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CREATIVE SELF-EFFICACY, TECHNOLOGY ACCEPTANCE AND THE THEORY OF PLANNED BEHAVIOR: ANTECEDENTS TO A MAKER'S INTENTION TO RETURN TO MAKE

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CREATIVE SELF-EFFICACY, TECHNOLOGY ACCEPTANCE AND THE THEORY OF PLANNED BEHAVIOR:
ANTECEDENTS TO A MAKER'S INTENTION TO RETURN TO MAKE

A THESIS APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

BY

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Dedicated to Fab Labs around the world, and to makers past, present and future.

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Abstract

Fab Labs, Makerspaces and Hackerspaces are part of a decentralized global Do-It-Yourself movement providing unique resources to tinkerers, hobbyists, inventors and artists to make almost anything. Individuals who use these facilities are often called "makers." This preliminary research offers insight into why people intend to return to making by testing a proposed Maker Behavioral Model based on the Theory of Planned Behavior, the technology acceptance model, and creative self-efficacy. This model proposes three key characteristics which predict an individual's intentions to continue making, namely social interactions, creative behaviors, and perceived behavioral control. A survey of the membership of Fab Lab Tulsa and other U.S.-based Fab Labs was used to test the maker model by examining the members' attitudes and behaviors about creativity and making, technology, their social group, their openness to experience, and their creative role identity. It also examined the correlation with their intention to return to make. The results demonstrate that perceived behavioral control is the biggest predictor of maker intention, followed by creative behaviors and social interactions. Technology perceptions were related to social interactions but did not predict intention. This preliminary research has implications for any Fab Lab that seeks to bolster its membership, improve its staffing or increase facility usage. Future work should include development of the survey for non-English speakers and non-U.S. cultures.

Creative Self-Efficacy, Technology Acceptance and the Theory of Planned Behavior: Antecedents to a Maker's Intention to Return to Make

Fab Labs, Makerspaces and Hackerspaces are proliferating at a rapid pace and are all part of a decentralized global Do-It-Yourself movement providing unique resources to tinkerers, hobbyists, inventors and artists to make almost anything almost anywhere. These facilities are havens for clever individuals who have nowhere else to go (Gershenfeld, 2015). The people who use these facilities are called many things, but the most fitting moniker is "maker," a term which *Make Magazine* founder Dale Dougherty coined in 2005, along with the term "maker movement" (Dougherty, 2016, para. 1). Makers make many things ranging from robots to furniture, food to mobile computing applications, and drones to wooden toys. The advent of these "making" facilities is a precursor to a new model of personal manufacturing that emphasizes mass personalization instead of mass production. This represents a paradigm shift in manufacturing. When things can be made for one, for a few or for many, then new possibilities exist for economic, manufacturing and social development (Gershenfeld, 2015). These possibilities are further enhanced when it is "possible to fabricate items globally by doing it locally across many locations, and shipping the data to make the product, but not the product itself" (Gershenfeld, 2015, p. 11). In contrast to current industrial practices, the maker movement democratizes technology so that design projects maintain a personal context and are of personal interest while simultaneously having the potential to be shared and distributed globally through a network of making and invention (Fab Foundation, n.d.).

This paradigm shift presents many interesting questions, primary of which is "what makes a maker?" This question must be answered if Fab Labs, Makerspaces and Hackerspaces are to become common resources in society for makers and non-makers alike.

Fab Labs

An outgrowth of a program which originated at MIT, the Fab Lab concept brings together five core pieces of computer numeric controlled (CNC) equipment (i.e., 3-axis table mill, 3-axis desktop mill, 40W desktop laser cutter, desktop vinyl cutter, and electronics fabrication station) into a single facility for individuals to design and fabricate everything from shoes to electronic sensors, and nearly everything in between. From the first Fab Lab in South Boston established in 2001, to the latest Fab Labs in South America, China or Africa, makers are establishing Fab Labs as school-based classrooms, community centers, critical infrastructure in urban planning, or even as vital response tools in refugee camps or during disaster recovery. Fab Labs have almost universal application.

Fab Lab Tulsa

The Hardesty Center for Fab Lab Tulsa was founded in 2008 as a 501(c)3 non-profit corporation with the mission of providing 21st century tools and equipment to the general public to make almost anything (Fab Lab Tulsa, n.d.). In 2015, the Hardesty Center for Fab Lab Tulsa had nearly 18,000 visitors including about 2,500 students (N. Pritchett, personal communication, 2015). The lab has almost 400 dues-paying members but still relies heavily on philanthropic foundations, corporations and individual donors to sustain its operations. Fab Lab Tulsa and similar labs seek to

increase the number of dues-paying members given that earnings from memberships are not restricted to spending on specific programs whereas philanthropic funding from foundations and corporations often are restricted. Consequently, the success of maker organizations depends in part on increasing their numbers of dues-paying members.

One of the observations made by Fab Lab Tulsa staff since the lab opened is that such a wide array of fabrication equipment and design possibilities is simply overwhelming to many people and therefore intimidating (N. Pritchett, personal communication, 2015). As a blank page is to the writer, so is the Fab Lab to a potential user. Fab Lab Tulsa has sought to overcome this barrier to usage by offering low-priced introductory memberships, training classes, friendly staff and free hands-on technical support.

Fab Lab Research

Academic research into the subjects of makers, making, makerspaces and Fab Labs appears to be quite new. The majority of existing sources (e.g., School Library Journal; American Libraries; Knowledge Quest; Psychology of Aesthetics, Creativity, and the Arts; Nexus Network Journal), in order of prevalence, tend to be related to: libraries and their integration of makerspaces, the relationship between makers and the general field of innovation, makers and entrepreneurship, and makers and intellectual property. Popular sources abound, however, in books, blogs and websites.

The current study is not the first academic research, however, involving Fab Lab Tulsa. The Center of Applied Research for Nonprofit Organizations (CARNO) from the University of Oklahoma-Schusterman Center in Tulsa conducted research focused

on measuring the influence that Fab Lab Tulsa has on children's measures of self-perception and attitude regarding science, technology, engineering and math (STEM) experiences (Dubriwny, Pritchett, Hardesty, & Hellman, 2016). The study was conducted with school-age children from Tulsa metro area schools. Students self-perceptions of science, technology, engineering and math were measured before and after using the Fab Lab to complete a project. The results indicated that the students' experiences with Fab Lab significantly increased their self-efficacy regarding their own STEM abilities. The current study represents an extension of Dubriwny et al.'s (2016) research to focus specifically on creative self-efficacy and using an older demographic. The current study seeks to both understand why some individuals intend to return to Fab Lab to continue making while others do not and to understand which variables are most likely to influence participants to return.

Maker Behavioral Background

In order to best understand factors related to a maker identity, this research proposes a model entitled the Maker Behavioral Model which was developed as a hybrid of the Theory of Planned Behavior (TPB; Azjen, 2002) and the Technology Acceptance Model (TAM; Davis, Bagozzi, & Warshaw, 1989) and which also incorporates results of evidenced-based research regarding the construct of creative self-efficacy (Bjornberg & Davis, 2015). Each of these contributes to the proposed model in a different way. The Theory of Planned Behavior forms the backbone of the model owed largely to its widespread use and acceptance explaining behavior. The Technology Acceptance Model is included to help account for a maker's acceptance or reluctance to use the technology typically found in a Fab Lab. Creative self-efficacy

is included as it is presumed that creativity and the creative process are integral to making.

Components

Theory of Planned Behavior. Icek Azjen proposed the Theory of Planned Behavior (TPB) in 1985 as an expansion of the Theory of Reasoned Action (Azjen, 1985). The Theory of Reasoned Action follows the causes and links from beliefs, through attitudes and intentions, to actual behavior. It focuses primarily on behavior which is within a person's volitional control (Azjen, 1985). The TPB is applicable because not all behavior, however, is under control. This means that the success of an attempt to execute a behavior depends on both the strength of the attempt and also on the individual's control over factors like information, skills, abilities, will power, time, and opportunity (Azjen, 1985). Overall, people will attempt a behavior if they believe the behavior is supported by their referent social group (i.e., subjective norm or peer pressure), and if they believe the behavior is important, valued or worthwhile (i.e., their attitude toward the behavior). Further, they will succeed in their attempt if they have adequate control (i.e., perceived behavioral control) over internal and external factors such as their free time to visit the Fab Lab, transportation or finances (Azjen, 1985).

The TPB, shown in Figure 1, is widely used to describe behavior across a number of domains. It has been used to predict above-average participation in volunteerism (Greenslade & White, 2005) and also individual creative performance (Choi, 2004). Greenslade and White's (2005) research on volunteerism is particularly interesting because it demonstrates that the TPB accounted for three times more

variance in predicting above average volunteerism than did the alternate functional approach they studied. Greenslade and White (2005) suggest that the social factors in TPB may be the cause for the increased variance compared to the functional approach, which emphasized individual factors. This suggests that a maker's social affiliations inside and outside of Fab Lab Tulsa might play a larger role in their intention to continue making than their individual motivations. In other research, the TPB has found use in identifying factors influencing teachers to use educational technology (Lee, Cerreto, & Lee, 2010) as well as studying offline and online civic engagement amongst young adults from different ethnic groups (Jugert, Eckstein, Noack, Kuhn, & Benbow, 2013). Research by Lee et al. (2010), which demonstrated that the TPB is best used as a behavioral predictor when the research questions are as specific as possible, provides support for the current study given that it investigates a specific topic (i.e., making) over specific behaviors (i.e., design and fabrication) and constraints (i.e., lab equipment and access). Given its wide use and focus, the TPB is a relevant model for the current research about makers and their intention to return to making.

Technology Acceptance Model. The Technology Acceptance Model (TAM) was introduced in 1986 by Fred Davis as an adaptation of the Theory of Reasoned Action (Azjen, 1985) which was specifically tailored for modeling user acceptance of information systems (Davis et al., 1989). Ideally, the TAM is a model that is not only helpful for prediction but also explanation. This means that both researchers and practitioners can identify why a system is unacceptable and can pursue corrective steps (Davis et al., 1989). TAM postulates that a person's behavioral intention to use

a system is influenced first by his or her beliefs about the system's ease of use and perceived usefulness, and second by the person's attitude toward using the system. Perceived usefulness also influences behavioral intention (Davis et al., 1989), while behavioral intention influences actual system use.

Like the TPB, TAM has been used in several technology domains (see Figure 2) such as to predict teachers' adoption of technology (Holden & Rada, 2011) including mobile technology (Tsai, Want, & Lu, 2011). Further TAM has helped to predict consumer acceptance of smart grid technology (Toft, Schuitema, & Thogersen, 2014) and nurses' acceptance of electronic medical record systems (Kuo, Liu, & Ma, 2013). In research about medical record systems, Kuo et al. (2013) showed that the TAM is a valid predictor of intention to use technology and those who are optimistic about technology are the most likely to use it. Inclusion of TAM in the proposed Maker Behavior Model is especially appropriate given the observations of Fab Lab Tulsa staff about users' mixed reactions to the computing and fabrication systems in the lab.

