicated: "one person just said oh I will find the parts and the other just said oh I'll help you both, that kinda." Ian (SLM) stated: "We were doing the robots...we can never find a

piece so we just like start investigating like across the whole entire makerspace for that one piece until we found it we wouldn't sto" Ryan (PLM) noted: "we saw that of course Simon has a degree in engineering I think, so we were like oh Steve, where would we find this."

4.4.2 Collaborative problem solving

This major theme, collaborative problem solving, is defined as the participants seeking information together when they deal with shared problems and barriers in their activities, especially the how-to questions. Eight (38%) participants [three (14%) from the SLM and five (24%) from the PLM] report the moments of engaging collaborative information seeking when they encounter shared problems in group activities. This type of situation often arises in the process of makings and doings. To solve shared problems, the participants engage in a range of different seeking practices, including collaborative searching, collaborative asking, collaborative learning, and collaborating experimenting. In some cases, the participants engage in different practices to solve shared problems.

Seven (33%) participants [one (5%) from the SLM and six (29%) from the PLM] indicate that they search online to figure out the how-to questions in solving their shared problems. Collaborative searching involves social interactions such as asking for opinions and collective decision-making. For example, Kaden (PLM) indicated how his group searched concurrently on two computers for some shared problems:

> We have a problem or two but they are like related, so we would just work on two computers and just keep on searching different websites at a time, and eventually would find something…like two people for each computer so I guess what if found something that seemed helpful, we would just like tell the other people that oh this might help and if we really thought it was good, we both looked at it, and just decided together, since we are friends and know each other, we just do this so much that like we are not super, it's not like professional level but we are still serious about our searching, it's a little bit of like informal talking to our friends.

Five (24%) participants [one (5%) from the SLM and four (19%) from the PLM] indicate that they ask questions together, especially when none of them is able to solve the shared problems. For example, Nathan (PLM) indicated: "If nobody knows how to do anything, we talk to Simon about it." Anna (SLM) stated:

> My friend's younger brother was asking me, there's this website Scratch, it's like a more complicated coding site and he said how you did this and I don't remember and I was trying to help him, but I don't, I'm not good at Scratch, I don't usually use it that often, and we couldn't figure it out, so we just asked Ms. William...We both asked, we went out and asked together cause I was curious about what the answer was.

Anna's account shows a transition from individual information seeking about a question on Scratch to an effort of collaborative information seeking.

Four (19%) participants [two (10%) from the SLM and two (10%) from the PLM] indicate that they engage in collaborative experimenting when problems in shared activities arise. They experiment through testing ideas and observations together. For example, Kaden (PLM) indicated: "we didn't figure it out in one day, so just like meeting over meeting, we just tested the same problem over and over again until we thought ok this was good enough, we moved on." Kal (PLM) noted: "We picked our own material and then tried to see if that worked. It was a trial and error in seeing which parts would help the trebuchet function."

Two (10%) participants [one (5%) from the SLM and one (5%) from the PLM] report that they follow the instructional sources together with others when trying to solve encountered problems. For example, Adam (PLM) stated: "We all messed u..then we looked over the instructions. We realized oh wow we did too much wrong...We looked 10 times carefully, we redid it and then we finally put it together."

4.4.3 Figuring out how-to questions

This theme, figuring out how-to questions, refer to the situations when the participants make an effort together to understand the process of doing and making something at the beginning phase of the participants' maker projects. This category is different from collaborative problem solving in that it does not necessarily indicate a problematic situation. Five (24%) participants (all from the PLM) sought information collaboratively with their group members to understand the process of doing and making something prior to the actual construction phase. For example, Ken (PLM) indicated: "We used the computer to do research on how to build a trebuchet...find how to build it, find information on it." Nathan (PLM) stated: "We are trying to find the most efficient and cheap methods, so that's where we are currently going through, is research and how to build it." Adam (PLM) recounted how his group together looked up ways to improve a robotic car:

> We'll look up if we could improve it and how would we do that… Say they built like a small robot like a car, Nick would be like 'Oh, yeah. I built my own car once.' Then we'll look up cars that people built like RC cars and how they improved them adding motors and stuff and see how ... like it just stems off random ideas someone will talk about.

4.4.4 Generating ideas

This theme, generating ideas, is defined as the situation when the participants search or experiment together to come up with ideas for group activities. Three (14%) participants [one (5%) from the SLM and two (10%) from the PLM] report such experiences. For example, Ryan (PLM) indicated: "After we finished our previous project, we were looking at good projects to start." Anna (SLM) commented: "We were trying to figure out what to make and I think someone said let's make a little house." Adam (PLM) recalled how his group sought project ideas collaboratively:

> So we sat with Simon, we looked it up and then Simon is like 'Oh yeah, there's this website, let's look on this'. It was just like he was kind of leading us through and Nick was also throwing in. Everyone was pitching it where they've probably seen it, where they've seen like it's a good website to search on.

Statement of finding: This study identifies that four situations trigger young people to seek information collaboratively. At the beginning of a shared project, young people engage in collaborative information seeking (CIS) to find materials and supplies within a budget and to understanding how to possibly build something for their shared activities. During the process of making their shared project, they engage in CIS to solve problems. Young people also turn to CIS when looking for ideas on what to make together, which can occur at the beginning or towards the end of a shared project. Collaborative information seeking is further composed of collaborative searching, collaborative asking, collaborative learning, and collaborative tinkering.

4.5 Summary of the findings organized by RQs

RQ1: What are the opportunities and desired outcomes, if at all, that drive young people to participate in library makerspace activities?

Make

1. Young people are drawn to the makerspace because of the opportunity of having freedom to make something with the availability of technological and financial resources. When the opportunity to make is interrupted, young people feel frustrated.
2. Desired outcomes of young people's makerspace participation include making tangible products that are of practical and entertainment purposes, and gaining positive feelings such as enjoyment and excitement from hands-on creations and productions.

Learn

1. Young people are driven to participate in makerspace activities for the opportunity to engage in free-choice learning.
2. Desired outcomes of makerspace participation include constructing new or in-depth understanding in STEAM, developing skills that are grounded in real-life situations, and gaining a sense of career readiness.

Social

1. Young people choose makerspace as a convenient venue to hang out with friends and peers.
2. Desired outcomes of makerspace participation include having fun and enjoyment though social interactions, gaining teamwork experiences, and building new relationships with others or sustaining long-time friendships.

Interests

1. Young people choose to participate in makerspace activities for the opportunity to engage with diverse personal interests.
2. A desired outcome of makerspace participation is to develop new interests on STEAM related areas.

RQ2: In what ways do young people seek, use, and share information to start and accomplish their makings as they participate in makerspace activities?

Seeking and using information

1. Tinkering, sensing, and imagining and improvising are ways of knowing in the activities of designing, making, learning, and problem solving. What is counted as information to the participants at the makerspaces may not always

be external resources or information sources in tangible forms. Young people's stock of knowledge is composed of their ongoing participating in social life, school life, and community life.

2. Young people value the librarians as a source of information and they naturally and frequently ask the librarians questions. The types of questions for the librarians include help-seeking, instruction-seeking questions, permission-seeking questions, and material-locating questions.
3. Asking friends and peers is a practice of information seeking embedded in the young people's social and making practices in the makerspaces. Types of questions for friends and peers are mainly about seeking help on how to do something and negotiating group related activities.
4. Young people identify other human sources such as computer teachers, parents, and experts in virtual maker communities and ask for help regarding their makerspace activities.
5. Young people engage in the practice of searching online to figure out how to make something, to find particular parts within a budget, to design, to answer general questions, to get project ideas, and to retrieve formally published scientific articles. In particular, finding parts within a budget is sometimes time consuming and makes the participants feel frustrated.
6. Seeking information from online tutorials and instructions are embedded as a part of their learning activities at the makerspaces. Young people seek formal instructional sources to learn about computational coding and programming and to learn about how to make physical objects at the makerspaces.

Sharing information

1. Young people encounter information shared from the librarians, friends and peers, and invited IT professionals. Types of information shared by the librarians include helpful guidance, directions of what to do, and introductions of technologies and materials. Types of information shared by friends and peers include help-giving, idea-sharing, and task-delegating. While the IT professionals share information about IT related careers, the participants show a resistance to it.
2. Makerspace has a culture of sharing, in which the practice of pooling ideas is naturally embedded as part of their makerspace participation. Young people pool ideas together to make a collective decision when they try to figure out what to do as a grou

RQ3: What are the criteria by which they prefer some information sources to others?

1. Young people value the librarians as a source of information for their perceived authority, resourcefulness, expertise, and friendly relationship,
2. Young people choose to ask their friends and peers because of the perceived expertise, perceived authority, and the proximity and convenience talking with them.
3. Young people identify and ask other human sources such as computer teacher, parents, and experts in virtual maker communities because of their perceived expertise.

4. Young people have various levels of awareness regarding the quality of information on the Internet. Common criteria they apply to use certain sources include their perceived authority of the sources, their own firsthand experience, and a collective view on a certain source.

RQ4: What are the motives of sharing information as young people participate in their makerspace activities?

1. A motivation for young people to share information is to help others, especially for the sense of gratification from giving helps.
2. Another motivation to share information is to create a sense of self and identity in the community of makers.

RQ5: When and in what kinds of circumstances do young people collaborate in their information seeking?

1. Four situations trigger young people to seek information collaboratively. At the beginning of a shared project, young people engage in collaborative information seeking (CIS) to find materials and supplies within a budget and to understanding how to possibly build something for their shared activities. During the process of making their shared project, they engage in CIS to solve encountered problems. Young people also turn to CIS when looking for ideas on what to make together, which could occur at the beginning or towards the end of a shared project.
2. Collaborative information seeking is further composed of collaborative searching, collaborative asking, collaborative learning, and collaborative tinkering.

RQ6: How do technologies and materials at makerspace afford and/or constrain young people's individual and collaborative information practices?

Affordances

1. The availability and instant connection to the Internet through computers afford the participants' information searching practices. Information in visual format on websites such as YouTube and Google Images affords young people to understand the process of making and designing activities. The prescribed sequence of concrete steps of online tutorials and instructions afford young people to progress at appropriate levels
2. Physical objects such as Lego creations and the connectivity and visualization of ICTs afford young people to share information in the makerspaces.
3. Technologies such as the 3D printing and Legos support young people's practice of imagining and improvising in their creative activities.
4. The connectivity of information technologies affords young people's engagement with experts in virtual maker communities.

Constraints

1. The availability of information on the Internet and the connectivity of ICTs constrain young people to find relevant and credible information.
2. The constraints of online tutorials and instructions such as a lack of flexibility, being too vague or too specific, and time-consuming are evident from young people's perspectives.
3. This study finds that 3D printers constrain young people's information creation in terms of time and size.

The list of finding summaries, by research question, are not presented as generalizations for other library makerspaces. These findings are presented as elaborations of an understanding of young people's information practices in the context of the two library makerspaces in this dissertation, which are further discussed in Chapter 5.

Chapter 5 – Discussion & Conclusion

This chapter discusses the findings that pertain to the six research questions (RQ) that are reported in Chapter 4. It details their theoretical contributions and practical implications, describes the limitations of this dissertation, and points out the future research directions, and ends with a conclusion.

5.1 Discussion of RQ1 – opportunities and desired outcomes

The first purpose of this dissertation is to understand the opportunities and desired outcomes of makerspace participation from the perspective of young people. Findings related to RQ1 show that young people are driven to go to the makerspaces for the opportunity to make, to learn, to hang out, and to engage in personal interests. Through participation, desired outcomes include producing tangible objects, developing STEAM learning, gaining real-life skills, fostering career readiness, feeling enjoyment, building teamwork experience, building friendships, and generating new interests. These opportunities and desired outcomes constitute the notion of makerspace – makerspace as a creative space, an informal learning space, a social space, and an interest-exploratory space. Compared to previous literature that focuses on makerspace as a learning space through making (e.g., Barker & Holden, 2017; Bowler & Champagne, 2016; Colegrove, 2017; Koh, 2015) or a conceptualization of makerspaces from the perspective of information professionals (e.g., Barniskis, 2016; Fourie & Meyer, 2015; Moorefield-Lang, 2015; Willett, 2016), the empirical research-based notion of makerspace focused on young people's perspective provides a more holistic picture. The conceptualization of makerspace is further detailed in section 5.7.1. The findings related to RQ 1 further highlight the freedom of choice in makerspace activities and the connection between

informal learning and formal STEAM education. These two aspects are further detailed in the following sections.

5.1.1 Freedom of choice and equity

As mentioned in the previous section, a good amount of existing literature emphasizes the learning opportunity in makerspaces, a small number of researchers have expressed the concern that makerspace may privilege dominant social groups who are familiar with newish technologies and have the means to use them to make products (Barniskis, 2016; Willett, 2016). The findings of this dissertation address this concern and suggest that if information professionals can accommodate a variety of makerspace activities and acknowledge the freedom of choice at makerspaces, makerspace can promote equality, in particular, through the freedom of choice in making, learning, collaboration, and interest engagement.

5.1.1.1 Choice in making

The finding that young people have the freedom of choice to make something at makerspaces suggests they are often a permissive and inclusive environment that do not privilege any kind of making activities. Young people who participated in this dissertation demonstrate that the activities of making range from low-tech to high-tech involvement for various purposes. This recognition of freedom in making is highlighted by a number of practitioners and researchers in LIS. For example, Daley and Child (2015) indicate that not all makerspace activities have to be high-tech and some of the best learning and making experience is found when creating with cardboard construction. Apodaca (2017) suggests that librarians need to give makers freedom and autonomy in choosing projects and accomplishing projects. Barniskis (2016) suggests practitioners and

policymakers enable intellectual freedom and provide equity for people no matter if they can make or not.

Freedom of choice in making is closely related to freedom of choice in learning, especially in the area of STEAM. For example, Vossoughi, Escudé, Kong, and Hooper (2013) show that the freedom in making "makes room for different modalities – some moments may look or feel more like tinkering and others may look or feel more like making, planning, art or traditional forms of engineering" (3). The diverse forms in making "stretches the boundaries of engineering" (Tucker-Raymond, Gravel, Wagh, & Wilson, 2016, 208). The freedom of choice in learning found in this dissertation is further discussed in the subsequent section.

5.1.1.2 Choice in learning

While much literature indicates that makerspaces are informal learning spaces (e.g., Abbas, & Koh, 2015; Bowler, 2014), few of them provide empirical evidence to justify why makerspaces are informal learning spaces, let alone an examination of the notion of informal learning. A review of literature on informal learning shows that it cannot be simply defined based on the location where learning takes place (Bell et al., 2009). Informal places such as museums can apply formal instructional practices and values, and schools can be places where informal learning practices and values are also applied (Polman & Hope, 2014; Tal & Morag, 2007). What is essential to informal learning appears to be the freedom of choice (Bell et al., 2009).

The findings related to RQ1 shows that young people are driven to participate in makerspace activities for the opportunity to learn about technologies and have choices to decide what to learn and the extent to which they are involved in learning. This provides

an empirical base to claim that library makerspaces are informal learning environments. Choices in learning are also described in Koh (2015), however, different from Koh's (2015) concern that free choice may be a challenge as students spend time switching between projects, the findings of RQ 1 highlight the importance of giving choices to young people.

5.1.1.3 Choice in interest-exploration

The connection between personal interests and makerspace has been drawn in the existing literature, with some emphasizing it in defining makerspaces (Colegrove, 2017; Fleming, 2015; Oliver, 2016), some identifying it in empirical cases (Koh, 2015), and some utilizing it to design activities (Kurti, Kurti, & Fleming, 2013; Petrich, Wilkinson, & Bevan, 2013). Aligning with the literature, this study strengthens this connection between interests and makerspace through concrete examples reported from the young people. This finding also shows that makerspace equips young people with desired competences that are described by the American Association of School Librarians' (2018) standards for learners, for example, "expressing curiosity about a topic of personal interest or curricular relevance" (5).

Yet, different from these abovementioned studies that assume one's interests stay the same over the course of participations, the findings of RQ1 also show interests are not just the initial motivator that drives young people to participate, but also an outcome of participation. Makerspace allows and accommodates such variations in interest development. As shown in section 4.1.4.2, while the initial interest of participating makerspaces on 3D printing does not sustain, other opportunities such as making and hanging out may still play a larger role in driving young people's participation. Thus, this

dissertation's findings show that young people's interests may develop, and new interests may emerge through their participations.

5.1.1.4 Choice in social interaction

The findings related to RQ1 show that young people are driven to library makerspaces for the opportunity to hang out with friends and peers, and desired outcomes include simply having fun and enjoyment, gaining teamwork experience, and building friendshi These findings suggest that library makerspaces add a convenient and permissive venue for social interactions for young people. This is similar to Agosto, Magee, Dickard, and Forte's (2016) findings that one of the reasons that teens go to libraries is for social interactions with friends and peers. While researchers suggest makerspace is a "convivial space" for people to build social capital (Barniskis, 2016; Willett, 2016) and an environment for building social network (Fourie & Meyer, 2015), these views represent the perspective of information professionals. Findings from this dissertation complements these suggestions by providing young people's perspectives to show the importance of social interactions in makerspaces.

Giving young people freedom of choice in interacting with other people leads to a culture of asking (see section 4.3.1.2), norms of information sharing (see section 4.3.2), and collaborative information practices (see section 4.4). These social interactions provide young people "the zone of proximal development" (Vygotsky, 1978, 86), through which young people develop and learn new understandings. The connection with social constructivism in LIS (Talja, Tuominen, & Savolainen, 2005) will further discussed in section 5.7.2.

Furthermore, the opportunity for social interactions found in the results related to RQ1 suggests that makerspace can be leveraged to transit from a traditional view of making as a highly technical practice to multi-faceted practices that are also socially oriented. As Tucker-Raymond, Gravel, Wagh and Wilson (2016) argue, this characteristic may lead to "a more expansive and inclusive way of describing engineering practice" (208).

5.1.2 Enjoyment through makerspace participation

The findings related to RQ1 show that enjoyment through making and hanging out with friends are desired outcomes of makerspace participation, suggesting that makerspaces provide an educational "playground" for young people to have fun. In current literature, only a small number of studies have addressed the emotional aspect in makerspace participations. For example, Bowler and Champagne (2016) suggest makers ask themselves "what will make me happy?" as a starting question in becoming a "mindful maker" (122). This finding echoes the suggestions in designing makerspaces as a place for fun (Barniskis; 2016; Fourie & Meyer, 2015). Additionally, the findings related to RQ1 on enjoyment as a desired outcome of makerspace participations could contribute to the reasons why makerspace is needed at libraries, as indicated by John Cotton Dana – "library is the center of happiness first, of public education next" (as cited in Hamilton & Schmidt, 2015, 2).

5.1.3 Connection between informal learning and formal learning

While the existing literature commonly characterizes makerspaces as informal learning places, in which people learn about emerging technologies and materials by learning about how to make things (Hatch, 2014), one of the most frequently asked

questions about informal learning spaces such as makerspaces, is whether or not people are actually learning through these experiences (Koh, 2015; Petrich, Wilkinson, & Bevan; 2013). Yet, a review of current literature rarely shows empirical research-based findings that can indicate the learning impact through makerspace experiences with the exception of Koh (2015), in which she shows that young people learn science and technology-related knowledge through makerspace activities. In addressing this pressing need to know if people are actually learning in makerspaces, the findings of RQ 1 provide concrete evidence that young people develop knowledge in STEAM areas and desirable real-life and workplace skills through makerspace participation (see sections 4.2.2.2 – 4.2.2.4). These findings are important, as Abbas and Koh (2015) indicate, "research findings that show what and how teens learn in learning spaces will contribute to sustainability and expansion of informal learning spaces in libraries and museums" (18).

These learning outcomes related to STEAM described in section 4.2.2.2 provide real-life examples of when young people are given opportunities to explore and pursue their curiosity and hobbies in informal learning environments, they often build competences and experiences that are relevant to scientific processes and understanding that are required in formal education. This finding is in line with O'Reilly's definition of makerspace:

> By helping schools and communities everywhere establish Makerspaces, we expect to build your Makerspace users' literacy in design, science, technology, engineering, art, and math . . . We see making as a gateway to deeper engagement in science and engineering but also art and design…In effect, a Makerspace is a physical mashup of these different places that allows projects to integrate these different kinds of skills (as cited in Colegrove, 2013, 2).

It is important to point out that in this dissertation, the researcher applies Lave and Wenger's (1991) conceptualization of learning as a process of "legitimate peripheral

participation" in communities of practices (29), as opposed to a traditional learning-as-transfer viewpoint (Lave, 1988). From this perspective, learning in makerspace is an engagement in scientific and engineering practices (Petrich, Wilkinson, & Bevan, 2013).

The findings related to RQ 1 also point out the value of library makerspace as a rich research site for LIS, and informal learning science. The findings show that even though being embedded in the formal institutional structures of libraries, makerspaces are venues to provide young people valuable opportunities for informal learning. The importance of studying informal learning environments has been increasingly addressed in the field of learning sciences since the seminal paper presented at the 1987 annual meeting of the American Education Research Association by Lauren Resnick (1987). It is important to understanding learning in informal contexts, as researchers have pointed out that "school is a special place and time for people—discontinuous in some important ways with daily life and work" (Resnick, 1987, 13) and merely focusing on learning activities and outcomes in formal educational environments "is fundamentally at odds with the ways in which individuals learn across various social settings" (Bell, Lewenstein, Shouse, & Feder, 2009, 27). The findings of this study further support the connection between library makerspace and informal learning. As shown in the 2012-2016 strategic plan of the Institute of Museum and Library Services (IMLS), libraries are envisioned as "essential and trusted components of the nation's learning ecosystem providing opportunities for lifelong, 'life-wide' learning" (as cited in Abbas & Koh, 2015, 2).

Together with the findings related to RQ2 that young people apply knowledge learned in formal learning to informal learning activities (see section 4.3.1.1.4.2), this

dissertation shows that the boundary between formal and informal learning is blurry and that they may influence one another. Although the notion of informal learning is often characterized in relation to formal learning, the relation between these two notions is a continuity, rather than a dichotomy. Situated on this continuous spectrum of learning settings, library makerspaces play an overarching role in integrating formal and informal learning that is beneficial for young people's intellectual development.

5.1.4 Teamwork and social justice

While existing literature has highlighted the social aspects of makerspace activities, the findings related to RQ 1 on gaining desired teamwork experience has not been addressed in the extant literature on makerspace, except for a short report that shows young people gain leadership capabilities through makerspace participation (Graves, 2014). This finding on teamwork as a result from makerspace participation aligns with the American Association of School Librarians Standards Framework for Learners (AASL, 2018). For example, the desired competences to share is that "learners work productively with others to solve problems by: 1. Soliciting and responding to feedback from others. 2. Involving diverse perspectives in their own inquiry processes" (AASL, 2018, 4).

The finding that everyone contributes equally in accomplishing shared team goals in makerspace activities suggests that makerspace is an environment that manifests social justice among these groups of young makers. This finding supports Dadlani and Todd's (2016) study that the value of social justices is evident among young people when they engage in collaborative or cooperative learning tasks.

5.2 Discussion of RQ2 – Practices of seeking, use, and sharing information

5.2.1 Tinkering as an embodied information-seeking practice

The findings on young people's information-seeking practices suggest that information seeking is more dynamic than merely seeking out external sources such as print based materials. One salient practice among these young people to become informed during makerspace activities is through direct experience such as tinkering and engaging with their keen observations, feelings, touching, and licking. This reliance on embodied practices to know has not been widely discussed in the LIS, except for a small number of scholars such as Lloyd (see Bonner & Lloyd, 2011; Lloyd, 2006, 2010, 2012; Lloyd & Wilkinson, 2016) and Olsson (see Olsson, 2010; Olsson & Lloyd, 2017). Lloyd (2006) expands on her doctoral research and indicates the role of body and embodied information to become information literate. Olsson (2010) finds that theater professionals' understanding of Shakespeare is anchored within their physical and material world. The role of embodied information, especially through keen visual reception, is also apparent in studies that investigate artists' information needs and seeking (Cowan, 2004; Lo & Chu, 2015). Cowan (2004) finds that to know what to create as a professional artist relies heavily on perception from paying close attention to what she sees and hears such as light, color, and space. Against this backdrop, the findings of this dissertation complement these abovementioned studies that focus on professionals and echo the gap identified in the current literature (e.g., Olsson, 2010) on the embodied process of knowing and becoming informed.