Creative Self-Efficacy. Creativity has been defined as any creation which is novel, appropriate, and useful as determined by society or a group (Sawyer, 2012). Creativity also includes elements of style, defined as the degree to which the creation combines unlike elements in a refined, developed, and coherent unit (Besemer, 2006). This means that both the context of a creation (i.e., its novelty and style) and its perceived usefulness determine whether or not it is truly creative. Creative products may range from knitting or other crafts to metal shapes machined with computer-controlled equipment. Building upon creativity, creative self-efficacy is a domain-specific efficacy belief describing an individual's opinions about being able to

generate creative outcomes (Bjornberg & Davis, 2015). An individual's attainment of such a creative behavioral goal, however, is dependent on his or her control of the behavior involved (Azjen, 1985). In other words, in creative pursuits people with high creative self-efficacy believe they can develop novel ideas or solutions because of their high perceived behavioral control (PBC), an element of TPB.

Bjornberg and Davis (2015) demonstrated through a meta-analytic examination that there are five antecedents to creative self-efficacy in organizations: creative role-identity, openness to experience, workplace support, leadership, and workplace creativity expectations. In the proposed maker model, leadership and workplace creativity expectations as antecedents will not be examined because they focus externally on an individual's workplace whereas Fab Lab Tulsa, as it relates to makers, is not a workplace having the typical departments, teams, support, leaders, management or expectations found in an employment setting. Therefore, three elements remain: workplace support, creative role identity and openness to experience which are relevant to the current research because they focus on external social support systems and internal personal characteristics. For this research, workplace support is renamed Fab Lab support.

Purpose of the Current Study

The goal of the current study is to identify factors that affect individuals' likelihoods of returning to a Fab Lab to make again, and then to synthesize them into the Maker Behavioral Model. This research will use empirical analysis of user (i.e., customer) attitudes, opinions and beliefs to understand intent to continue making, an important practical concern for Fab Lab growth. With this understanding there exists

the potential to determine which of those predictors can be utilized to stimulate growth of the organization. This knowledge can help other Fab Labs boost their numbers of dues-paying members, or even help identify well-suited potential volunteers or staff members.

Maker Behavioral Model

The TPB, the TAM and creative self-efficacy are blended to form the presented Maker Behavioral Model. Specifically, the TPB is enhanced with the TAM and creative self-efficacy to produce the complete model, and this research, conducted through a survey of new and seasoned Fab Lab users, tests it. The model is shown in Figure 3.

Elements noted as "Future Research" in Figure 3 are shown for reference only and are borrowed from research on sustained volunteerism. In that research, sustained volunteering is preceded by a volunteer identity which is preceded by an intention to return to volunteering, which in turn is preceded by an initial volunteer experience, and which is preceded by an intention to volunteer (Penner, 2002). While it is desirable to understand sustained making, it is outside the scope of this research to undertake longitudinal efforts to do so. Therefore, based upon research regarding intention to return to volunteering, the key element of intention to return to make was the foundation of the presented model, with specific focus on how intention overlaps with the TPB and the TAM, shown in Figures 1 and 2, respectively. Thus, it is hypothesized that,

> *Hypothesis 1: The intention to return to make will be predicted by an individual's perception of technology usefulness, creative self-efficacy, perceived behavioral control, subject norm and attitude toward making.*

Hypothesis 1 is relevant for several reasons. Self-efficacy and perceived behavioral control are related within the context of the TPB, which has been integrated into the MBM because of its suspected relationship to makers and their decisions related to making. Subjective norm is used so that the relationship between an individual's intention to return to make and the influence of the individual's social relationships on his or her intentions can be understood. The TPB stipulates that an individual's attitude toward a specific behavior will indicate his or her intention to behave that way. Therefore, attitude is included in the MBM in order to understand the role that attitude plays in predicting an individual's intention to return to make.

To further explain H1, the elements ease of technology use and usefulness of maker technology are borrowed from the TAM. They are used to test the relationship of technology to both creative self-efficacy and intention to return to making. Regarding ease of technology use, it is believed that an individual who finds technology easy to use will have higher creative self-efficacy (PBC) because if the individual can effectively use technology for making, then his or her belief that the technology can be used to generate creative outcomes should be enhanced. The other element of the TAM, usefulness of maker technology, is essential to understand because experience at Fab Lab Tulsa suggests that technology usage is a barrier to making. It is believed therefore that if an individual does not believe that maker technology is useful then he or she will not use it, and that intention to return to making will be reduced.

Creativity is believed to be a key component of making, and so the elements openness to experience, creative role identity, and creative self-efficacy are borrowed

from research by Bjornberg and Davis (2015) about creative self-efficacy, as noted previously. Openness to experience reflects the degree to which an individual is willing and confident to try new things (Bjornberg & Davis, 2015). While openness relates to any new experience, in this research, an example might be an individual enrolling to be a member of Fab Lab Tulsa, or a current member starting a new project with an unfamiliar piece of equipment. This suggests that,

> *Hypothesis 2: Openness to experience will correlate positively with an individual's creative self-efficacy.*

Creative role identity is an internalized identity developed by an individual over time based upon expectations of others (Bjornberg & Davis, 2015) thus, this identity has a social context. For example, in a work or non-work organizational scenario, team members may view one person as particularly creative. Those expectations would influence that team member to internalize and to develop a creative role-identity, and therefore to increase the likelihood of continued making. Expectations leading to creative role identity will manifest themselves in the research through an individual's interactions with other people inside and outside of Fab Lab activities. Thus, it is predicted that,

> *Hypothesis 3: Creative role identity will correlate positively with an individual's creative self-efficacy.*

Workplace support, known here as Fab Lab support, is a demonstrated antecedent to creative self-efficacy and is included in the current research because of this relationship (Bjornberg & Davis, 2015). Thus, it is predicted that,

> *Hypothesis 4: Fab Lab support will correlate positively with an individual's creative self-efficacy.*

As noted earlier, it is believed that a person's attitudes about technology will play a role in both his or her creative self-efficacy and his or her attitude about the usefulness of that technology. From this perspective, technology and creative self-efficacy may have a deep relationship because the easier an individual perceives the technology to use, then the more confidence in or stronger the beliefs that the individual has in his or her ability to be creative and to make things. Building on this logic and incorporating previous research on the TAM, it follows that a person's attitude about the ease of use of technology will be related to his or her attitude about the usefulness of the technology. Thus, is it hypothesized that,

> *Hypothesis 5: An individual's attitudes about technology ease of use will correlate positively with an individual's creative self-efficacy.*
>
> *Hypothesis 6: An individual's attitudes about technology ease of use will correlate positively with an individual's attitude about the technology's usefulness.*

As users spend more time making it is believed that their intention to return to and to continue making should strengthen as a result of their exposure to the maker environment and culture. Conversely, users with less making experience should be less committed to making and have less intention to return to make. Thus,

> *Hypothesis 7: Tenure will be positively correlated with intention to return to make.*

Methods

Participants

Participants in the study were adult members of Fab Lab Tulsa and other U.S.-based Fab Labs. The participant pool included new as well as long-established Fab Lab members. A total of 96 individuals responded to the survey. Of those, 83 provided usable responses. Fitting with recent demographics from Fab Lab Tulsa

(King, Holbrook, Sanders, & Williams, 2014) the majority of respondents were males between the ages of 30 and 49 years. Specifically, the sample was 81% male and 19% female with an average age of 44 years (*SD=14.1*). Self-reported educational attainment suggested that most participants had advanced education: 35% indicated having a graduate degree, 35% had a bachelor's degree, 20% attended some college, and 10% indicated having completed high school or a trade school.

Measures

Several constructs were measured. Creative self-efficacy, technology acceptance, subjective norm, attitude toward making, creativity and intention to return to make were measured in this study with instruments which have demonstrated suitable levels of reliability and validity in prior research. All assessments and instruments are shown in Appendix A. Cronbach's Alpha coefficients provided below are from published research. Reliability coefficients based on the current study's data set are provided along the diagonal in Table 1.

Pilot tests. After the initial set of items for the measures were selected, the survey was further developed and revised. First, the survey was pilot tested with a group of graduate students knowledgeable in survey design who were also studying the creative process. The cohort proofread the survey for basic grammar and item clarity and provided both written and verbal feedback. Members of the pilot sample were timed while completing the survey, which helped establish that completion took 15 minutes or less. The survey was then revised and re-evaluated by graduate faculty. Many items received only minor alteration but the intention to return to make and attitude with beliefs items were thoroughly reworked to make them more relevant for

the study context. Information from Azjen's website which included a rubric for survey development were utilized in the revisions (Azjen, n.d.). The reworked items were submitted to the faculty committee for review and were subsequently approved.

Intention to return to make. Greenslade and White's (2005) three-item intention to volunteer scale ($\alpha = 0.97$) was used with minor modification for the current study. An example item is "It is likely that I will engage in three or more hours of making during the next month." Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree (1)* to *strongly agree (6).*

Creative role identity. A three item scale developed by Farmer, Tierney, and Kung-McIntyre (2003) to measure creative role identity ($\alpha = 0.80$) was modified for use in this study. The modifications involved removing the word "employee" from the items because employment is not a subject of the current research. Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree (1)* to *strongly agree (6)*. A sample item is "I often think about being creative."

Openness to experience. Openness to experience was measured with 10 items from the International Personality Item Pool (Goldberg et al., 2006), specifically items from the "Openness to Experience, NEO Domain" ($\alpha = 0.82$). Responses were made on a 6-point Likert-type scale with response options ranging from *very inaccurate* (1) to *very accurate* (6). Participants rated how accurately statements described themselves. A sample item is "Have a vivid imagination."

Creative self-efficacy. A three-item scale developed by Seo, Chae, and Lee (2015) to measure creative self-efficacy for IT employees ($\alpha = 0.87$) was modified for use in this study. Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). A sample item is "I have confidence in my ability to solve problems creatively."

Attitude toward making. A four-item evaluative semantic differential scale ($\alpha = 0.94$) developed by Greenslade and White (2005) to measure attitude in their research on volunteerism was modified for use in this study. The modifications involved testing the concept "making" instead of the concept "volunteering." Responses were scored on a 6-point evaluative semantic differential scale ranging from (3) to (-3) in which participants rated their attitudes toward making using bipolar adjectives as anchors. A sample adjective pair was "*Pleasant – Unpleasant*."

Beliefs about Making. A four-item scale to measure beliefs about making was developed specifically for this research to understand how individual's beliefs influenced their attitudes. The scale was developed from information posted on Azjen's website (Azjen, n.d.) using guidance for constructing a TPB questionnaire. Responses were scored on a 6-point Likert-type scale with response options ranging from strongly *disagree* (1) to *strongly agree* (6). As sample item is "Expressing my creativity is important."