In addition, tinkering as an embodied information practice does not mean there is no space for cognitive involvement in becoming to know. As Lloyd (2010) denotes, "knowing refers to the entwining of cognitive and corporeal sources" (8). The

involvement of mind and body is also apparent in the ways of defining tinkering in current literature. For example, tinkering is defined as "thinking with your hands" (Sennett, 2009), "rich intellectual activities" (Vossoughi et al., 2013), and "a branch of making that emphasizes creative, improvisational problem solving" (Bevan, Gutwill, Petrich, & Wilkinson, 2015, 99). Similarly, Petrich, Wilkinson, and Bevan (2013) state that when learners tinker, they "are exploring phenomena, testing ideas, and responding to feedback with their hands" (53), which is a powerful practice to engage with learning in science and engineering.

Furthermore, tinkering suggests there is not a set of correct answers in makerspace participation. Rather, it implies a wide range of solutions that are situated in the makers' tasks at hand. This practice of knowing indicates the tolerance of failures in the activities of making and doing at makerspace. These rounds of revisions to figure out a good enough solution with whatever resources are available within that time and space are denoted as "drafts - moments in the process of creation that offer insight and fertile ground for new ideas" (Vossoughi, Escudé, Kong, & Hooper, 2013, 3) and indicate the needs of design thinking (Bowler, 2014). The mistakes and failures encountered in tinkering are also regarded as powerful moments that can be leveraged to further one's mindful inquiries (Bowler & Champagne, 2016).

5.2.2 Culture of asking at makerspace

The finding that young people commonly engaging in asking as a way to seek information suggest a culture of asking at makerspace, in which activities of making and doing are socially oriented. As indicated by the findings related to RQ 1, one of the opportunities to participate in makerspace activities is to hang out and socialize with

friends, and asking questions is a way of engaging with others (Farmer, 2007). Moreover, this finding is consistent with the results of previous empirical studies in the LIS that highlight young people's preferences of asking interpersonal sources in a range of contexts (Barriage, 2016; Farmer, 2007; Meyers et al., 2009; Murphy, 2014; Shenton & Dixon, 2003). Asking is a powerful way of knowing, as Kuhlthau (2010) indicates that inquiring creates a "third space" between young people's prior knowledge and curriculum, and "third space is where the most meaningful, lasting learning takes place" (21). In activities of innovation, asking good questions is perceived as an important inquiry skill (Small, 2014). Despite the importance of asking in young people's learning and creations, only a limited number of researchers have investiaged the practice of asking and nature of questions at makerspaces. For example, Bowler and Champagne (2016) have focused on question-asking at makerspaces. They design eight question prompts to help young people ask "mindful" questions (117).

The common information-seeking practice of asking friends suggests that a new division of labor emerges at makerspace, in particular, with the introduction of technologies such as 3D printers, Makey Makey, and littleBits in the libraries. Instead of only seeking help from the librarians, the young people commonly turn to their friends and peers for help and answers. In this newly formed division of labor, young people take the role and responsibilities of facilitating and helping each other. In addition, this finding suggests that as young people participate in makerspace activities, they are aware of expertise distributed among a range of human sources. When young people seek information from asking the computer teacher, experts on online maker community, and parents, it shows that expertise is not confined to the physical space of makerspace.

5.2.3 Visual information in practice of searching

The finding that young people search online for information (especially in visual format) suggests the value of visual information in the activities of making and designing such as 3D modeling at makerspaces. This finding is consistent with the characteristic of "digital age youth" that is described in Dresang and Koh (2009, 35). The practice of seeking visual information is in line with Lo and Chu's (2015) finding that art and design students heavily use visual information in their creative works. A number of studies on young people's search behaviors have pointed out their preferences of images and videos in selecting sources (Agosto, 2002; Cooper, 2002; Koh, 2013) and highlight the needs of visual design for young users' web experience (Druin, 2005; Large, Beheshti, & Rahman, 2002).

While the findings of this dissertation along with some similar previous studies highlight the value of visual information in young people's information-seeking practices, the American Association of School Librarians (AASL) standards framework for learners emphasizes the "culture of reading" and identifies that "reading is the core of personal and academic competency" (2018, 3) without taking into account visual literacy. The practical implications of this finding will be further discussed in the section of "implications for professional practice".

5.2.4 Using information at the micro-level

People engage in evaluating the usefulness of different sources after seeking information (Savolainen, 2008). According to Savolainen, "micro-level studies" on information use usually focus on the change of "an individual's cognitive structure" (149). For example, Kuhlthau (2010) indicates that "the fundamental concept of using

information is to find meaning and gain a deep understanding" (23). The findings of this dissertation show that at this micro-level, information is used in more ways than just to gaining a deeper understanding of the task at hand. As shown in section 4.3.1.2.1, information sought from the librarians is used for problem solving, instruction following, getting permission, and knowing where certain materials are. Information sought from friends is also reported to be used in problem solving. Yet, different from using information obtained from the librarians, information sought from friends is used to make collective group decisions and keep up with group awareness. Information sought online is used to answer simple and general questions, to get inspiration, and to engage with scientific inquiry. Further, information sought from formal instructional sources is used to learn about computational coding and programing.

5.2.5 Information sharing

The findings on information sharing show that makerspace is an information-rich space where young people encounter information shared by the librarians and friends/peers. They commonly give information to help others and share their information creations within the community of makers. Such information-sharing activities can help young people to "deepen engagement, encourage connections across artifacts and their makers, and create openings for children to stretch into new roles and practices" (Vossoughi et al., 2013).

Information sharing has been described as one of the foundations of maker movement (Hatch, 2014) and maker culture (Niemeyer & Gerber, 2015), which aligns with the missions of public and school libraries (Garcia & Colegrove, 2015; Yockey & Donovan, 2015). Furthermore, the finding on information encountering without active

seeking (such as getting inspired from seeing Lego creations on the Lego shelf reported in section 4.2.2.1.2) shows that information seeking sometimes is serendipitous (Erdelez, 2005).

The finding that young people engage in information and help giving may be an opportunity for young people to see themselves as experts, which is in line with the sociocultural approach on learning that view learning as a "transformation of participation" (Rogoff, 1994, 209). In this "community of learners" at makerspace, as young people become more experienced in making, they all start "serving as resources to the others" (Rogoff, 1994, 214).

5.3 Discussion of RQ3 – criteria in using information sources

The findings related to RQ 3 show that young people choose human sources, such as the librarians and friends/peers for their perceived expertise, which is seen through their social roles in the makerspace and social groups. This finding is in line with the findings of Shenton and Dixon, (2003) and Meyers et al. (2009) in that perceived level of trust and expertise are connected with human sources' social roles and social types. Another factor that shapes young people's use of information in this dissertation is the social relationship, which is consistent with the findings of Meyers et al. (2009) on the potential embarrasement of asking others, which is also reported by one participant in this study. This finding further supports Radford's (2006) suggestions on the importance of establishing positive relationships bewteen librarians and young people. Furthermore, the finding that convenience and proximity shape young people asking other human sources is consistent with previous studies (Murphy, 2014; Shenton & Dixon, 2003). This finding

suggests that Zipf's (1949) Principle of Least Effort applies to this particular age group as well.

5.4 Discussion of RQ4 – motives to share information

Motives of sharing information has rarely been explored in the literature on makerspaces, except for Tucker-Raymond et al.'s (2016) finding that a young maker routinely shared information about his creation of the book cover online to seek recognition. In LIS, a good number of studies on information sharing are focused on scholars in academic settings and professionals at workplaces (Fulton, 2009; Pilerot & Limberg, 2011; S. Talja, 2002), with little attention on young people's information sharing practices in everyday life settings.

The findings of RQ 4 can fill in the gap in current literature, showing that young people are motivated to share information because they want to help others, especially for the gratification from giving hel They are also motivated to share information that embodies their creativity and knowledge for building a sense of self and identity in the community of makers.

5.5 Discussion of RQ5 – collaborative information seeking

Despite the emphasis on social nature of makerspaces in existing literature (e.g., Barniskis, 2016; Fourie & Meyer, 2015), none of them have investigated the collaborative aspects of makerspace activities, such as collaborative information seeking. The findings related to RQ 5 fill in this gap in the literature on makerspaces. Previous research on collaborative information seeking (CIS) shows that collaborative activities naturally occur in various environments (Shah, 2014; Talja & Hansen, 2006) and they are as frequent as individual information seeking (Talja, 2002). The majority of research on

CIS has been focused on how professionals engage in collaborative seeking and searching at the workplace, especially in medical fields (e.g., Paul & Reddy, 2010). Only a small number of research has been conducted to understand students' CIS in formal classrooms when they work on mandatory assignments (e.g., Hyldegård, 2009; Reynolds, 2016). Yet, few studies have explored how the activities of CIS in informal leanring environments, in particular, in library makerspaces. While a good amount of literature describes makerspace as a collaborative environment (e.g., Bowler, 2014; Fourie & Meyer, 2015; Hlubinka et al., 2013; Moorefield-Lang, 2015; Sierra, 2017), few of them provide empirical evidence in depicting how young people collaborate to seek information.

Against this backdrop, the findings related to RQ 5 address the gap in the extant literature with empirical evidence to show that young people switch from individual information seeking to collaborative information seeking fluidly and naturally. CIS mostly occurs at the beginning stage of makerspace activities and during the actual process of constructing. The finding that young people turn to CIS when they need to make a collective decision on what to make, how to make something potentially, and materials and supplies needed for their shared projects is in line with Paul and Reddy's (2010) assertion that team members needed to maintain "social awareness, action awareness and activity awareness" in collaborative sensemaking (p.328).

Occasions for CIS also take place during the process of actual making within shared makerspace activities, such as the ongoing projects that last for several months or the spontaneous ones that last for one meet-up session. These CIS practices include

collaborative searching, asking, learning, and tinkering when they counter problems in shared makerspace activities.

5.6 Discussion of RQ6 – affordances and constraints of technologies and materials

The notion of affordances adopts Norman's (1999) definition as "perceived affordances" (p.39). The findings on the affordances and constraints of technologies and materials in young people's information practices show that the inner characteristics of technologies do not simply determine how young people engage with information, but that their mediating roles support or limit young people's information practices in specific contexts. These findings on the affordances and constraints of technologies and materials challenges a popular technological deterministic view that suggests technological forces shape human society (Baym, 2015). For example, the finding shows that online learning tutorials afford young people's learning based on a prescribed sequence of concrete steps, while constraining their learning because of the lack of flexibility in instructions or being too vague or too specific. This can be seen in 3D printing when young people are able to imagine and improvise a creation, yet are constrained to only creating small sized objects.

The findings on the affordances and constraints of technologies, materials, and tools at the makerspaces were unique because of the nature of the environment at the makerspaces. However, the findings related to challenges and enablers of technologies, especially information technologies, were not new. For example, Kuhlthau (2010) suggests "we need to move beyond teaching how to use technology tools to teaching in use for creativity and meaning" (p.18). Makerspace can be a good place for young people

to learn not only about emerging technologies, but also how to utilize their affordances and use them for creative works.

5.7 Preliminary comparisons between two library makerspaces

While it was not the goal of this dissertation to be a comparative study, some preliminary differences between young people's information practices in the two library makerspaces emerged.

- The PLM had funding for the participants' projects, whereas the SLM did not. Hence, young people at the PLM had opportunities to engage in budgeting and information searching for project materials and supplies and asked the librarian permission-seeking questions pertaining to purchasing.
- The participants at the PLM engaged in engineering related maker activities more often than the participants at the SLM.
- Collaborative information practices occurred more often at the PLM.
- The participants at the SLM appeared to use their imaginations and improvisational ideas in creative works more than the participants at the PLM.
- The SLM was had talks given by the invited professionals on IT-related careers. However, the participants showed a resistance towards the information shared by them.

It is important to note that these comparisons are preliminary in nature and more research with a larger sample size is needed to develop an in-depth comparative study.

5.8 Theoretical contributions and implications

The findings of this dissertation have two key theoretical contributions and implications. The first contribution is the empirical research-based conceptualization of library makerspaces. The second one is a theoretical contribution to the body of scholarly work on young people's information practices in everyday life.

5.8.1 Conceptualization of makerspace

Within the past few years, an increasing number of libraries have implemented makerspaces. While there is no specific data available on how many makerspaces are out there, the makerspace librarian at the public library from this study indicated:

> Regarding the amount of library and school makerspaces (in New Jersey), the best estimate I could get was roughly 400, it's more of an educated guess than a hard number because new makerspaces are opening up all of the time, and no survey was used to determine the number (personal email communication, March 2nd 2018).

As makerspaces are gaining in popularity, it is important to note that there is a tension in the attitudes among information professionals and librarians towards this idea. This tension is partly due to a lack of understanding of what makerspace is (Colegrove, 2013). An examination of the existing literature on the topic of makerspaces in library settings shows that many articles consist of short reports on individual makerspaces or personal blogs or opinion pieces. This characteristic of the current discourse on makerspace has also been pointed out by other researchers (Johnson, 2016; Moorefield-Lang, 2015). Based on this existing literature, the definition of makerspace has an emphasis on several aspects, from a place for creation (Graves, 2014), to informal learning space (Abbas & Koh, 2015; Bowler, 2014; Fleming, 2015), to space that is more than making (Fourie & Meyer, 2015). However, none of these definitions of makerspace is derived from empirical studies and conceptualized from the perspective of makerspace

users. Given the lack of clarity and support from empirical research in conceptualizing library makerspaces, the findings related to RQ 1 helps to fill this gap in the literature.

This dissertation provides a conceptualization of makerspace that sheds light on young people's perspectives and is derived from their real-life participations and experiences. While the researcher appreciates the diverse forms that makerspaces take in aspects such as targeted audience, nature of programs, settings, budget, resources, and participant demographics (Flintoff, 2017; Fulton, 2009), the conceptualization of makerspace reported here emerges from the particular contexts of the makerspaces in this current study.

Based on the findings related to RQ1, makerspace is conceptualized as a space for young people to make, to learn, to socialize, and to engage in their personal interests. It is a creative space that encourages the construction of tangible objects and enjoyment from the activities of making; it is a learning space that leads to an increased understanding of STEAM areas that connects to formal learning, real-life skills, and a sense of career readiness; it is a socializing space that allows having fun with friends, gaining teamwork experience, and building new and existing relationships; and it is an exploratory space that triggers new interests. The conceptual model of makerspace that is derived from this dissertation is presented in Figure 5. The four ovals show the opportunities that a makerspace can offer, and the eight desired outcomes of makerspace participations are marked surrounding the ovals. The overlapped center of all these four ovals indicates what a makerspace is.

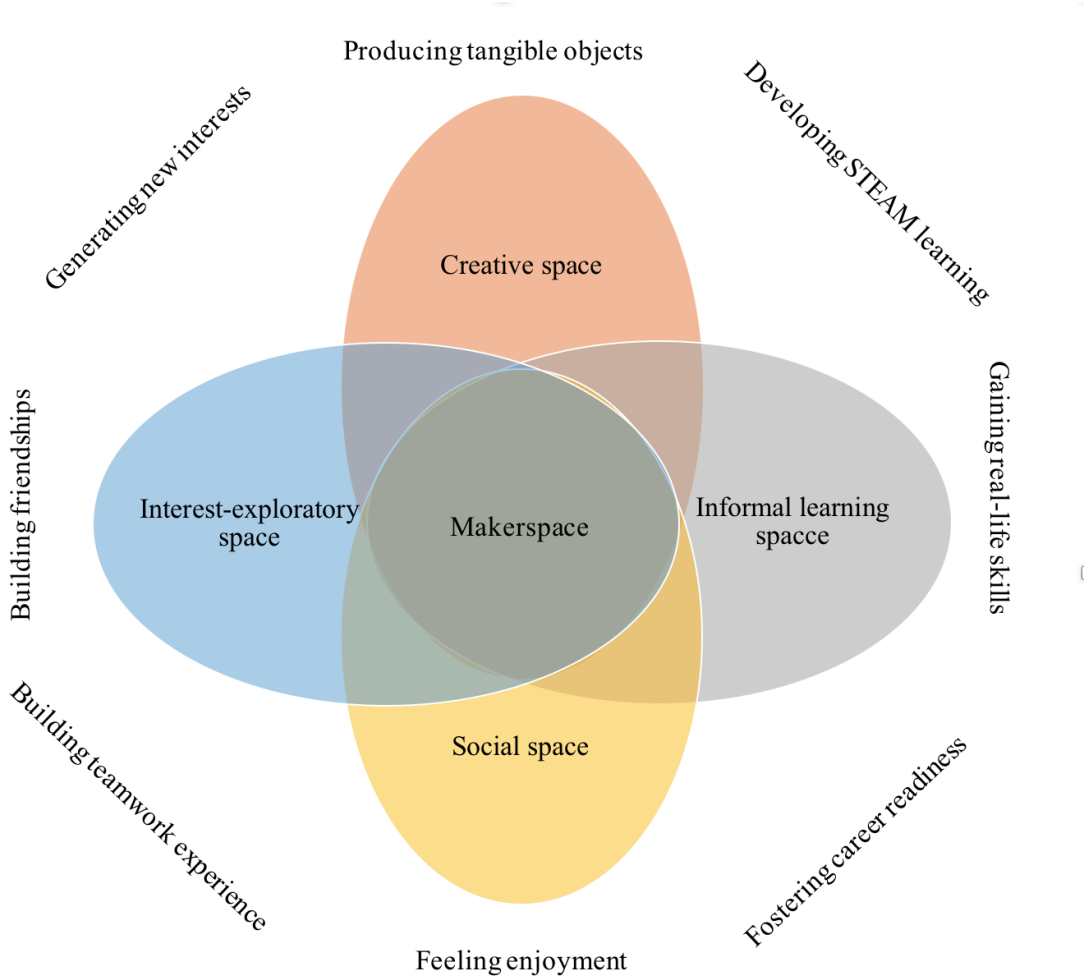


Figure 5: Conceptualization of makerspace

The conceptual model of makerspace derived from this dissertation shows a natural connection to the "hanging out, messing around, and geeking out" (HOMAGO) conceptual framework that describes young people's informal learning and engagement with new media (Ito et al., 2009). In particular, the major theme of socialization in library makerspaces aligns with the friendship-driven practices of using new media in the HOMAGO framework. Similar to how social network sites create another space for young people to socialize and are integral to young people's everyday life, library makerspaces offer a physical space that allows young people to socialize and these

makerspace activities are an integrated part of their social, school, and community lives. Yet, different from the HOMAGO framework, the conceptual model of makerspace in this dissertation addresses activities that are not limited to engagement with new media. Rather, the major theme of make indicates young people's engagement with creative works that may range from low-tech to high-tech involvement.

5.8.2 Conceptualization of information practices at makerspace

The findings of this dissertation depict a holistic picture of how young people seek, use, and share information in makerspace activities. These findings contribute to the ongoing debate among research on information behavior and information practice by confirming current conceptualizations of information practices as an inseparable and natural aspect of individuals' social practices and everyday life events (Agosto, Magee, Dickard, & Forte, 2016; McKenzie, 2003; Meyers, Fisher, & Marcoux, 2009; Savolainen, 1995). Young people's knowledge and past experience in their social lives, school lives, and community lives all play valuable roles in their practices to become informed as they participate in makerspace activities. The technological and material aspects of makerspaces also shape young people's information practices through their affordances and constraints. Young people's information practices, such as the awareness of mixed quality of online information (see section 4.3.1.3.7.1), are also influenced by the sociopolitical events (e.g., 2016 Presidential Election and the fake news crisis). Together, these suggest that information practices are influenced by individuals' life experiences and stock of knowledge, and are mutually shaped by the social, cultural, political, technical contextual factors.

The findings on young people's information practices further illustrate a connection to the meta-theory of social constructivism in LIS (Talja, Tuominen, & Savolainen, 2005). This meta-theoretical approach is built upon the assumption that "knowledge is social in origin" (p. 82). Vygotsky's (1978) sociocultural approach to learning provides a foundation for the social constructivism. Vygotsky (1978) suggests "a dialectical relationship" between human development and sociocultural environment. The key difference between the Piagetian cognitive constructivist approach and Vygotskian social constructivist theories is that the former asserts that individuals develop mental models and knowledge structures within their minds before interacting with others, while the latter suggests that individuals create meanings as a result of interacting with others (Vygotsky, 1978).

The findings contribute to the emerging discussion on embodied ways of knowing in information science (e.g., Anderson, 2007; Olsson, 2010), suggesting that information practices are intertwined with social activities, embodiment, and materials. This shifts the focus from cognitive and print based sources to other equally important sources. Young people's embodied information practices highlight the importance of "context-dependent know-how" – "knowledge depends on being in a world that is inseparable from our bodies, our language, and our social history – in short, from our *embodiment* (Varela, Thompson, & Rosch, 2016, p.148 – 149, emphasis added in the original text). Such context-dependent knowledge is also referred to "the very essence of creative cognition" (p. 149), which is "perhaps impossible, to package into explicit, propositional knowledge – 'knowledge that' in the philosopher's jargon" (p. 148).

This perspective on information practices is also a push-back towards the dualism regarding mind and body and supports Dervin's (1999) conceptualization of humans as "a body-mind-heart-spirit living" (p.730). This dissertation adds to the current understanding of information practices by moving away from everyday life to an informal and collaborative social entity in a formal institution – the library makerspace. With the unique opportunities and resources provided, this study further gives attention to the social, embodied, and material aspects of information practices.

5.9 Methodological contributions and implications

This dissertation has methodological contributions for future studies on young people's information practices in informal learning environments. First of all, this study shows the importance of conducting pilot studies to validate the research questions, selection of sites, and decisions on data collection methods. Prolonged engagement with potential research sites and participants improves the trustworthiness of data analysis. Knowing about the sites and participants helps the researcher better understand the data collected.

This study shows that applying multiple data collection methods is useful in eliciting rich and comprehensive data from the participants. In particular, the use of video-recorded reenactments and the photovoice technique contributes to understanding visual methods of collecting data and conducting research with young people. This study also demonstrates that a combination of photovoice and focus group generates engaging conversation among the participants. Compared to the video-recorded reenactment method used in the second pilot study in which the researcher holds the camera to record young people's actions, it is important to note that giving a voice to young people means

to give them the tools to capture their experiences. The method of photovoice appears to give young people more power in their roles in this dissertation. When the researcher gave $10 Barnes & Noble gift cards and pizzas for the focus groups, a few young people said that they did not need any incentive but simply wanted to contribute and help the researcher understand makerspaces.

Individual interviews that apply Flanagan's (1954) critical incident technique (CIT) are useful in eliciting rich and in-depth data. It helps the researcher probe the reasons behind the participants' initial response to a question. While the multiple methods of data collection provide this dissertation with the width of data collected, this method of individual interview that incorporates the CIT gives the dissertation the depth of data collected. Together, they provide a sound and comprehensive strategy for data collection and analysis.

5.10 Implications for the field of LIS and the discipline of education

First of all, drawing upon sociocultural approaches to learning (i.e., Lave, 1988; Lave & Wenger, 1991; Vygotsky, 1978) and theoretical models in LIS (i.e., Savolainen, 2008), this study demonstrates the interdisciplinary nature of LIS research. This dissertation demonstrates that emerging spaces, such as makerspaces in libraries, are rich research sites that can give equal attention to both sub-fields in LIS – library studies and information studies. It has important implications for the field of LIS, especially today when the outdated stereotypes of libraries and librarians prevail. An example is the much-disputed (on the JESSE listserv) article published on *USA Today* on October 13, 2017, which poorly listed librarian as the first job that "won't exist in 2030". The reason, according to this article author Michael Hoon (2017), is:

> More and more people are clearing out those paperbacks and downloading e-books on their Tablets and Kindles instead. The same goes for borrowing — as books fall out of favor, libraries are not as popular as they once were. That means you'll have a tough time finding a job if you decide to become a librarian. Many schools and universities are already moving their libraries off the shelves and onto the Internet (para.4).