Subjective Norms. Based on TPB information from Azjen's website (Azjen, n.d.) for creating a TPB questionnaire, a four-item scale to measure subjective norm for makers was developed specifically for this research to understand how individual's beliefs about their social relationships influenced their intention to return

to make. Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). As sample item is "When it comes to making, I want to be like my friends."

Fab Lab support. An eight item scale from the International Personality Item Pool (Goldberg et al., 2006) was modified for use in assessing Fab Lab support. Specifically items from the "Empathy, TCI" ($\alpha = 0.86$) scale were used. Responses were made on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). A sample item is "Other Fab Lab users are reassuring to me."

Perceived technology usefulness. A three item scale developed by Teo (2012) previously used to measure perceived usefulness with computers ($\alpha = 0.95$) was modified for use in this study to examine perceived technology usefulness. The modifications involved using the words "tools" and "making" instead of "computers." Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). A sample item is "Using technology will improve my making."

Perceived technology ease of use. A three item scale developed by Teo (2012) used to measure perceived ease of use with computers ($\alpha = 0.91$) was modified for use in this study to examine perceived technology ease of use. The modifications involved substituting the word "tools" for "computer." Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). A sample item is "I find tools easy to use."

Perceived behavioral control. A nine-item scale to measure perceived behavioral control for makers was developed specifically for this research to understand individual's perceptions of their control of their making behaviors. This element is sometimes referred to as maker behavioral control. The scale was developed using information from Azjen's website (Azjen, n.d.). Responses were scored on a 6-point Likert-type scale with response options ranging from *strongly disagree* (1) to *strongly agree* (6). As sample item is "How much making I do is up to me."

Design

Operational definitions. Several operational definitions were required to explain the various terms used throughout the research. These terms reflect aspects of creativity, technology and social behavior, and therefore provide a basis to help describe maker activity.

Fab Lab support. Fab Lab support, known in prior research as workplace support, is analogous to the support a user receives from fellow users within a Fab Lab and refers to perceptions that other users care about and value another user's contributions (Bjornberg & Davis, 2015). It is recognized in the current research as the social support system and was derived from the IPIP TCI scale for empathy (Goldberg et al., 2006).

Creative role identity. Creative role identity is an internalized identity developed by individuals over time based upon expectations placed upon them by others (Bjornberg & Davis, 2015). Creative role identity creates a motivational pull

toward creative endeavors and engagement which increase creative self-efficacy over time.

Openness to experience. The final antecedent to creative self-efficacy, openness to experience, is an internal characteristic of those individuals who are more open to new ideas and experiences, and more willing and confident to try new things (Bjornberg & Davis, 2015). Having such openness will lead to increased creative self-efficacy over time.

Technology ease of use. Technology ease of use is defined in this research as the degree to which an individual perceives a particular piece of maker technology as easy to use or free of effort (Davis et al., 1989). Perceptions of ease of use vary between people and will vary depending on the sophistication of the technology.

Technology usefulness. Technology usefulness is defined in this research as the prospective user's subjective probability that using a specific maker technology will increase his or her making performance (Davis et al., 1989). Usefulness was determined by the effectiveness of the technology at achieving the requirements of the creative effort or the desires of the maker.

Maker technology. In the current research, maker technology is defined as technology used in a Fab Lab. This includes the design tools (e.g., design software, computer coding tools, and CNC programming tools), main equipment (e.g., 3D printers, CNC router, laser cutter, vinyl cutter, mini-mill, and electronics workbench) and supporting equipment (e.g., band saw, belt sander, other power tools, and hand tools).

Fab Lab members and users. Other definitions include those for new and seasoned users, as well as Fab Lab members. For the purpose of this study, member is operationalized as an individual who had a current, non-expired individual or family/group membership to a Fab Lab at the time of study.

New and seasoned users are differentiated by the combined length of their Fab Lab usage and/or membership. *New users* are defined as those individuals who first used the Fab Lab or paid for their first membership within the last six months. The mention of a "first" membership or usage is important because some seasoned users may have been users or members some time ago, then let their usage or membership lapse but have recently rejoined within the last six months. In these circumstances, these users would not be new users. *Seasoned users* are defined as those individuals who have used or paid for combined memberships for six months or more. In this case, for example, a member who had a membership or had been a user for eight months, left the lab for six months, and then returned as a user or to the membership rolls again would have a combined membership/usage of 14 months. In the study, participants were not asked to define themselves as new or seasoned users but only to indicate the combined length of their memberships or usage.

Research design. The design included use of multiple statistical methods. In addition to Pearson correlations, exploratory factor analysis was conducted to determine whether the large number of experimental variables could be grouped, therefore simplifying and focusing the results for future application in Fab Labs. If the data cannot be shown to group using this analysis then it might be more difficult to use the expansive research results to offer focused recommendations to improve Fab Lab

operations. The exploratory factor analysis was performed on the following independent variables reported in Table 1: perceived technology ease of use, perceived technology usefulness, Fab Lab support, subjective norm, creative role identity, openness to experience, creative self-efficacy, and perceived behavioral control. Intention to return to make was not included in the factor analysis because it was the primary dependent research variable.

Procedure

Following IRB approval (see Appendix B) a recruitment letter (see Appendix C) was distributed to relevant Fab Labs in the U.S. Fab Labs which agreed to help recruit members for participation in the study included: Fab Lab Tulsa (Tulsa, OK), BiG Fab Lab (Bowling Green, OH), and AS220 (Providence, RI). Fab Lab San Diego (San Diego, CA) was invited to participate but no responses were collected from San Diego area zip codes. Similar community-based Fab Labs in Biddeford, ME and El Paso, TX were contacted, but did not respond to requests. Surveys were distributed via Qualtrics, an online survey tool. Participants were only allowed to respond to the survey once. The survey was opened on March 21, 2016 and closed on May 31, 2016 after approximately 96 responses were collected from users of the three Fab Labs mentioned above.

Two major issues surfaced during data collection. First the vast majority of respondents were from zip codes near Tulsa, OK despite multiple efforts to expand the pool of respondents including offering a $25 USD cash incentive. Of the 96 respondents, 86 were from Tulsa, nine were from Bowling Green, and one was from Providence. The second issue was that the items for intention were erroneously

missed in the original survey release. This required another release but only 10 responses were recorded for intention to return to make before the data collection time period ended.

After collection, the raw data set was reviewed and cleaned to ensure data could be analyzed. For instance, the birth year of respondents who only provided a 2-digit year instead of the requested 4-digit year were corrected; similarly the word "months" was removed from a response asking how many months the respondent had been using a Fab Lab. Second, relevant items were reverse-coded prior to analysis. Reverse coded items were used on scales for creative role identity, openness to experience, attitude, and intention to return to make. The responses from the survey were analyzed using IBM SPSS version 24 (IBM Corp., 2015). Internal consistency reliability analyses were conducted to ensure adequate reliability prior to forming composite scores for each scale. Internal consistency reliability could be improved by removing some items prior to forming composite scores. This included removing one item from each of the following scales: beliefs, attitudes, and subjective norms. Item removal raised Cronbach's alphas for these scales from 0.94 to 0.95, 0.84 to 0.88, and 0.65 to 0.70, respectively.

Results

Descriptive statistics, internal consistency reliabilities, and bivariate correlations for all variables are reported in Table 1. For this study the criterion for significance for Pearson correlation analysis was set as $\alpha = 0.05$ (two-tailed), while it was set as $\alpha = 0.10$ (one-tailed) for regression analysis to increase power. The criterion for the regression analysis was relaxed because of the study's small sample

size (i.e. low power). The Maker Behavioral Model (MBM) is shown in Figure 3 (note the key for current and future research). Causation within the relationships between the elements was hypothesized by the direction of the arrow, however, based on the cross-sectional nature of the current study, causal conclusions are not possible.

Hypothesis 1

Hypothesis 1 was tested as planned but based on very limited data for intention to return to make. Results of correlational analyses in Table 1 and of a multiple regression analysis suggest that Hypothesis 1 was only partially supported. The full regression model was not statistically significant when intention to return to make was regressed onto perceived behavioral control, perceived technology usefulness, creative self-efficacy, subjective norm and attitude toward making, [$F(5,3)=2.94, p=.20$]. Examination of the standardized weights showed that perceived behavioral control ($\beta=.75, p=.07$) did significantly predict intention to return to make but that perceived technology usefulness ($\beta=-.56, p=.17$), creative self-efficacy ($\beta=.18, p=.58$), subjective norm ($\beta=.34, p=.37$) and attitude toward making ($\beta=.26, p=.42$) did not account for significant additional variance in intention to return to make. Due to the very limited sample size available to test this hypothesis ($n=10$), low power is likely for this analysis.

Hypothesis 2

Hypothesis 2 was supported. Results of a correlational analysis (see Table 1) indicated that openness to experience was positively correlated with an individual's creative self-efficacy ($r=.44, p<.01, df=85$). Thus, this linkage in the MBM shown in Figure 3 is supported.

Hypothesis 3

Hypothesis 3 was supported. Results of a correlational analysis (see Table 1) indicated that creative role identity was positively correlated to creative self-efficacy (*r=.46, p=.00, df=87*). Thus, this linkage in the MBM shown in Figure 3 is supported.

Hypothesis 4

Hypothesis 4 was not supported. Results of a correlational analysis (see Table 1) indicated that Fab Lab support was not significantly positively correlated with creative self-efficacy (*r=.18, p=.109, df=84*). Thus, this proposed linkage in the MBM shown in Figure 3 was not supported statistically but was in the direction hypothesized.

Hypothesis 5

Hypothesis 5 was not supported. User's attitudes or perceptions about technology's ease of use was not positively correlated with intention to return to make (*r=.19, p=.59, df=9*). Thus, this proposed linkage in the MBM shown in Figure 3 was not supported.

Hypothesis 6

Hypothesis 6 was supported. User's attitudes or perceptions about technology's ease of use was positively correlated with his or her's attitudes about technology's usefulness (*r=.34, p<.01, df=82*). Thus, this linkage in the MBM shown in Figure 3 was supported.

Hypothesis 7

Hypothesis 7 was not supported. Tenure was not significantly positively correlated with intention to return to make (*r=.40, p=.26, df=9*). Thus, this proposed linkage in the MBM shown in Figure 3 was not supported although the direction of the relationship was as hypothesized based on limited data.

Exploratory Factor Analysis

An exploratory factor analysis of composite scores was conducted to determine whether the individual variables clustered into multiple factors. This helped to test whether the results were impacted by common method variance as well as whether a simplified conceptual model could be developed to explain findings.