Even though *USA Today* published another article on November 6, 2017 to correct this previous statement, there is a need for LIS researchers to actively show the public what libraries are, what people do at libraries, and what librarians do. Now at a time when libraries are incorporating the maker movement and transforming their missions to knowledge creation, this dissertation has implications for future directions of research in LIS.

This dissertation shows the connection between LIS and the broader formal educational agenda, especially in STEAM learning. In comparison to traditional classroom learning, young people enjoy learning through informal activities and gain a better understanding of abstract scientific concepts through hands-on exploration at makerspaces. This suggests an important opportunity for collaboration between informal learning in libraries and formal learning in classrooms. Because of the value of informal learning, it is important for educators to incorporate it into a formal learning environment. More importantly, the characteristics of informal learning experience at library makerspaces may contribute to the curriculum design in formal education and foster STEAM success.

5.11 Implications for professional practices

The findings of this dissertation have two key practical implications for information professionals and librarians, especially makerspace designers and facilitators. One implication is that librarians and makerspace facilitators should emphasize

makerspace as an opportunity to promote public libraries and school libraries as informal learning spaces, even though "for too long, we have ceded the informal learning space to commercial entities or other community agencies" (Hamilton & Schmidt, 2015, p.3). The other implication is on practical guidance in facilitating young people' inquiries in their makerspace activities. These two implications are detailed in the following sections.

5.11.1 Supporting makerspace as an informal learning environment

5.11.1.1 Visual guide for makerspace activities

The findings related to RQ 1 show that from the perspective of young people, it is important to have freedom in choosing what to make, what technologies and materials to use in their makings, what are the purposes of making, what to learn, and to what extent do they learn. Information professionals and makerspace facilitators should acknowledge and support this freedom of choice at multiple levels in young people's makerspace experiences.

Based on the visual conceptual model of makerspace presented in section 5.8.1, the researcher further proposes a visual guide for librarians and makerspace facilitators to use (see Figure 6). In this visual guide, the researcher draws connections to the four domains emphasized in the AASL standards: "think (cognitive), create (psychomotor), share (affective), and grow (developmental)" (American Association of School Librarians, 2018, p.7). These connections show how the opportunities and outcomes of library makerspace activities contribute to the Common Beliefs from the AASL (American Association of School Librarians, 2018). For instance, the opportunities and outcomes to make and learn in makerspaces align with the Common Beliefs that "1. The school library is a unique and essential part of a learning community," "3. Learners

should be prepared for college, career, and life," "5. Intellectual freedom is every learner's right," and "6. Information technologies must be appropriately integrated and equitably available" (American Association of School Librarians, 2018, p.3). This visual tool, along with the lists of practical suggestions for makerspace activities (see Table 14), may help makerspace visitors have an immediate grasp of what they can do in makerspaces and help facilitators to understand what visitors want to achieve through their participation.

For example, in introducing and facilitating visitors to the emerging technologies, librarians and makerspace facilitators may use this visual tool to show they can make any kind of tangible objects, from low-tech to high-tech productions. Another example is to bring the inclusiveness and informality to the forefront to reveal opportunities and desired outcomes such as exploring interests, socializing, and learning something helpful and practical in real-life settings. It is important for librarians and makerspace facilitators to recognize these variations and accommodate them meaningfully.

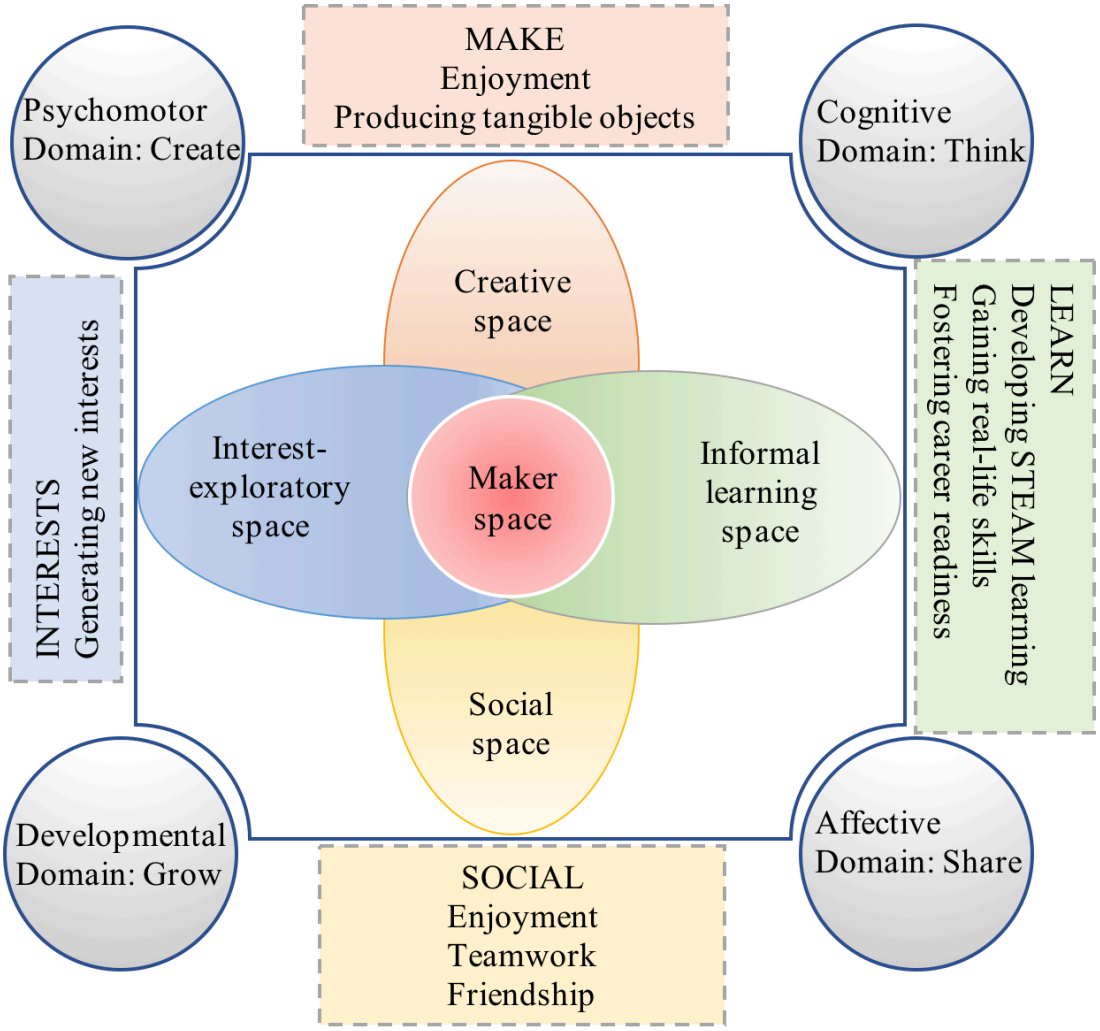


Figure 6: Visual guide for makerspace activities

Make	Learn	Social	Interests
• Provide low-tech materials, such as popsicle sticks, recycled paper, tape, paper tubes, and yarns. • Provide high-tech technologies, such as 3D printers, laser cutters, a green	• Offer STEAM related knowledge that is involved in activities, such as concepts on circuits in building Makey Makey, and physics concepts in building a trebuchet.	• Encourage social interactions among makerspace users. • Encourage users to have fun with others. • Build rapport with makerspace users.	• Learn users' personal interests. • Recognize the moments when users' new interests are triggered. • Support sustaining

screen backdrop, and digital cameras. • Provide building sets, such as K'Nex, Legos, Makey Makey. • Facilitate users to make tangible products that they can take them home. • Encourage to have fun in making and tinkering.	• Offer guidance on different ways of knowing, such as through embodiment. • Offer real-life skills, such as how to use a drill. • Connect potential careers related to young people's activities of making.	• Outreach to build a community of makers, such as organizing maker festival. • Connect makerspace new comers with local experts.	newly triggered interests. • Help young people map out their interests' development across different contexts.

Table 14: Practical guidance for makerspace activities

Meanwhile, the challenges in providing freedom of choice and preparing resources for makerspace activities such as budget, as well as librarians' scheduling should be taken into consideration. It should be emphasized that not all activities of making are costly or need the most cutting-edge technology. As shown in the findings related to RQ1, some activities are low-tech that utilize normal everyday objects such as a banana or a popsicle stick. A good balance of different types of resources is key. In determining the budget for makerspace projects, it may be a good practice to ask young people to submit a budget request for libraries to approve. Even though young people may find it boring and challenging at times, they do gain the benefits of practicing financial management and being responsible for their own purchases.

5.11.1.2 Understanding the impact of makerspaces

To promote the maker movement and the development of makerspaces in libraries, it is important to show the public and funding agencies the impact and

relevancy of makerspaces. Yet, considering the informal nature of library makerspaces, measuring the impact of makerspace experiences becomes a challenge. This has been discussed in the field of informal learning science (Bell et al., 2009; Ellenbogen, 2002). Bell et al. (2009) indicate that testing such as pre- and post-tests are not useful and may disruptive people' experiences in informal settings. While many research methods exist for unpacking the outcomes of informal learning experiences, such as a quasi-experimental design in Falk and Adelman (2003) and a longitudinal ethnographic study in Ellenbogen (2002), this dissertation provides an example of using a qualitative approach in investigating young people's experiences in makerspaces. Librarians and makerspace facilitators can apply the same research methods that are employed in this dissertation. In particular, the use of photovoice method along with focus groups may elicit rich information from makerspace users.

5.11.2 Supporting young people's information practices

5.11.2.1 Supporting tinkering

The finding on tinkering as an information-seeking practice suggests while information professionals and makerspace facilitators design activities with particular learning goals to achieve, these activities should support young people's ability to tinker and experiment. This might require them to help and support users during activities, rather than just giving instructions in the beginning. The activities should be designed to be flexible to tolerate failures and remodeling. Makerspace facilitators should welcome failures in the process of making and encourage young makers to engage in iterative trial and error to figure things out. In addition, for information professionals and makerspace

facilitators, it is important to recognize the moments of failures to support valuable learning moments, either in terms of STEAM concepts or design process.

Information professionals and makerspace facilitators should also provide scaffolding tools for young people to keep track of their process of making and tinkering. Some makerspace facilitators have already asked young people to write about their activities in blogs or journals to capture their thoughts. It is also considered as an activity of making (Fontichiaro, 2014) or ask young makers to spend the last fifteen minutes to reflect on their learning process (Koh, 2015). In addition to these existing ways of capturing individuals' journal reflections, the dissertation suggests the use of photo-voice or other visual methods such as video recording their reflections, which helps make "private thinking public or invisible thinking visible in order to record evidence of learning in ways that are not possible with pencil and paper" (as cited in Niemeyer & Gerber, 2015, p.224).

5.11.2.2 Facilitating context-dependent inquiry

As shown in the chapter 4, young people engage with a range of practices to become informed in their activities of making. This points to the importance of the role of librarians in facilitating their inquiries. In particular, questions that young people most frequently use in their information practices are about *how-to* questions (see section 4.3.1.2.1.1 and 4.3.1.2.2.1, emphasis added). These how-to questions are often context-dependent and tacit, which cannot be simply reduced a set of "propositional knowledge" (Varela, Thompson, & Rosch, 2016, p.148). It is important for makerspace facilitators to know that prescribed instructions on making something are not always appropriate for context-dependent questions. This is where librarians play an essential role for young

people's inquiries in their makerspace activities. Librarian's contextual understanding of young people's tasks at hand can facilitate trouble-shooting and foster creative solutions.

To facilitate young people's inquiries in making, librarians can help them bring their whole self to the site of making. As shown in section 4.3.1.1, young people draw upon their past experience from social, school, and community life to construct understanding of how to make and solve problems at makerspace. Librarians should help young people utilize their common knowledge and past experience to bring their "full selves" (Vossoughi et al., 2013) to makerspace activities. In practice, this requires librarians to get to know young people as individuals with valuable experiences and knowledge, rather than just a simple makerspace visitor.

In addition, compared to machines and technologies, people "excel at perception, at creativity, at the ability to go beyond the information given, making sense of otherwise chaotic events" (Norman, 1997). Instead of leaving young people to search online for information, librarians should recognize the challenge of answering context dependent questions through vast online sources. Librarians can shine in providing information for young people's context-dependent how-to questions. In addition, librarians can guide this contextual inquiry to a meaningful learning experience, especially making an effort to guide young people to engage in scientific practices. Eberbach and Crowley (2009) argue that "to observe scientifically requires much more than sensory perception and using one's senses. Sensing—although highly tangible—is only one aspect of observation. True scientific observation requires coordination of disciplinary knowledge, theory, practice, and habits of attention" (p.40). This has implications for the educational training of future librarians. It appears important for librarians, especially makerspace facilitators, to have

some level of training and knowledge in scientific practices. The current curriculum for the MLIS programs (Master of Library and Information Science) should include courses that teach scientific practices. However, it is also important to make sure that such facilitations should not turn the rich informal inquiry-based characteristics of makerspace to another formal classroom.

5.11.2.3 Modeling information practices

As this dissertation reveals young people's information practices in library makerspace activities, it shows an opportunity for librarians and makerspace facilitators to model and elevate information practices for young people. For instance, librarians may demonstrate how they collect, curate, and manage information relevant to makerspace tasks at hand. Librarians may also show young people how information technologies afford and constrain information practices. In this way, young people may enhance their information literacy and more effectively engage with information in creative works.

In addition, while librarians and makerspace facilitators emphasize information literacy, visual literacy should also be introduced in the activities of making, especially for design-centric activities such as 3D modeling. In addition to print-based materials in libraries, multimedia web-based technologies and resources can be utilized to facilitate young people's activities of making.

5.11.2.4 Building a community of makers

Another implication from this dissertation for librarians and makerspace facilitators is to build a community of makers through reaching out to experts from local communities and building virtual networks with experts who are not immediately available within the local community. One anecdote from Nick and his team Maker

Realm from the public library was that they struggled to connect with local experts such as professors and doctoral students who could guide them through the nuances of scientific writing and procedure for a national engineering competition. While the researcher helped them connect with the Rutgers makerspace, nothing fruitful was achieved due to the requirements needed to work with minors. Thus, it would be helpful if librarians and makerspace facilitators can establish a community with local experts. With a pre-established community of makers and expert makers, young people who are interested in pursuing their makerspace projects further can easily be sustained.

In addition to reaching out to local experts, librarians and makerspace facilitators can also foster information sharing among peers. A Lego shelf, such as the one in the school library makerspace would afford information sharing and ideas' cross-fertilization among groups of people who visit the makerspace at different days and times. Librarians and makerspaces can also help young people to build social networks with other peers through displays similar to the Lego shelf.

5.12 Limitations of the study

This dissertation is not free from limitations. One stems from the make-up of the participants. The young people who were recruited for this study were active library makerspace users. This might have created biases in identifying the opportunities and desired outcomes of makerspace participations. Additionally, there was a lack of balance in terms of female and male participants. All eleven participants from the public library makerspace are male, and only three of the ten participants from the school library makerspace are female.

5.13 Directions for future research

To address the identified limitations in section 5.12, future research will expand the participant pool and research sites to involve more female young people and culturally diverse social groups. A strategic plan of recruiting equal distribution of female and male participants will be considered. With an enlarged sample size and the understanding of makerspaces and young people's information practices that are derived from this dissertation, it will be appropriate to carry out comparative investigations on different contexts of makerspaces. The limitation of the current participant pools also leads to the future research agenda on exploring how to support women and underserved young people to have equitable access to STEAM (science, technology, engineering, arts, mathematics) learning opportunities in library makerspaces.

As this dissertation only recruited active makerspace participants, young people who left makerspaces without returning were not included to capture the reasons that drove them away. During the extended period of visiting these two makerspaces for this dissertation, the researcher noticed some young people who were formerly active makers but not continuing their participations at makerspaces when new semesters started. Future research will explore the factors that drive young people away from makerspace participation, which may lead to a more holistic picture of the opportunities and outcomes of makerspace participations.

While this dissertation shows that young people become to know in ways of embodiment, asking, searching, and sharing, it is unclear how to support these inquiries in connecting to scientific practices. Thus, future research will examine the role of librarians and makerspace facilitators in fostering and facilitating scientific inquiry. In particular, as indicated by this dissertation, embodied knowing helps young people

develop a deeper understanding of abstract scientific concepts. This leads to the question of how to design makerspaces in terms of space, signs, materials, technologies, and tools that can contribute to young people's scientific inquiries in these spaces.

Additionally, this dissertation shows a "blurring" of boundaries between informal learning and formal learning. Questions such as how expertise and interests develop and transfer across the boundaries of informal and formal learning environments are worth further exploration.

The researcher plans to investigate the usefulness of applying the conceptualization of makerspace that is derived from this dissertation in designing makerspace and services, using the practical guidance for makerspace activities.

5.14 Conclusion

With an increasing interest in makerspaces in library communities, there is a lack of research-based empirical studies in the field of LIS that investigate this phenomenon of maker movement and the emergence of makerspaces. Situated in this context, this dissertation presents the opportunities and desired outcomes of makerspaces in libraries from the perspective of young people, a holistic picture of young people's information practices in makerspace activities, and an understanding of the affordances and constraints of technologies and materials in their information practices.

Derived from this dissertation, makerspace is conceptualized as a space for young people to make, to learn, to socialize, and to engage in their personal interests. It is a creative space that encourages the construction of tangible objects and enjoyment from the activities of making; it is a learning space that leads to an increased understanding on STEAM that connects to formal learning, real-life skills, and a sense of career readiness;

it is a socializing space that allows having fun with friends, gaining teamwork experience, and building new and existing relationships; and it is an exploratory space that triggers new interests. The notion of freedom of choice runs through all these opportunities and outcomes. This finding is important because it may help libraries transform their missions from knowledge consumption to knowledge creation and changing the stereotype of libraries as a warehouse for books to an inclusive and permissive environment for making, learning, socializing, and exploring interests. This will also help libraries to stay relevant to young people's everyday lives.

Equally important in this dissertation is to understand young people's information practices in library makerspaces as informal learning environments. The findings of this dissertation highlight the embodied, social, and technological and material aspects of information practices, as well as the collaborative aspects of information seeking. With an empirical research-based understanding of library makerspaces and young people's information practices in these informal learning environments, this dissertation points to the role of libraries in informal learning and has important theoretical, methodological, and practical implications for the field of LIS and information professionals. Overall, this dissertation contributes to the research fields of LIS and informal learning and to the broader educational agenda in the U.S. in fostering young people's STEAM learning.

Appendix 1 Definitions of terms

The following brief definitions of the key terms that have been used in this study derived from current literature review. The definitions of these terms depict the theoretical stance and perspective underlying this study.

Collaborative information practices. Collaborative information practices are composed of "many different activities, such as seeking, sharing, understanding and using information together" (Paul & Reddy, 2010, p.321).

Collaborative information seeking. Collaborative information seeking (CIS) is dynamic activities in which groups of individuals work together to seek, search, synthesize and share information (Sonnenwald & Pierce, 2000).

Collaborative learning. Group members work jointly all the time on same problems (Damon & Phelps, 1989) and maintain a shared conception in the context of joint activities (Suthers, 2006).

Collaborative sense-making. Collaborative sense-making, broadly defined, refers to group's effort to seek, share and use information surrounding groups of people in order to reach shared goals. Narrowly defined, collaborative sense-making is the groups' effort to "synthesize and understand different pieces of information that are shared during a CIS activity" (Paul & Reddy, 2010, p.321).

Cooperative learning. Cooperative learning involves "parallel coordinated activities", in which groups often divide the task into subtasks with different responsibilities (Suthers, 2006, p.318). Subtasks lead to individual work, reducing the level of mutuality among group members (Damon & Phelps, 1989).

Informal learning. Informal learning has been typically defined in relation to formal and traditional ways of learning. Compared to formal learning environments, informal learning has been characterized as participation not being compulsory (Bell et al, 2009), free choice (Falk & Dierking, 2000), interest-driven (Barron, 2006) and self-directed (Hsi, 2004). In an informal learning context, people initiate their tasks, set their own learning agenda, drive their focus and understand the information and the world around them in ways that are meaningful to them. Not everyone comes away with the same information because not everyone starts with the same information (Falk & Dierking, 2000).

Information. In opposing the idea of objective information, Dervin argues that information is not a "static absolute ontological category" defined by experts (Dervin, 1999, p.738; Dervin & Nilan, 1986). Rather, information is conceptualized as anything, including cognitive, spiritual, physical and emotional aspects of human actors' experiences, that is involved in their sense making and sense unmaking (Dervin, 1998, 1999, 2010).

Information behavior. Broadly defined, information behavior is defined as "the totality of human behavior in relation to sources and channels of information, including both active and passive information seeking, and information use" (Wilson, 2000, p.49). It encompasses "how people need, seek, manage, give and use information in different contexts" (Fisher, Erdelez, & McKechnie, 2005).

Information practice. Information practice is defined as "a set of socially and culturally established ways to identify, seek, use, and share the information available in various sources such as television, newspapers, and the Internet. These practices are often

habitual and can be identified both in job-related and non-work contexts" (Savolainen, 2008, p.2-3).

Information seeking. "Information seeking is a major component of everyday information practices" (Savolainen, 2008, p.83). Information seeking may include "seeking of orienting information that can serve the need of monitoring everyday events" and "seeking of problem-specific information that may be used for solving individual problems or performing specific tasks" (p.83).

Information sharing. "Information sharing incorporates both active and explicit and less goal oriented and implicit information exchanges. Information sharing is about sharing already acquired information" (Talja & Hansen, 2006, p.114).

Information use. This study adopts Savolainen's (2008) broader definition of information use, which refers to "the ways in which people interpret the value of information sources generally" (p.8).

Knowledge. Knowledge is the "sense made at a particular point in time-space by someone" (Dervin, 1998, p.36). Knowledge is "partial and temporary" (Dervin, 2003, p.115). It is more than just tangible artifacts that represent knowledge.

Makerspace. In 2013, Maker Media, the publisher of MAKE: magazines, defines makerspaces as: "learning environments rich with possibilities, Makerspaces serve as gathering points where communities of new and experienced makers connect to work on real and personally meaningful projects, informed by helpful mentors and expertise, using new technologies and traditional tools" (as cited in Benton et al., 2013, p.7).

Sense-making. Sense-making, broadly defined, is an essential and overall process in which people construct and make meanings of their everyday life. Framed in Dervin's

Sense-Making theory and methodology, sense-making is defined as processes that involve multiple information related activities to “bridge” “gaps” encountered in various “situations” (Dervin, 1992).

Appendix 2 Sense-Making Time-Line interview questions

1. Participating
    a. What brought you to the tech club and makerspace? How is it related to your school life, or your goal or everyday life in general?
    b. What are the rules to participate in this space? What do you expect to do at here? What are you expected to do at here?
    c. Describe a situation you have encountered in which you had to learn something in order to participate in the making activity
        i. What happened? Can you describe it step by step?
        ii. How did you learn? What helped your learning?
        iii. How does this learning affect your participation at makerspace?
2. Inquiring
    a. What kinds of questions do you usually have?
    b. Can you describe the situations?
    c. How do you solve your problems (or how do you end up completing your 'making')? Can you describe it step-by-step?
    d. How do you feel?
    e. When to use certain resources? Why?
3. Collaborating:
    a. Now think of a time when you worked as a team member (versus working individually) to make something, how did you work with others?
    b. What was the most difficult or challenging time you had in your teamwork?

c. What kinds of problems did you have in your teamwork?

d. How did you solve the problems? Can you describe it step-by-step?

e. How do you feel?

f. When to use certain resources? Why?

4. Making: (see questions under video recorded re-enactment)

Appendix 3 Video recorded re-enactment questions

1. What do you usually do in the space? Can you show me around what you usually do and make?
2. (After the participant talks about what he/she usually does), the research asks: can you show me how you usually make it?
3. (As the participant points out materials and space), the research asks repetitively: how do these objects/space support/limit your making, participation, collaborating and problem solving?
4. How do you feel?