Three statistically significant factors were identified amongst the analyzed independent variables as shown in Table 1. The resulting factors are shown in Table 2. The analysis was first run searching for Eigenvalues greater than one, followed by an assessment of a scree plot of the results. Initial indications from the plot matched the researcher's pre-review of Table 1, which revealed that three factors were a likely result based on similarities amongst the variables. The final analysis, therefore, extracted three factors and was run with Promax rotation. It showed that openness to experience, creative role identity, and creative self-efficacy loaded on Factor 1, entitled Creative Behaviors. Fab Lab support and subjective norm were loaded on Factor 2, entitled Social Interactions. Perceived technology ease of use and perceived technology usefulness were loaded on Factor 3, entitled Technology Perceptions. Neither perceived behavioral control, attitude toward making, nor beliefs about making loaded cleanly on any of these factors.

Discussion

The research reveals important findings about maker behavior and the influence of creativity, peer groups and technology. Three of the hypotheses were supported (H2, H3, and H6). These significant relationships are depicted in Figures 4 and 5. The results, however, also show a lack of statistically significant relationships hypothesized in the MBM, also shown in Figure 4. All arrows in Figure 4 are assumed relationship directions and are for reference only. Dashed arrows represent the relationships which were not statistically significant. In some cases, there were correlations of high magnitude that did not achieve statistical significance due to low power. Thus, low power was a major limitation of the current study. In other cases, the relationships were low in magnitude and simply may not exist as predicted; or instead may be an artifact of measurement.

Pearson Correlation

Overall, the findings regarding the proposed MBM demonstrate the role that both an individual's characteristics and social circumstances play in influencing the individual's intention to return to make in a Fab Lab. For example, creativity, as examined in the research, is an individual's personal characteristic, while his or her experiences within the Fab Lab or experiences within his or her peer group are social circumstances. On the other hand, technology appears in the supported MBM but does not appear to contribute to a person's intention to return to make. Within this context, the MBM was examined through an assessment of convergent validity with previous research.

Because the MBM is a combination of the Theory of Planned Behavior (TPB), Creative Self-Efficacy (CSE), and the Technology Acceptance Model (TAM), the validity of the MBM can be evaluated by a comparison of the data with those applicable theories. Beginning with the Theory of Planned Behavior, the three major antecedents to intention are attitude, subjective norm, and perceived behavioral control as shown in Figure 1. In the current research, however, the data show that only perceived behavioral control has any statistically significant relationship to intention to return to make, and that neither attitude nor subjective norm play a role. It is believed that the lack of these relationships is because the items for intention were not available in the first survey release. If the full cohort of participants had been given the items for intention, the relationships for attitude and subjective norm are believed to have been supported. Indeed, Table 1 shows that attitude toward making and subjective norm (and several other variables) all had Pearson correlations approaching or greater than 0.2, which indicates the relationships were strong enough but lacked the necessary statistical significance. On the other hand, the lack of demonstrated relationship may be the result of the attitude items being too general and not specific enough about making to capture meaningful results. This, however, must be tested in future research. The presence of the relationship between intention and perceived behavioral control, fortunately, was both present and predicted (H1); and so lends support to the MBM based on previous research which demonstrates the same relationship.

In other research by Bjornberg and Davis (2015) creative self-efficacy is predicted by creative role-identity, openness to experience, workplace support (i.e.

Fab Lab support), leadership, and workplace creativity expectations. As noted, leadership and workplace creativity expectations were omitted from the survey because they were not believed to be relevant to makers or Fab Labs. Of the three remaining antecedents, creative role-identity and openness to experience were likewise demonstrated to be antecedents to creative self-efficacy in the MBM, as shown in Table 1 and as hypothesized in H2 and H3. Fab Lab support, however, did not demonstrate a statistically significant relationship to creative self-efficacy even though it did have statistically significant relationships to other elements in the MBM. H4 was not supported; the lack of a significant relationship between Fab Lab support and creative self-efficacy in this research may be due in part to the make-up of each of these constructs. Recall that in the current research, Fab Lab support is based on empathy. It was used because it was an existing and reliable scale which contained items consistent with social support within a social context. The scale for workplace support used in previous research may not have had this same emphasis, and so may not measure the same behavior as the scale used in this research. Likewise, the scale for creative self-efficacy used in this research was borrowed from previous research and may not have been identical to the scale used in (Seo et al., 2015).

The relationship between perceived technology ease of use and perceived technology usefulness, which is based upon the TAM, was likewise supported in the MBM (H6). These findings lend support to the current research because it echoes findings from past work (Teo, 2012).

Several hypotheses (H1 partial, H5, and H7) predicted relationships with intention to return to make as shown in Figure 3. None of these, however, were

statistically supported. It is feasible that these relationships never existed in the first place, but it is also possible that the low number of responses in the survey for intention to return to make obscured relationships that might have existed. Future research with more complete data, and without the procedural issues of the current research, may reveal different outcomes. Therefore, at this time no explanation is offered as to the potential reasons why or why not H1, H5, and H7 were not fully supported.

Unpredicted Relationships

There were several relationships in the current research which were not hypothesized but which were demonstrated nonetheless. There was no demonstrated relationship between Fab Lab support and creative self-efficacy, although one was predicted in H4, but there was a demonstrated relationship between Fab Lab support and perceived behavioral control ($r=.25$, $p=.02$, $df=82$). Prima facie, this relationship is logical when considering that a supportive Fab Lab work environment with friendly users, staff and social scene should predict an individual's increased perception of his or her ability to control making behavior. To better understand this, consider that a supportive Fab Lab work environment, besides encouraging positive perceptions, might also reduce negative perceptions. The relationship between Fab Lab support and perceived behavioral control is more convincing in this case, because an individual may perceive more control over making behavior if there are fewer instances of Fab Lab workplace social toxicity. It is possible to imagine a Fab Lab user perceiving more control the less he or she is concerned about negative social experiences in a Fab Lab. It is further possible that there is a ceiling to Fab Lab

support within a Fab Lab, meaning that more Fab Lab support may not result in more perceived control of making, but that a less supportive Fab Lab may result in less. The scale for Fab Lab support did not contain items for negative support or workplace behaviors, and so this may be tested in future research.

Fab Lab support also was found to be related to other features of the MBM, as well, including subjective norm and both perceived technology ease of use and usefulness, none of which were hypothesized. Its relationship to subjective norm (*r=.27, p=.01, df=84*) is not surprising given that both elements are social measures which assess an individual's perceived relationship to others. The items in the scale for subjective norm are primarily concerned with determining how much of a maker's social circle supports making in general, the individual's making behavior specifically, and finally how much of one's social circle is composed of other makers. The positive relationship between Fab Lab support and subjective norm may be explained, therefore, if one considers that greater Fab Lab support within a Fab Lab may result in more social connections and peer relationships between makers which would, in turn, increase perceptions that this is a typical behavior. The relationships in Table 1 between Fab Lab support and technology ease of use (*r=.24, p=.03, df=81*) and usefulness (*r=.22, p=.05, df=81*) were not hypothesized by the MBM but are logical nonetheless. Even though the scales for perceived technology ease of use and usefulness do not contain items about receiving technical help through other Fab Lab users, this style of peer-to-peer "tech support" is common in a variety of social and work environments and it helps explain this demonstrated relationship between Fab Lab support and technology.

Results suggest Fab Lab support is also related to openness to experience (*r=.29, p=.01, df=82*) in the MBM (Table 1). In this relationship, openness to experience is a self-identified personality trait (Goldberg et al., 2006) whereas Fab Lab support is a report of one's perceptions or experiences of other's support within a Fab Lab. This relationship indicates that an individual's openness to experiences may influence and increase his or her perception of Fab Lab support, perhaps because an open person may be less wary about encounters within the Fab Lab and therefore more likely to feel supported. This was not tested directly, however, and would be subject to future research.

The element Weeks Since Last Project (Table 1) was not hypothesized in the MBM, but was featured in the research in order to understand if recent lab activity was related to other elements of the MBM. The only statistically significant relationship that developed, however, was a strong negative correlation with perceived technology usefulness (*r=-.47, p<.01, df=78*). This means that the more recently an individual completed a project, then the more useful he or she perceived Fab Lab technology; which is logical and also fits with the experiences that many people have had after they have recently used some piece of technology. In the opposite circumstance this means that a person who had completed a project many weeks ago would find the technology less useful given that he or she is not presently using the equipment. Other relationships in the MBM involving weeks since last project bear examination in future research.

Perceived Behavioral Control (PBC) figures prominently in the MBM, especially given it is a direct antecedent to intention. There are six statistically significant

relationships with Perceived Behavioral Control demonstrated in the model (Table 1), namely openness to experience, creative self-efficacy, creative role identity, subjective norm, Fab Lab support, and intention to return to make.

The relationship between openness to experience and PBC (*r=.39, p<.01, df=82*) is potentially explained by the confidence and motivation that openness might offer a person and his or her perception of control. The scale for openness to experience in Appendix A contains items about a person's imagination and attraction to new and abstract ideas. People with these qualities could very well approach activities and interactions with greater confidence or energy, and so therefore express more perceived control of their behaviors, especially if they're makers. In short, imagination and new ideas, as expressed through openness, may hold special importance for PBC as it relates to makers, making and Fab Labs.

The relationships between PBC and creative self-efficacy (*r=.29, p=.01, df=84*), and PBC and creative role identity (*r=.25, p=.02, df=84*) may be similar to the relationship between PBC and openness. Consider that both of these creative elements are associated with creativity, and that creative self-efficacy actually contains an item for confidence. In other words, it is logical that individuals scoring high on creative role identity or creative self-efficacy would have confidence in their creative potential, and therefore have increased perceived control of their making behavior in an environment like the Fab Lab which requires creativity and openness to new ideas. It is unsurprising that the data shows a relationship between PBC, creative role identity and creative self-efficacy.

The relationship between subjective norm and PBC (*r=.27, p=.01, df=84*) may be explained by the social support that a maker's peer group provides. The scale for subjective norm contains items about support for making, and the importance of making, and so would appear to enhance a maker's perceptions of behavioral control.

Finally, there is the relationship between PBC and Intention to Return to Make from H1, which is the strongest positive relationship demonstrated in the MBM. This finding is consistent with previous research, and so helps validate this research in the context of making. Therefore, the more individuals perceive they can control their making behaviors the more likely they are to return to make.

Exploratory Factor Analysis

The exploratory factor analysis revealed the three factors shown in Table 2: creative behaviors, social interactions and technology perceptions. Besides the statistical evidence which is presented, these loadings are reasonable because they appear to group based on obvious similarities between the individual variables in Table 1. Further, these loadings echo the observed realities of operating and using a Fab Lab. Fab Lab is a social experience, a creative experience, and a technological experience. These experiences are governed by social interactions with others and activities using both creativity and technology. The factors reflect the nature of the lab environment. Consequently, they are significant predictors of perceived behavioral control and intention which are shown in Figure 5.

Figure 5, therefore, was analyzed for Pearson correlations to understand the relationships of the Simplified MBM. The results are shown in Table 3. In light of the relationships which already existed as shown in Table 1, unsurprisingly

statistically significant relationships were demonstrated between technology perceptions and social interactions ($r=.31$, $p=.01$, $df=81$), social interactions and perceived behavioral control ($r=.29$, $p=.01$, $df=83$), creative behaviors and perceived behavioral control ($r=.35$, $p<.01$, $df=82$), and perceived behavioral control and intention to return to make ($r=.75$, $p=.02$, $df=9$). All the arrows in Figure 5 are assumed relationship directions and are for reference only. These results are consistent with Table 1, which shows that technology perceptions are not related to either perceived behavioral control or intention to return to make. As noted previously, the statistical evidence for this exploratory factor analysis, however, would be stronger had the sample size been larger. Nonetheless, this leaves social interactions and creative behaviors as the primary antecedents to perceived behavioral control, which is the sole antecedent to intention to return to make.

Post Hoc Mediation Analysis

A review of the results in Table 1 indicate there are potential relationships which are appropriate to analyze with a mediation analysis. Two of them are discussed here. First, it was surmised that Fab Lab support might mediate the relationship between subjective norm and PBC. Second, it was also surmised that creative role identity might mediate the relationship between creative self-efficacy (CSE) and PBC. The four steps for mediation analysis identified by Baron and Kenny (1986) were used, and the *r*-values demonstrating the requisite relationships for those steps are shown in Table 4. Because of the study's limitations due to sample size and low power, the test for significance was relaxed (α=0.10, one-tailed) for this analysis.

Fab Lab support mediation. A linear regression was used with PBC as the dependent variable, wherein both Fab Lab support (the mediator) and subjective norm (the independent variable) were regressed simultaneously. All three variables are related with statistically significant bivariate correlations. Table 4 shows that Fab Lab support is significant with $p = 0.06$, but that subjective norm is not with $p = 0.155$. As was postulated, this indicates that Fab Lab support partially mediates the relationship between subjective norm and PBC, because subjective norm loses its significance once Fab Lab support is added to the analysis.

This could indicate two possibilities. First, from the Table 4, *p*-values before mediation it appears that subjective norm i.e., a person's peer group, is important for a potential Fab Lab user to begin using the lab initially. Second, analysis seems to indicate that the Fab Lab support within a Fab Lab becomes more significant to a lab user than the influence that a person's subjective norm has on his perceived behavioral control of his making. This is logical because a person's group may or may not be composed of other makers. The linear regression analysis suggests, therefore, that the Fab Lab support within a Fab Lab should be a topic for future work to determine if it is a source of peer support for makers who intend to continue making.

Creative role identity mediation. Again a linear regression was used with PBC as the dependent variable, wherein both creative role identity and creative self-efficacy were regressed simultaneously. As before, all three variables in the mediation analysis are related with statistically significant bivariate correlations. Table 4 shows that creative self-efficacy is significant with $p = 0.07$, but that creative role identity is not with $p = 0.22$. This indicates that creative self-efficacy (the mediator) partially

mediates the relationship between creative role identity (the independent variable) and PBC, not creative role identity as was believed. It was estimated that creative role identity was the mediator because as someone identifies more as a creative person then it was believed that the signifiance of creative self-efficacy would decline. Instead, it appears that creative self-efficacy, not creative role identity, is the key personal trait preceding perceived behavioral control.

This is logical based on the scales in the survey for each item. The scales for creative role identity focus on a person's impression of his or her creativity, while those for CSE focus on a person's belief in his or her ability to generate ideas and solve problems. In this scenario, it appears that creative role identity may represent a more superficial form of creative confidence bestowed upon oneself by others, while creative self-efficacy has a deeper base in one's personal experience with actual creative activity and accomplishment. From this perspective, CSE may be more indicative of a person's perception of his or her ability to control their making behavior.

Post Hoc Moderation Analysis

Likewise with the mediation analysis, a review of the results in Table 1 indicate there are potential interactions which are appropriate to analyze for moderation. Only one such interaction is discussed here. It was predicted that the variable Weeks Since Last Project would moderate the relationship between creative role identity and perceived behavioral control, mainly because it seems likely that there are differences in the relationship between a person's creative role identity and his or her perceived control of his or her making behavior based on how recently he or she has completed a

project. It is possible that someone who has completed a project more recently has a less prominent conception of his or her perceived behavioral control based upon creative role identity. A moderation analysis is useful to test this. As previously, because of the study's limitations due to sample size and low power, the test for significance was relaxed (α=0.10, one-tailed) for this analysis.

As earlier, a linear regression was used with PBC as the dependent variable, with centered variables simultaneously regressed, namely: weeks since last project, creative role identity, and the product of weeks since last project and creative role identity (i.e., interaction term). All variables were centered for this analysis.

Table 5 and Figure 6 indicate that Weeks Since Last Project (WSLP) does moderate the relationship between creative role identity and PBC [$F(3, 73)=2.19$, $p=.096$]. Table 5 shows the changes in significance for the analysis variables. WSLP is not significant ($p=.72$). Creative role identity is significant ($p=.03$), as is the interaction term ($p=.07$). Because the interaction term is significant, the analysis indicates that WSLP moderates the relationship between creative role identity and PBC as believed.

This conclusion is further supported by Figure 6, which graphs the data for PBC versus creative role identity, and has the data grouped by three levels of WSLP. The three levels WSLP are people who completed projects more than four weeks ago ($n=26$), one to four weeks ago ($n=27$), and one week ago or less ($n=26$). Plotting regression lines through these three levels demonstrates that makers who completed projects four weeks ago or more contribute 29.6% ($R^2=.296$) of the variance in the relationship between PBC and creative role identity, while those who complete

projects a week ago or less contribute virtually 0% (R^2=*.0007*). Despite this evidence, previously stated limitations of the study plus the influence of outliers in the data could change these results, and should be examined in future work.

So why is it that WSLP holds this influence, particularly for those makers that completed projects some time ago? It is possible that these makers have had an opportunity to reflect on their last project, their perceptions of their own creativity and control of their making, and they have developed a greater sense of identity and control with the passage of time. In addition, they may have experienced unexpected success with the project after some time, and consequently may have been recognized by their peers; both of which may enhance PBC. Those makers with newer projects may still remember the issues or shortcomings of their design or may still be somewhat frustrated with the fabrication process; and so the relationship between creative role identity and PBC is lessened. Future work will be required to understand the full influence of WSLP, as it may impact CSE, subjective norm, openness to experience, or Fab Lab support as well.

Extraneous Variables

Extraneous variables included several elements. These included the excitement of joining or using a Fab Lab for the first time or the recent success of a well-received project. Recency in any one of these may have artificially driven-up user self-efficacy, increased openness to experience or encouraged intention to return to make. Likewise, the disappointment of an unsuccessful project, or the inability to take beginner classes could have the opposite effect. Other extraneous variables included a maker's experience with non-Fab Lab equipment or projects. These could likewise

improve the antecedent conditions of intention to return to make because those makers may have already experienced some benefits of making that might be confused with the hypothesized benefits of making in a Fab Lab.

Study Implications

The Simplified Maker Behavioral Model has implications for Fab Labs. As noted earlier, by measuring a maker's intention to return to his or her Fab Lab to make again, the results of this research informs Fab Labs and similar operations of the particular keys or aspects to improving staffing decisions, increasing membership or usage, improving membership retention, and enhancing member satisfaction. To a certain extent, these recommendations are part of a business plan or strategy for building a sustainable Fab Lab which operates well into the future.

The supported Maker Behavioral Model from Figure 4 is simplified into three essential pieces: social interactions, creative behavior and perceived behavioral control shown in Figure 5 which was developed from exploratory factor analysis in Table 2. Social interactions are composed of Fab Lab support and subjective norm. Creative behavior is composed of creative role identity, openness to experience and creative self-efficacy.

This section will discuss each of the pieces of the simplified Maker Behavioral Model, make basic recommendations, and then rate each one for the effort required to implement the recommendation and the potential impact it might have on a Fab Lab. This discussion will not include the role of technology because the results indicate they are not predictors of intention as was originally hypothesized.

Social Interactions

Social interactions consist of users' perceptions of both Fab Lab support within the Fab Lab and their subjective norms. Fab Lab support is loosely interpreted as how friendly, supportive or welcoming people within a Fab Lab are to each other. Subjective norm is a measure of how much support for making that a maker perceives from friends and family members. One is specifically internal to the Fab Lab environment, while the other is generally external. Of the five antecedents of perceived behavioral control from Table 1, subjective norm was the least strongly correlated. Fab Lab support had a slightly stronger correlation.

Subjective norm could be influenced in a Fab Lab environment by affecting the perceptions that makers have of their peer group. This is likely quite difficult to do, however, unless there is significant overlap between the lab membership and the maker's peers. The most impact would be had if those groups were the same, and were therefore equally accessible to lab organizers for receiving influential media or messages. If there is little or no overlap, then changing the subjective norm likely requires high effort from lab leaders to communicate with separate groups, with low impact on outcomes.

Fab Lab support, however, presents opportunities for increased impact with low effort. In this case, messages can be focused on the lab users. Those communications could contain messages about the need for friendliness or other related values between users, and could also explain the positive relationship between support and a user's experience. Any other initiatives which seek the same outcome should also see similar results.

Creative Behaviors

Creative behaviors consist of creative role identity, creative self-efficacy, and openness to experience. Creative role identity is defined as an internalized identity developed by an individual over time based upon expectations placed upon them by others. In short, it is how closely a person identifies him or herself as creative. Creative self-efficacy describes individuals' beliefs that they are able to generate creative outcomes and solve problems creatively. Openness to experience is defined as the degree to which an individual is willing and confident to try new things (Bjornberg & Davis, 2015).

Fortunately, creativity is a skill which can be taught and learned (Sawyer, 2012), and so creative behaviors like creative role identity and creative self-efficacy are apt to be influenced with low to medium effort and high impact. These efforts include: teaching classes or lectures on creativity and the creative process; highlighting member projects through web and social media; developing lab messaging and media which explicitly recognize and encourage creativity; and informing users that they are creative. Research indicates that everyone can be creative, and suggesting so will prompt more creativity (Sawyer, 2012).

That said, openness to experience is a personality trait that likely cannot be influenced directly or uniformly across an individual's entire spectrum of behaviors; but within the context of the Fab Lab, it would be worth the effort for a lab to encourage openness. This could be done in a number of ways with potentially high effort but also high impact: encouraging cross training on machines and software; hosting non-maker events at the lab and encouraging makers to attend (e.g., book

events, art shows, lectures, musical events), and helping makers associate their lab as a hub of various activities and interests including those that are for non-makers as well.

Perceived Behavioral Control

Perceived behavioral control is examined within the context of making. It is a maker's perception of ability to control one's own making behavior. In general, perceived behavioral control includes a wide range of characteristics, but for this research it includes subjects such as Fab Lab equipment, hardware or software resources, technical support and design ideas, as shown by the scale for perceived behavioral control in Appendix A.