Appendix 4 Individual Interview Schedule

Background questions

1. Tell me a little bit about yourself (Probe for teens: What are your interests? For tweens: what is your favorite thing to do?)
2. How long have you been participating in makerspace activities?
3. What are the reasons for you to go to the makerspace? What do you want to achieve through makerspace?
4. Tell me about what you usually do when you are at makerspace.
5. How well do you feel prepared for makerspace activities? Do you feel like you know what you are doing at makerspace?
6. [Positive Critical Incident Question] Tell me about your favorite time in the makerspace. What happened? Why was it your favorite?
7. [Negative Critical Incident Question] Tell me about your least favorite time in the makerspace? What happened? Why was it your least favorite?

Information practices

8. [Positive Critical Incident Question] Remember a time, either recently or in the past, when you were able to find information that you were looking for and felt good about it? Tell me about this. Where did you find it?
    - What is it about this time that makes you remember it as easy or successful?
9. [Negative Critical Incident Question] Remember a time when you had difficulty in finding some information and did not feel good about it? Tell me about it.

- What is it about this time that makes you remember it as hard or unsuccessful?

10. How do you know if it is good information when you are looking for some information either online or in person? (Probe: do you check the author of a webpage or URL or something else?)

Collaboration

11. [Positive Critical Incident Question] Tell me about a time that you were working/playing/building something with someone else's help in the makerspace and it was fun. What happened? Why was it fun?
12. [Negative Critical Incident Question] Tell me about a time that you were working/playing/building something with someone else's help in the makerspace and it was not fun. What happened? Why wasn't it fun?
13. [Positive Critical Incident Question] Tell me about a time that you helped someone else work/play/build something in the makerspace and it was fun. What happened? Why was it fun?
14. [Negative Critical Incident Question] Tell me about a time that you helped someone else work/play/build something in the makerspace and it was not fun. What happened? Why wasn't it fun?

Technologies and materials use

15. [Positive Critical Incident Question] Tell me about a time at makerspace that you used some technologies, tools, or materials that was very helpful for your making stuff. What happened? Why was it so helpful?

16. [Negative Critical Incident Question] Tell me about a time at makerspace that you used some technologies, tools, or materials but it was not helpful at all for your makings. What happened? Why wasn't it helpful?

Ending

17. Is there anything else you would like to tell me about your experience at makerspace?

Appendix 5 Photovoice statements

1. Your most favorite place at makerspace
2. Your least favorite place at makerspace
3. The favorite stuff (e.g., technologies, tools, objects, materials, and people…) to use at makerspace
4. The least favorite stuff (e.g., technologies, tools, objects, materials, and people…) to use at makerspace
5. The most helpful stuff (e.g., technologies, tools, objects, materials, and people…) in your participations at makerspace
6. The least helpful stuff (e.g., technologies, tools, objects, materials, and people…) in your participations at makerspace
7. Stuff (e.g., technologies, tools, objects, materials, and people…) that you used to share information with others
8. Stuff (e.g., technologies, tools, objects, materials, and people…) that you used to help you collaborate with others

Appendix 6 Example of field observation notes

Date: 3/24/2017

Three teens showed up and prepared for their demo tomorrow for the maker day. Standing next to each other and trying to figure out.

2:35 Nick types in his laptop and he shows other guys a tutorial

Dylan asks hey they need two...

Everyone is looking at the laptop screen

Nick opens a program Open Pilot

Dylan: “Lets do this”

2:37 Nick said we might need to ask Simon and then Dylan and Nick both left for Simon

Adam stays and reads the tutorial that Nick showed to everyone

2:39 Adam browses and watches the tutorial

Nick gives them the task (“basically this is the task for you to do”)

Adam was looking for something and shouted out that he couldn’t find it and then Nick and Dylan went to see

They talked about other ideas that Nick heard from an Indian kids story

2:46 They all watched together the video tutorial. Nick ask if they want him to fast forward to where they left last time.

While they watch the video, Nick left

2:48 Dylan checks his phone, while Adam worked on the laptop

Dylan stopped and they watch together again

Adam unscrews the blades of the drone

Dylan helps too and asked all the way?

2:53 Troubleshooting together for a second

Nick asks for an Ipad charger and then Dylan gives him

2:56 The controls make noises and Nick stood up and walked over to figure out the problem

Adam and Dylan are trying to figure out he program on the laptop

Nick said that this happened last time

Nick: “Now the red light is on here?” Pointing to the drone

Then Nick walked over and said you have to disconnect the battery

Dylan: “Oh its working”

Nick: We are just start. we just last time just one and two worked --bring prior experience

Adam: There is smoke coming out

Nick asked to sit at Dylan’s seat and unscrew one blade, and when Asad was hitting something Nick said no no no

Nick: Hit next, not the start

Nick: Wait for the beeping end

Dylan is on his phone

Nick: It’s burned right? This happened last time…--bring prior experience

Nick feels the drone by touching it

Nick: Why it went perfectly ...

3:07 Nick: this is weird, this is hot, its beyond hot

Nick operates on the drone, Adam works on the laptop

Quiet group compared to the BETA team

Nick: Did you select this?

Adam: Yeah the video said so

Nick: We don't have that, that might be it

Adam: You said two?

Nick: Yeah

Adam: Save it or not

3:11 Nick: Yeah

Adam watches the tutorial

Watching the tutorial and following the steps to configure the control

Quiet

3:17 Some of the blades not working

Adam: You finish the whatever water thing and I'll do this

Ok, what just happened? Computer just spoke?

Nick: Its progress, progress, it didn't happen last time

Adam: I'll do the four?

Nick: No no don't do anything

Dylan falls asleep on the table

Nick: Use two blades, would it fly?

3:22 Talking about the school and extracurricular stuff

Nick asks Dylan to go get the box

Adam and Dylan tie up the parts together while Nick works on the water park

Adam: We did it and you want us to plug in and stat?

Nick: Yeah

Smoke coming out, then Nick walked over right away

Nick touches the parts and try to figure out where the smoke come from

3:49 They try to figure out the problem

Simon helps them to get the pressure off, and suggesting them figure out what parts needed to be replaced and he could purchase them

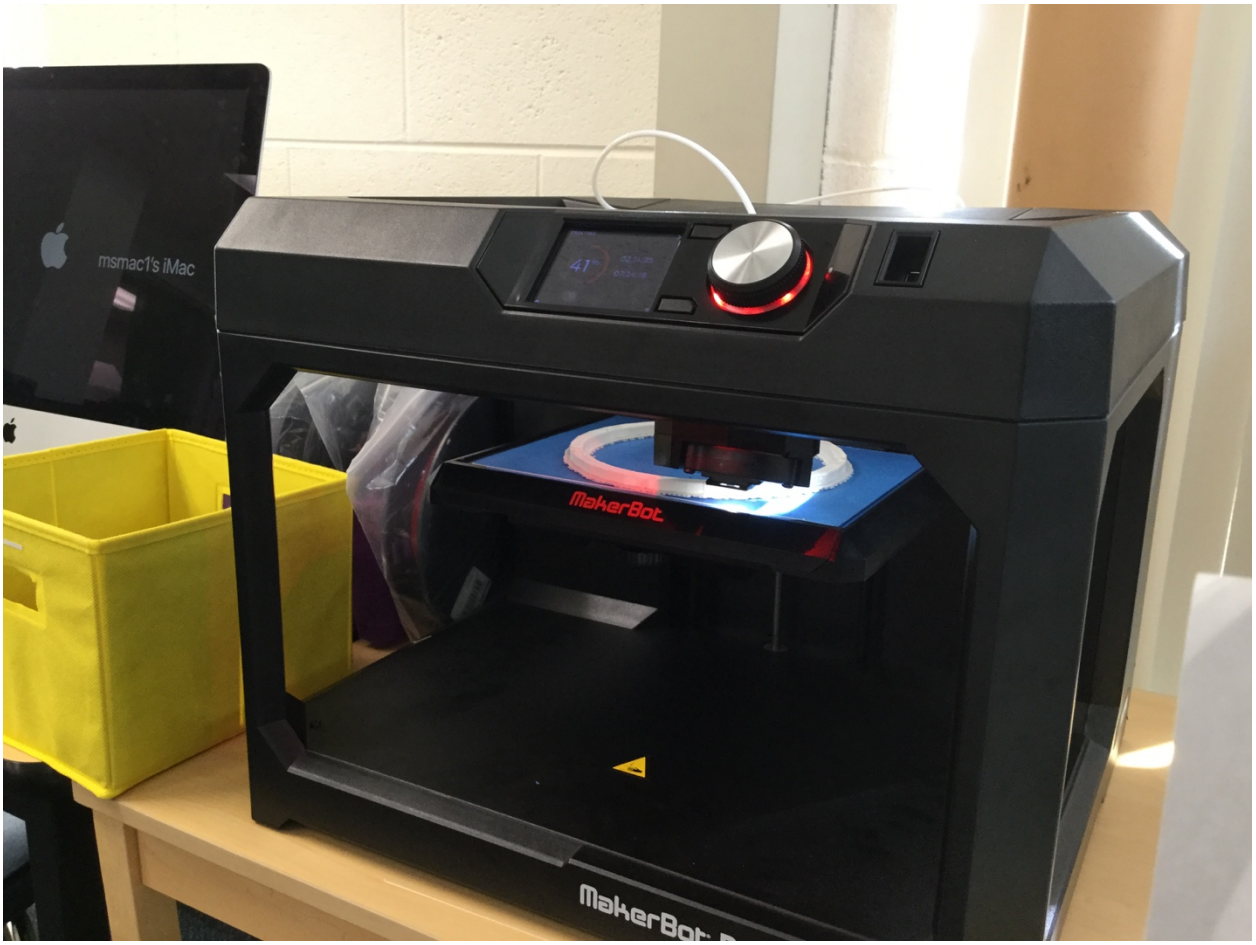
3:55 At the end, Dylan flies off a rubber band to Adam and Adam is upset

Then they had some kinda argument about who has done damage to the drone. Nick said that he has an hour to trouble shoot