Perceived behavioral control is a first order antecedent to a maker's intention to return to make, and therefore is an essential piece of any lab effort to enhance the user experience. Programs aimed at improving the quality, quantity or type of lab equipment, or enhancing training or mentoring services, would involve high effort because of cost or implementation time but would likely be high impact. Supporting user design activities or ideation through improved emphasis on creative behaviors, however, would require low to medium effort with the same high impact.

Study Limitations

The study had several limitations. These include those related to the sample and to the ability of the results to be generalized outside of the confines of the study. The sample represented the demographics of the current Fab Lab Tulsa members but was not representative of the U.S. making population nor to the U.S. general population, and may not have been representative of the lab memberships in Bowling Green or Providence, despite inclusion of a few members from these labs. The male

to female ratio and the educational levels of the respondents are examples of the skewed lab demographics. The consequences of an unrepresentative sample, as a limitation, may have negative implications given that Fab Lab and similar organizations seek to attract the general public to become makers. A truly representative sample may produce different results. There are also limitations related to the hypothesis that intention to return to make and membership tenure are related. Even though this hypothesis was not supported in this study, recall that the study was not longitudinal and did not actually measure an individual's intentions at different times. Additionally, common method variance may account for some relationships noted because the survey was offered in only one format and available only at one time to each participant. Providing the survey in alternate formats or at various times for each participant could minimize the likelihood of impact on study results from this source of error.

Future Work

Future work should focus on several fronts. First, it should include the development of a survey for international English language speakers in order to broaden the test population and to persist with determining the reliability and validity of the Maker Behavioral Model. Likewise, with data from a broader test population, an analysis of gender and age could be conducted. The current research collected some of this data but it was limited and skewed. Second, the next analysis should also use Structural Equation Modeling to determine the directionality of the relationships in the MBM. Likewise the post hoc mediation analysis deserves more attention as future work may yield further insight into the relationships in the model that are presented in

Table 1. Similarly, further examination of moderators is recommended, especially in regard to the influence of the variable Weeks Since Last Project. Finally, future research might also include validation of the recommendations made within the section entitled Study Implications.

Conclusions

There are several important conclusions to draw from this research. First, the Simplified Maker Behavioral Model demonstrates that a maker's intention to make appears to consist of three characteristics, namely social interactions, creative behaviors, and perceived behavioral control. Perceived behavioral control, a maker's perception of their ability to control their making behavior in this context, was the biggest predictor of maker intention. This research also indicates that these three characteristics can be influenced to the benefit of Fab Labs and other maker organizations.

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Table 1
Mean, Standard, N, and Pearson's Correlations – All Variables

Variable	M	SD	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Fab Lab support	4.73	.70	88	*(0.86)*													
2 Creative Role Identity	5.41	.85	88	-.01	*(0.75)*												
3 Perc. Behavioral Control	4.69	.54	85	.25*	.25*	*(0.68)*											
4 Openness to Experience	4.67	.65	86	.29**	.50**	.39**	*(0.74)*										
5 Creative Self-Efficacy	5.08	.61	88	.18	.46**	.29**	.44**	*(0.75)*									
6 Beliefs about Making	2.01	1.48	86	.01	.05	.10	.10	.14	*(0.95)*								
7 Attitude toward Making	5.68	.68	87	.18	.21	.05	.06	.18	.03	*(0.88)*							
8 Perc. Tech. Usefulness	5.21	.88	84	.22*	.05	.09	.02	.16	.01	-.03	*(0.95)*						
9 Perc. Tech. Ease of Use	4.41	.89	83	.24*	-.12	.22	-.06	-.02	.10	.03	.34**	*(0.88)*					
10 Subjective Norm	3.84	.77	88	.27*	.07	.22*	.10	-.02	.04	.14	.15	.19	*(0.70)*				
11 Intent. to Ret. to Make	4.73	.78	10	.25	.44	.75*	.26	.30	.06	.17	-.05	.19	.35	*(0.96)*			
12 Age (Years)	44.3	14.1	80	.10	-.17	-.05	-.06	-.18	-.03	.21	-.10	.08	-.07	-.15	-		
13 Weeks Since Last Proj.	6.2	9.7	80	.02	.11	.08	.08	-.10	-.10	.12	-.47**	-.11	-.07	.10	.13	-	
14 Months using Fab Lab	15.1	12.8	84	.15	-.02	.16	-.06	-.01	.17	-.02	-.10	.11	-.12	.40	.09	-.06	-

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Table 2
Exploratory Factor Analysis Loadings

Variable	Creative Behaviors	Social Interactions	Technology Perceptions
Openness to Experience	.79	-	-
Creative Self-Efficacy	.66	-	-
Creative Role Identity	.64	-	-
Fab Lab support	-	.83	-
Subjective Norm	-	.34	-
Perceived Technology Ease of Use	-	-	.68
Perceived Technology Usefulness	-	-	.41

Variables used are composite scores.
Extraction: Principal Axis Factoring
Rotation: Promax with Kaiser Normalization (converged in 5 iterations)

Table 3
Mean, Standard, N, and Pearson's Correlations – Factored Variables

Variable	M	SD	N	1	2	3	4	5
1 Social Interactions	4.29	.59	85	-				
2 Creative Behaviors	5.05	.57	86	.16	-			
3 Technology Behaviors	4.82	.72	83	.31**	.01	-		
4 Perceived Behavioral Control	4.70	.54	85	.29**	.35**	.18	-	
5 Intention to Return to Make	4.73	.78	10	.33	.44	.07	.75*	-

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 4
Post Hoc Mediation Analyses

Fab Lab Support as Mediator of the Subjective Norm-Perceived Behavioral Control Relationship		
Baron and Kenny (1986) steps	**Standardized β**	**Partial Correlation**
Step 1: X related to Y		
Subjective Norms	.22*, *p*=.046*	.22*
Step 2: X related to M		
Subjective Norms	.27, *p*=.013*	.27*
Step 3: M related to Y controlling for X		
Subjective Norms	.16, *p*=.155	.159
Fab Lab Support	.21, *p*=.064	.206
Step 4:		
X-Y relationship changes due to M	Marginal evidence for mediation	
Additional Tests for mediation		
Sobel test:	1.515, *p*=.130	
Arorian test:	1.445, *p*=.148	
Goodman test:	1.597, *p*=.110	

Creative Self-efficacy as Mediator of Creative Role Identity-Perceived Behavioral Control Relationship		
Baron and Kenny (1986) steps	**Standardized β**	**Partial Correlation**
Step 1: X related to Y		
Creative Role Identity	.25*, *p*=.019*	.25*
Step 2: X related to M		
Creative Role Identity	.46, *p*<.001*	.46*
Step 3: M related to Y controlling for X		
Creative Role Identity	.15, *p*=.216	.136
Creative Self-efficacy	.22, *p*=.069	.200
Step 4:		
X-Y relationship changes due to M	Marginal evidence for mediation	
Additional Tests for mediation		
Sobel test:	1.726, *p*=.084	
Arorian test:	1.695, *p*=.090	
Goodman test:	1.759, *p*=.079	

Table 5
Post Hoc Moderation Analysis Results – Coefficients

Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**β**	**t**	**p**
(Constant)	4.67	.06		79.99	.00
Centered weeks since last project	-.00	.01	-.05	-.36	.72
Centered creative role identity	.17	.08	.26	2.18	.03
Centered weeks since last project x centered creative role identity	.02	.01	.24	1.85	.07

NOTE: For Table 5 the following applies - dependent variable: perceived behavioral control; predictors are centered weeks since last project, centered creative role identity, and centered weeks since last project x centered creative role identity.

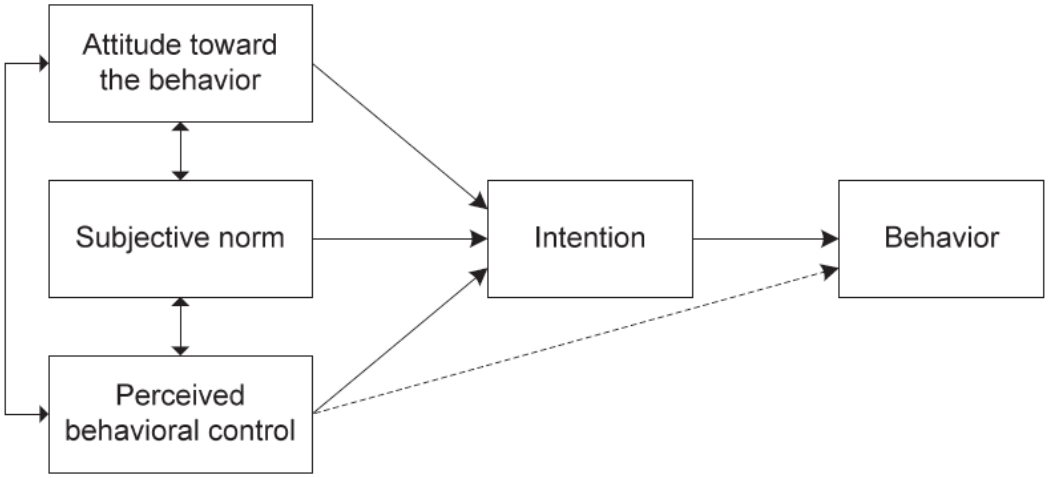


Figure 1. Theory of Planned Behavior Model (Azjen, 2002).

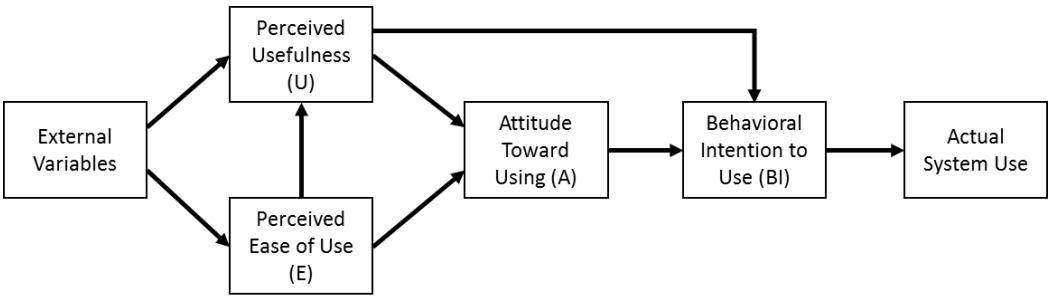


Figure 2. Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989).