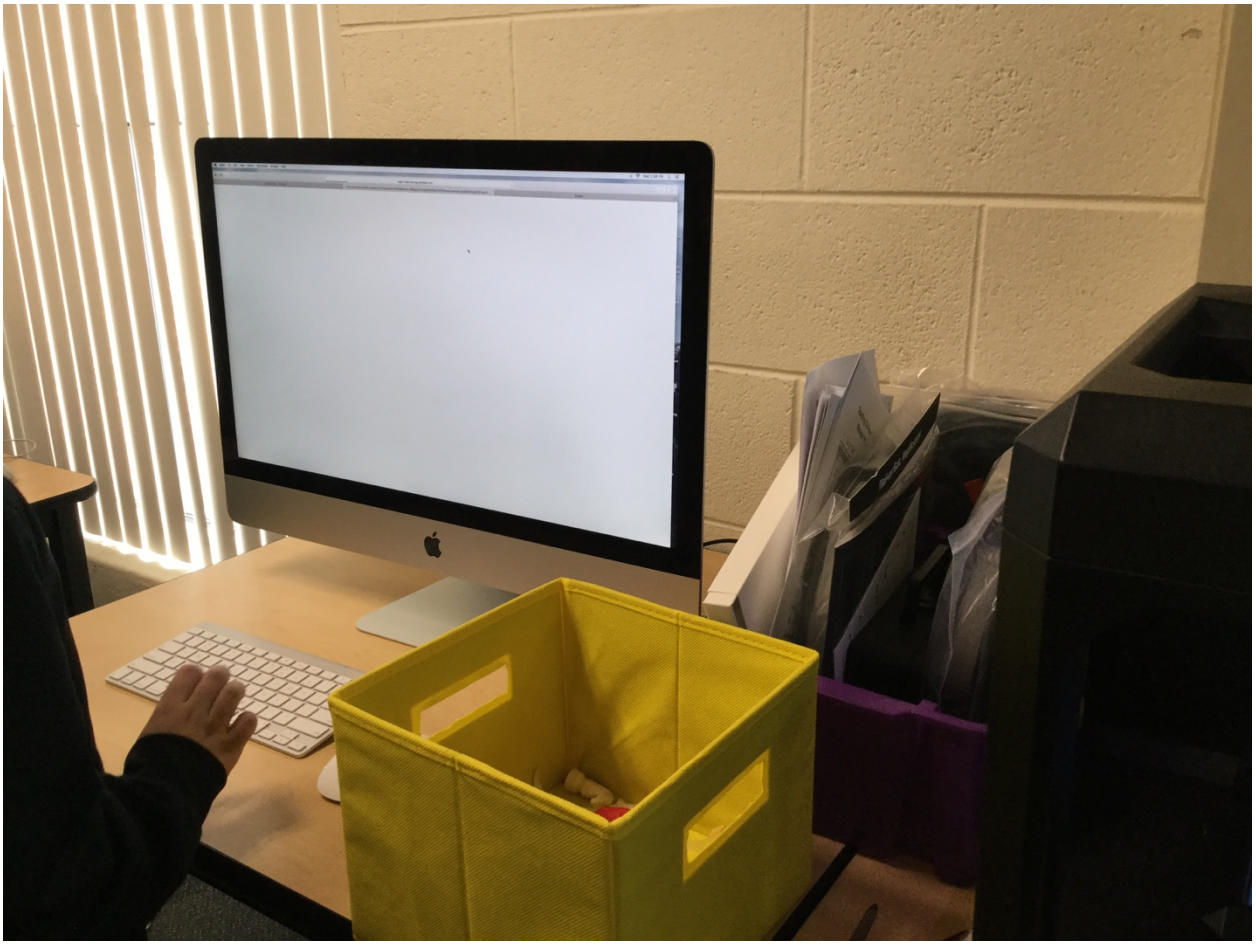
It got a little bit tense at the end when Dylan threw a rubber band at Adam. They also got pressured from the failure of flying the drone. They said they will spend another hour to work on it. But if not, at tomorrow's maker day, they will just show their unfinished drone.

Appendix 7 Example of photos collected from the photovoice method

These three photos are examples for the photovoice task #3: The favorite stuff (e.g., technologies, tools, objects, materials, and people…) to use at makerspace.



Example for #3 photo task 1



Example for #3 photo task 2

Example for #3 photo task 3

Appendix 8 Example of memo in data analysis

Below is the memo that captures the researcher's process of coding, especially when the researcher decides to add new codes or change existing codes. It also captures the researcher's confusions in the process of data analysis.

4/11/2017

As I read this transcript, I notice a recurring thought but that is not coded before, so now I generate a new code. Next I need go back to the texts that I have coded to identify other texts that can fit to this code.

4/12/2017

I also constantly listen to the audio while I code to make sure I do not miss any sentences or words from the participants, or I do not misunderstand participants' words.

4/13/2017

As I was coding the second transcript, somewhere in the middle of this transcript, I started to organize the nodes because they were getting too many and I can also see some patterns and themes emerging, for example, I have been coding emotions, collaborations, and resources.

4/15/2017

I have been reading literature on makerspace and informal learning as well as collaborative information seeking, concurrently with the process of coding. Sometimes I wonder what specific code I use means and if the literature talks about it. As I am coding Mauger_P1, I first see if a section of transcript can fall under the existing codes. If not, I create new one and think about the relation between the new ones and existing ones, for example, what is the relation between novelty and curiosity.

As I code, I also look through the existing codes and see if I can combine and merge some of the codes that basically refer to the same thing, or I move some codes under a higher level code.

But at the same time, I try not to create too many levels of hierarchy to avoid the difficulties of rearranging them as I code more transcripts. Charamaz talked about this in her book. Need to check.

4/17/2017

Right now it seems it's difficult to figure out the relations between individual information seeking and use, use of stuff in makerspace, and collaborative information seeking. It seems that when people seek information, it is more like problem solving, sometimes they are asked to help others; they get ideas from the teachers.

7/13/2017

How I coded Mauger_P6 today was to quickly code the transcript paragraph by paragraph mostly. I usually generate new codes and not think about which existing code this new code should belong, unless it's very obvious for me that this code falls under a certain existing code. After I code the whole interview, I go back to all the new codes, and compare it to existing codes, to see if this new code can be combined and put under a certain existing code, and if this new code doesn't not fall under any existing code, I will treat it as a new finding.

I am comparing the node "Makerspace as a creative space" and the node "Makerspace as a wonder space". I think just saying Makerspace as a creative space is not clear. So now I am distinguishing the nodes that indicates that makerspace allows young people to use imaginations and creativities, and makerspace gives young people

freedom of doing whatever they want without following certain steps like how they learn in traditional classes. For instance,

"P: I mean…like over time the teachers tell you, you have to listen to these steps for you to get the correct answers, you have to listen to these steps for you to succeed, just do good and follow these steps and you will be fine, but you don't get people saying, you know, try to figure it out, use your imagination, you get people saying, follow the exact steps, so while here in the technology club and in the makerspace, you get to kind of use our creativity and our imagination to create things, but with Legos, I think I saw some sort of, I don't even remember what it was, but I think it was pretty cool, over here, you don't follow certain steps, you get to create your own steps, so I think this is, the makerspace is a great thing and I think all schools should have one" (Mauger_P6).

After comparing the node "Makerspace as a creative space" and the node "Makerspace as a wonder space" which had the node "Freedom of doing whatever they can think of", I deleted the node "Makerspace as a creative space" and moved the node "Freedom of doing whatever they can think of" directly under characteristics of MS

Question: what is the relation between node "Makerspace allows young people to use imagination adn creativity" and node "Freedom of doing whatever they can think of"

7/19/2017

In deciding if I should code it as stock of knowledge or prior experience, I think I would go with prior experience, because of the theoretical framework using Lave and Wenger's community practice and situated learning. With this theory, I shouldn't talk about knowledge, it should be experience.

7/21/2017

I’m having a hard time to code "why makerspace" vs. "makerspace norms", and the sub codes "opportunities" and ‘desired outcomes’ of "why makerspace"

8/14/2017

changed a lot of codes to -driven codes, which were influenced by the notion of connected learning. I think my findings will point out that makerspace is an example of connected learning.

8/15/2017

I’m going to go through all the codes under RQ1 and make sure that all the sources were coded, and make sure that all the coded texts fit the themes under RQ1.

8/31/2017

deleted code “opportunity of hands-on experience” and moved the cases under the code “opportunity of creations and productions”.

Appendix 9 Examples of "juicy quote"

Alice (SLM) stated: "P: I don't really know, it's just I never really saw anyone walking around with something from the 3D printer. My friends never 3D printed last year when they had it, so I just, I have never really noticed that it was like I have never seen it being printing, so I just, I just didn't really think about it, it's just seems like oh we have a 3D printer, so she said that, she was showing us how to make a chain, the other kids, I was doing the Sphero at the time, but she was showing the other kids how to make a chain, and I was like it was just a simple chain, it couldn't move, it was just like a block, a block kinda looks like a chain, and I said oh can you make something move and she said I'm not teaching that, I don't know how to do that, but if you want, you can figure it out, so I figure it out (laughter), and I actually printed out a couple of trials, and they all turned out pretty well, but I, like each time I got to make the chain better and better, and so I had set goal of, with my computer teacher in my computer class told us that later in the year we would be doing 3D printing, and that everybody is going to print a costume piece, so everybody in the play that I'm in is gonna wear, hopefully, wear a costume piece made from the 3D printer, so that's combining kinda like two of my favorite things, and so I'm going to make amount of codes for certain characters in the show, so I was making a chain, then I have a couple of chains, then I just have to disassemble them everything, but I'm almost done, I'll show you the finished product later, but I'm almost done with the chain, I have all the parts and stuff, and now I'm making something for my friend's birthday."

Mike (SLM) stated: "well, I mean, in both classrooms and when creating anything, you still have to follow steps, if you do in some random order, nothing is going

to happen, you have to follow certain steps for you to get, if you want to succeed, so hmm you…if you do not follow the correct steps, you are going to mess up, if, also, there are some differences, for example, here we are kind of more independent well over there, the teacher also checks on us, but in a classroom, the teacher would help us most of the time, you have such tutorials first on what we are doing, and we have to follow the exact same things and do the exact same thing, and not have the independence and the ability of create our own design, and the other thing is in a classroom, you are in a less flexible environment, here you can move the chairs around if you wanna do something, and over there, you move a chair, the teacher says what are you doing, put the chairs back, not to mention there are like 50 other students, and like 25 other students, and most of them would be sitting on the chairs that (IF) you are moving, that's a problem, you…in a classroom, you still, you do, you work hard, and same thing here, over there, you might not be interested in a topic or you might not want to do it, which I personally I love math, I love science, I love pretty much every school subject, so I'm not so against, but in many other cases, it's different, where students don't want to do it, and then the students to join the makerspace, they have the ability to do whatever they want to do, and kind of work their way, so yeah."

Neil (PLM) stated: "I think it depends on what the person really wants to do. Some people just want to have a 3D printed object of their own. Some people want to learn how a 3D printer works, and some people want even more than that. For those who want even more than that, it's great that the makerspace provides these options to learn more, but for those who don't care or simply want or have the time to learn those new

applications, it's nice that they can simply go up and find a file and print something out of their own."

Ken (PLM) stated: "Okay. So the difference between learning at makerspace and learning in the classroom is learning in a classroom, a lot of it is theoretical. We'll learn theories, we'll learn things, but we won't always in experiments. Once in a while we'll do an experiment in class, but we can't always model what we learn in class. Like if we learn something in Physics, like Hooke's law, we may not always in experiment. Like Hooke's law is a law about force applied on like a spring and so it's about the force that's needed to apply to stretch it a certain length. You might not always do an experiment on it to determine certain parts of the equation. But like being able to do in makerspace is what we learn, we apply. It's hands on and so we don't get that in the classroom studying all the time. We get why ... no, we get what in a classroom setting, but we don't really get why. So why is this? Why does it work this way? We don't get that. We just get what this happens. But when we're doing something hands on like makerspace, we get the what and the why. What happens and why does it happen. That's why makerspace is a pretty good experience."

Nick (PLM) stated: "or the longest time before, I didn't have a meter when I was younger. I got used to determining different voltages by tongue so I can just tell. I can tell what nine volts it, and what five volts is. It's about how much it zaps my tongue."

Appendix 10 Coding scheme for RQ 1[2]

Theme/category	Definition	Example	# of participants (N = 21)	# of mentions
MAKE (major theme)	Actions of creating and constructing something, either tangible or digital, with the use of technologies, materials, and tools at makerspace		21 (100%)	345
Opportunity to make (sub-theme)	A hand-on opportunity where young people can create and build products		18 (86%)	69
Freedom to make (category)	Participants value the freedom, choices, and independences in making something at makerspace	"you could create anything you want to, you could use the 3D printer to make your own design or find a design on your own and print it out" (Nathan, PLM)	12 (57%)	36
Resourcefulness (category)	Participants value the stuff that makerspace offers	"there is plenty of tools that one can use inside the makerspace…" (Ryan, SLM)	9 (43%)	12
Disruption of making (category)	Frustration when the opportunity of making is disrupted	"I get frustrated sometimes when people tell me to relax, because then that makes it worse	5 (24%)	8

[2] This is a portion of the coding scheme. The full coding scheme is too long to include in the appendix. Major themes, sub-themes, categories, and sub-categories of the coding scheme are described in Chapter 4.

		for me cause I don't, cause I am trying to do something" (Alex, SLM)		
Outcome Enjoyment (sub-theme)	Positive feelings as a result of making and building	"usually it's always fun, I love coming here like Wednesday is the highlight of my week" (Ian, SLM)	21(100%)	140
Outcome Construction of products (sub-theme)	The results of making and building, either tangible or digital		21 (100%)	128
For fun (category)	Making for entertaining purposes	"I made this cool doorbell, and it was pretty funny because I made a really funny sound so it was pretty cool" (Katie, SLM)	15 (71%)	44
Practical purposes (category)	Making to meet a real-life need	"I'm making something for my friend's birthday" (Alice, SLM)	16 (76%)	33

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