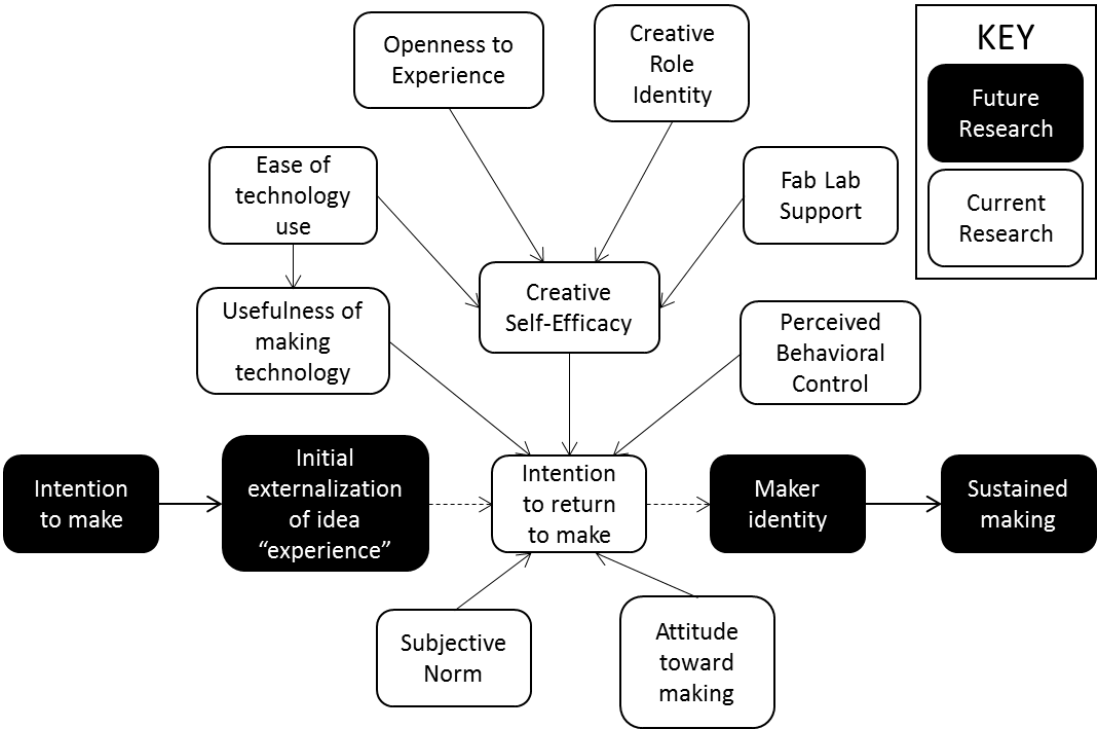
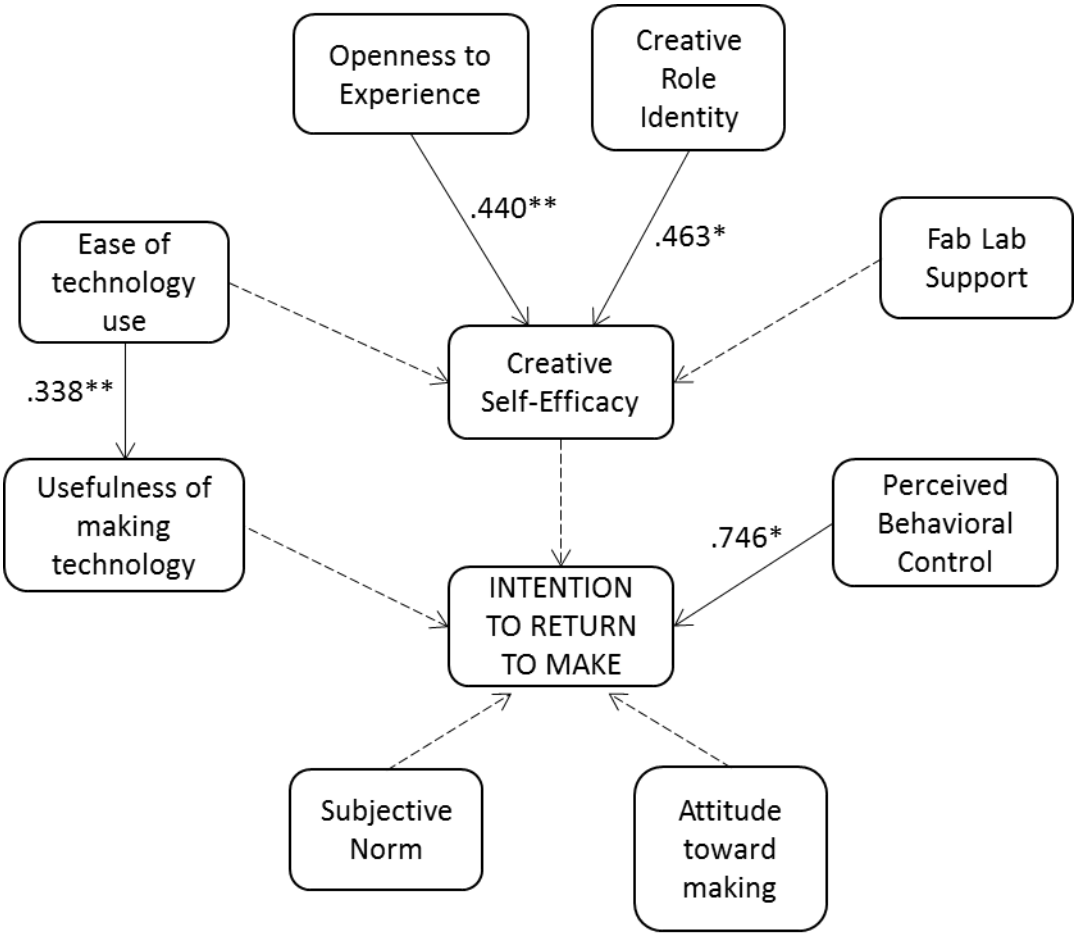


Figure 3. Hypothesized Maker Behavioral Model.



All results are two-tailed.
* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
Relationship directions (arrows) are assumed and are for reference only.

Figure 4. Maker Behavioral Model.

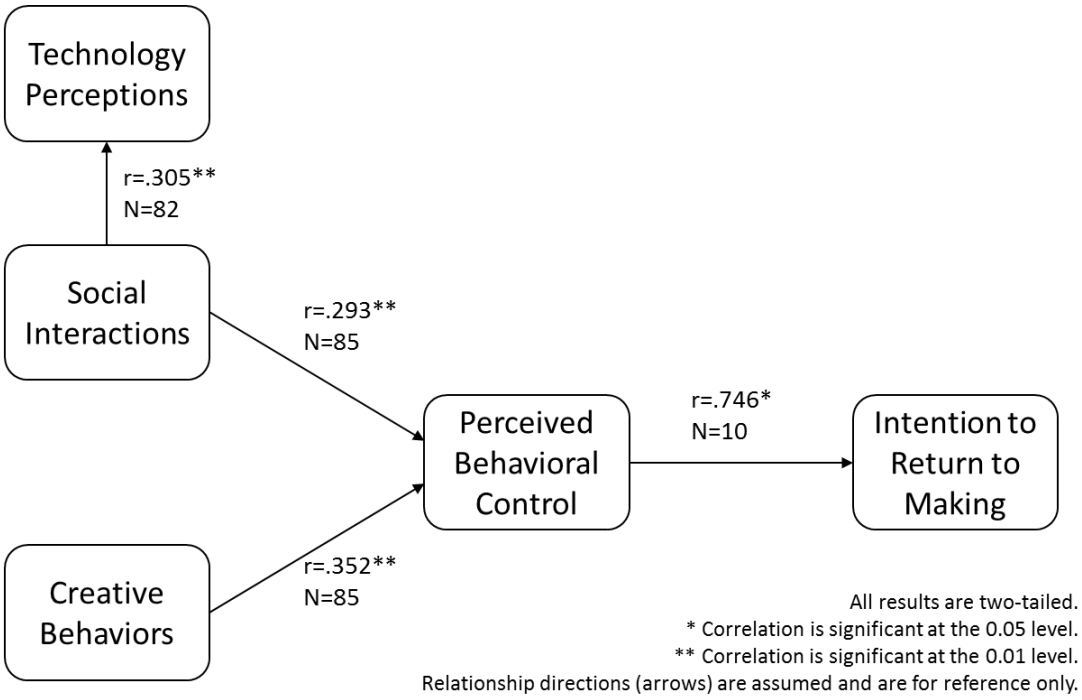


Figure 5. Simplified Maker Behavioral Model (Reference Table 3).

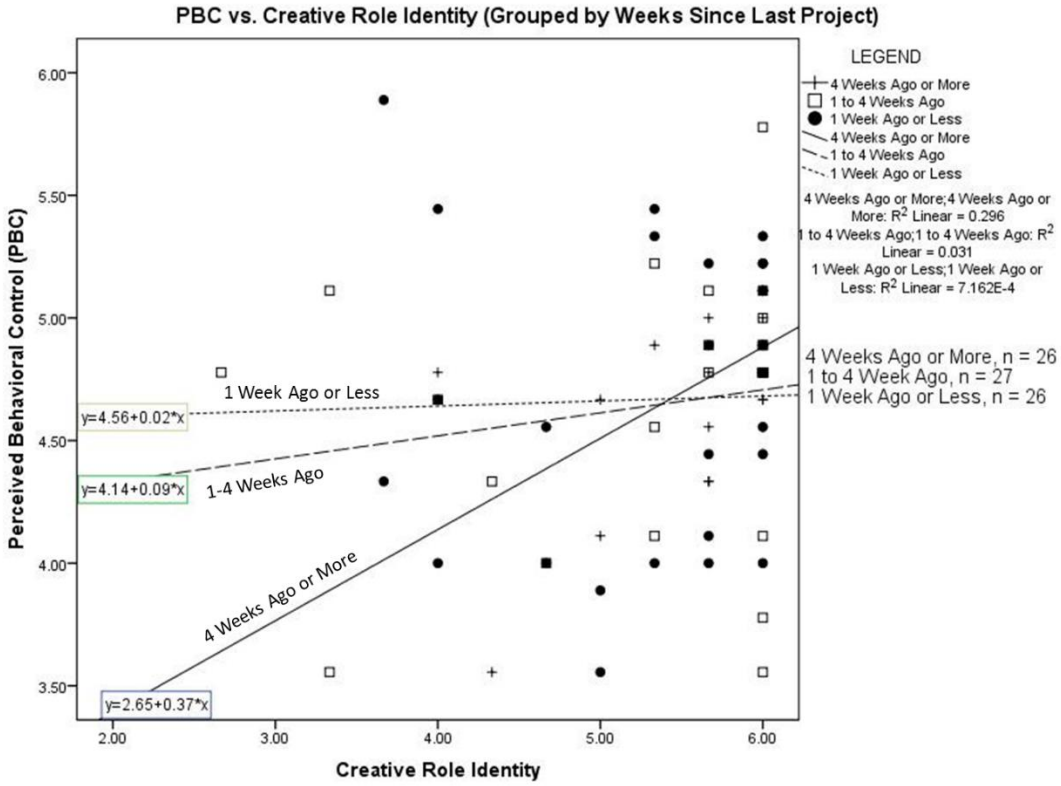


Figure 6. Graph of Perceived Behavioral Control versus Creative Role Identity (Grouped by Weeks Since Last Project)

Appendix A
Main Questionnaire Items

Introductory Demographics. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence.

Does your local Fab Lab offer memberships for a fee?

Yes (1)

No (2)

Not Sure (3)

Have you ever used a Fab Lab to make something?

Yes (1)

No (2)

On average, how frequently do you visit Fab Lab for design or other making activities?

Daily (1)

Weekly (2)

Monthly (3)

Quarterly (4)

Semi-annually (5)

Annually (6)

How many months have you been a Fab Lab user? If you have had lapses in usage, report the number of months of active usage only.

What is your 5-digit zip code?

What's the highest level of education you have attained?

Some High School (1)

High School Graduate (2)

Some College (3)

Technical or Trade School Graduate (4)

Bachelor's Degree (5)

Graduate or Professional Degree (i.e. law or medicine) (6)

Questionnaire Instructions. Each of the following questions include phrases that describe people's behaviors. Please use the rating scales below to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. Please read each statement quickly and carefully, and then mark the answer that corresponds to the number on the scale. Please describe yourself as accurately as possible. Your responses will be kept in absolute confidence.

Fab Lab support. Indicate how well the following descriptions apply to yourself and other Fab Lab users.

Other Fab Lab users are reassuring to me. (1)

Other Fab Lab users are concerned about me. (2)

Other Fab Lab users have a good word for me. (3)

Other Fab Lab users make me feel welcome. (4)

Other Fab Lab users take time out for me. (5)

Creative Role Identity. Indicate how well the following descriptions apply to you.

I often think about being creative. (1)

I do NOT have any concept of myself as a creative person. (2)

To be a creative person is an important part of my identity. (3)

Perceived Behavioral Control. Indicate how well the following descriptions apply to you.

How much making I do is up to me. (1)

I have time to make when I want to. (2)

I can make what I want in the Fab Lab. (3)

The Fab Lab's capabilities are critical to enabling my making. (4)

I usually have good ideas or designs to make. (5)

I have the resources to make what I want to make. (6)

Having good ideas or designs is critical to enabling my making. (7)

Fab Lab has the equipment I need to make what I want. (8)

Having the right resources is critical to enabling my making. (9)

Openness to Experience. Indicate how well the following descriptions apply to you.

I believe in the importance of art. (1)

I avoid philosophical discussions. (2)

I have a vivid imagination. (3)

I am NOT interested in abstract ideas. (4)

I tend to vote for liberal political candidates. (5)

I do NOT like art. (6)

I carry the conversation to a higher level. (7)

I do NOT enjoy going to museums. (8)

I enjoy hearing new ideas. (9)

I tend to vote for conservative political candidates. (10)

Creative Self-Efficacy. Indicate how well the following descriptions apply to you.

I feel that I am good at generating novel ideas. (1)

I have confidence in my ability to solve problems creatively. (2)

I have a knack for further developing the ideas of others. (3)

Beliefs about Making. Indicate how well the following descriptions apply to you when you are making.

Learning is important. (1)

Expressing my creativity is important. (2)

Meeting new people is important. (3)

Having a source of inspiration is important. (4)

Subjective Norm. Indicate how well the following descriptions apply to you.

Most people who are important to me support my making. (1)

When it comes to making, I want to be like my friends. (2)

Most of the people who are important to me would call themselves makers. (3)

Most of the people I know believe making is important. (4)

When it comes to making, I want to please the people who are most important to me. (5)

Attitude Toward Making. Please rate your attitude toward making on each of the following dimensions.

Unpleasant:Pleasant (1)

Good:Bad (2)

Favorable:Unfavorable (3)

Negative:Positive (4)

Intention to Return to Make. Indicate how well the following descriptions apply to you.

It is likely I will continue making as much or even more this next month as I have in the past month. (1)

I do NOT intend to continue making as much in the next month as I have in the past month. (2)

I intend to continue making as much or even more in the next month as I have in the past month. (3)

Maker Technology Usage. Maker technology is defined as technology used in a Fab Lab. This includes the: Design tools (design software, computer coding tools, and CNC programming tools) Main equipment (3D printers, CNC router, laser cutter,

vinyl cutter, mini-mill, and electronics workbench) Supporting equipment (band saw, belt sander, other power tools, and hand tools).

Please indicate how often you usually use maker technology on your projects.

Laser Cutter (1)

Vinyl Cutter (2)

CNC router (3)

Mini-mill (4)

Electronics Workbench (5)

3D Printer (6)

Design tools (7)

Supporting Equipment (8)

Please rate the complexity of your projects using this technology.

Laser Cutter (1)

Vinyl Cutter (2)

CNC router (3)

Mini-mill (4)

Electronics Workbench (5)

3D Printer (6)

Design tools (7)

Supporting Equipment (8)

Perceived Technology Usefulness. Please rate your perception of maker technology on each of the following dimensions.

Using maker technology will improve my making. (1)

Using maker technology will enhance my effectiveness when I make. (2)

Using maker technology will increase my productivity when I make. (3)

Perceived Technology Ease of Use. Please rate your perception of maker technology on each of the following dimensions.

Maker technology is clear and understandable. (1)

I find it easy to get maker technologies to do what I want them to do. (2)

I find maker technology easy to use. (3)

Last Project Description. Please describe your last project, even if it wasn't made in a Fab Lab or didn't use Fab Lab tools (90 characters max).

For the project you just described, about how many weeks ago did you complete it? For projects completed a week ago or less, just enter 1.

Closing Demographics. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence.

What year were you born?

What is your gender?

Male (1)

Female (2)

Other / Choose not to answer (3)

Appendix B

Original IRB Approval

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Initial Submission – Exempt from IRB Review – AP01

Date: March 14, 2016 **IRB#:** 6636

Principal Investigator: Matthew Lee James Norris **Approval Date:** 03/14/2016

Exempt Category: 2

Study Title: Creative Self-Efficacy, Technology Acceptance and the Theory of Planned Behavior: Antecedents to a Maker's Intention to Return to Make

On behalf of the Institutional Review Board (IRB), I have reviewed the above-referenced research study and determined that it meets the criteria for exemption from IRB review. To view the documents approved for this submission, open this study from the *My Studies* option, go to *Submission History*, go to *Completed Submissions* tab and then click the *Details* icon.

As principal investigator of this research study, you are responsible to:

- Conduct the research study in a manner consistent with the requirements of the IRB and federal regulations 45 CFR 46.
- Request approval from the IRB prior to implementing any/all modifications as changes could affect the exempt status determination.
- Maintain accurate and complete study records for evaluation by the HRPP Quality Improvement Program and, if applicable, inspection by regulatory agencies and/or the study sponsor.
- Notify the IRB at the completion of the project.

If you have questions about this notification or using iRIS, contact the IRB @ 405-325-8110 or irb@ou.edu.

Cordially,

E. Laurette Taylor, Ph.D.
Chair, Institutional Review Board

IRB Approval Modification #1

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Study Modification – Expedited Review – AP0

Date: April 19, 2016 **IRB#:** 6636

Principal Investigator: Matthew Lee James Norris **Reference No: 651547**

Study Title: Creative Self-Efficacy, Technology Acceptance and the Theory of Planned Behavior: Antecedents to a Maker's Intention to Return to Make

Approval Date: 04/19/2016

Modification Description:
Nothing in the study is changing, except that 2 additional Fab Labs are being proposed to add to the study. Right now Fab Lab Tulsa and Fab Lab San Diego are in the study. BiG Fab Lab (Bowling Green, OH) and AS220 Fab Lab (Providence, RI) are being proposed.

The review and approval of this submission is based on the determination that the study, as amended, will continue to be conducted in a manner consistent with the requirements of 45 CFR 46.

To view the approved documents for this submission, open this study from the My Studies option, go to Submission History, go to Completed Submissions tab and then click the Details icon.

If the consent form(s) were revised as a part of this modification, discontinue use of all previous versions of the consent form.

If you have questions about this notification or using iRIS, contact the HRPP office at (405) 325-8110 or irb@ou.edu. The HRPP Administrator assigned for this submission: Nicole A Cunningham.

Cordially,

E. Laurette Taylor, Ph.D.
Chair, Institutional Review Board

IRB Approval Modification #2

The UNIVERSITY of OKLAHOMA

Institutional Review Board for the Protection of Human Subjects

Approval of Study Modification – Expedited Review – AP0

Date: April 22, 2016 **IRB#:** 6636

Principal Investigator: Matthew Lee James Norris **Reference No: 651634**

Study Title: Creative Self-Efficacy, Technology Acceptance and the Theory of Planned Behavior: Antecedents to a Maker's Intention to Return to Make

Approval Date: 04/22/2016

Modification Description:
3 questions are being added to the survey in order to more accurately capture a maker's intentions to continue making. The original survey lacked these questions, and so therefore lacks the full ability to analyze intention.

The review and approval of this submission is based on the determination that the study, as amended, will continue to be conducted in a manner consistent with the requirements of 45 CFR 46.

To view the approved documents for this submission, open this study from the My Studies option, go to Submission History, go to Completed Submissions tab and then click the Details icon.

If the consent form(s) were revised as a part of this modification, discontinue use of all previous versions of the consent form.

If you have questions about this notification or using iRIS, contact the HRPP office at (405) 325-8110 or irb@ou.edu. The HRPP Administrator assigned for this submission: Nicole A Cunningham.

Cordially,

E. Laurette Taylor, Ph.D.
Chair, Institutional Review Board

Appendix C

Recruitment Letter

TO: <representative of a participating Fab Lab>

FROM: matthew.lj.norris@ou.edu

SUBJECT: Research on "What Makes a Maker?!"

Thank you for participating in this "first of its kind" research on makers! Please feel free to distribute this email to your users, members or volunteers

CALLING ALL MAKERS…

The purpose of this survey is to understand "makers" and why they continue to make things. Makers are tinkerers, hobbyists, inventors, artists, designers, coders or crafters who make, build or create almost anything. Social science can help us understand the conditions under which makers will flourish, and can therefore contribute to the development of a community's creativity, innovation, and entrepreneurship.

If you are willing to participate, please click on the link below and complete the online survey. It should take about 15 minutes to complete. In order to participate you must be 18-70 years of age, live in the U.S., and be affiliated with a US-based Fab Lab.

SURVEY: https://ousurvey.qualtrics.com/SE/?SID=SV_4YnViF2VLrMpYP3

THOSE WHO COMPLETE THE SURVEY WILL BE ELIGIBLE FOR A DRAWING FOR A $25 GIFT CARD.

SEE THE ATTACHED ADVERTISEMENT FOR DETAILS.

Best Regards,

Matt Norris
Organization Dynamics, Graduate Student
University of Oklahoma – Schusterman Center – Tulsa

IRB NUMBER: 6636
IRB APPROVAL DATE: 03/14/2016