Work In Progress: Assessing the Long-Term Impact of Maker Programs on Career Outcomes and Industry Skills Development

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Abstract

Our project, led by the University of North Carolina – Chapel Hill and Rice University, seeks to assess the long-term impacts of Maker-focused educational programs on career outcomes and industry skills development. While much attention has been given to the positive educational outcomes of these educational programs, little has been written about their effects on career prospects and industry hiring trends. The project aims to identify relevant metrics for measuring career impacts and develop tools for assessing the relationship between makerspace experiences and career readiness. We anticipate that the data generated will be valuable for educational policy, philanthropic support, and employer decisions, guiding strategic investments in design and fabrication studios to enhance workforce skills development. This study has two parts; the first employs qualitative methods, consisting of interviews and focus groups with over 48 students, 15 alumni and 15 employers to identify common themes that reflect makerspaces' impacts on students' careers. From this data, we aim to create a universal framework for assessing the link between makerspace experiences and career readiness across diverse institutions and studios. The second part of the iterative study will consist of the development of a quantitative survey instrument utilizing this grounded, qualitatively informed framework that can be used to assess the quality of individual makerspaces in terms of their contribution to professional skill development and meaningful student experiences with long-term career impacts. We anticipate being able to share the work-in-progress results of our coding efforts from the interviews we will have completed.

Introduction

Over the past two decades, makerspaces have undergone a remarkable evolution, transitioning from grassroots communities of hardcore independent tinkerers to vital components of contemporary innovation ecosystems. Starting the early 2000s, initiatives such as TechShop [1], founded in 2006, and the Hackerspace movement played crucial roles in popularizing the makerspace concept [2]. These early spaces provided tech enthusiasts and DIY advocates with communal access to a wide array of tools, fostering collaborative innovation and hands-on learning. Later spaces at the community or university level have become sites that fuel innovation and innovation-backed ventures, leading to makerspace participation becoming one potential stop on the path towards commercialization of technologies. Prominent organizations like the Maker Media-backed Maker Faire [3] events and the global Fab Lab Network [4] have contributed significantly to the international expansion and standardization of makerspaces, as well as the development of the personal identity of the 'Maker' and the 'Maker Movement' [5].

As the maker movement gained momentum, libraries and educational institutions joined the movement, recognizing the value of makerspaces in cultivating creativity and practical skills.

The emergence of Fab Labs [6] in 2001, and the integration of makerspaces with hands-on projects in engineering undergraduate programs further propelled the makerspace evolution. Maker ecosystems and maker-focused pedagogical initiatives have been the beneficiaries of many millions of dollars invested which has in turn supported thousands of students in Maker focused programs.

A qualitative study of makerspace managers indicated a belief that these spaces are key developers of important workforce skills [7]. While this is in line with widespread anecdotes and notions about makerspace impacts, the ability of these spaces to build workforce-relevant skills among their users has not been well-quantified. That said, there is a wealth of literature that outlines the positive impacts that maker efforts have had on educational outcomes for students, and ample qualitative indications of student skill development in academic makerspaces. One study had makerspace student-users report an increase in their abilities to problem-solve and professionally socialize (including networking and collaboration) as a result of their time in a makerspace [8]. Makerspaces have also been qualitatively noted as catalysts for student confidence-building and innovative, creative thinking [9]. Studies of primary school student users of makerspaces have indicated impacts on their identity development connecting to their use of the spaces as well [10; 11]. Unsurprisingly, students have reported developing and honing skills in using any number of specific tools and making methods as a result of their makerspace experiences, including everything from 3D printing and welding to sewing and bike repair [12]. In many academic makerspaces, frequent and dedicated student-users may be given the opportunity to serve as formal mentors or in staff roles for the space. These opportunities carry their own documented benefits for students, including increased communication, leadership, and making skills [13].

However, little has been written about how these outcomes translate to long-term effects in developing industry-centric skills or career outcomes. It seems important to acknowledge that positive educational outcomes and positive career outcomes are not necessarily connected, and that there needs to be a better understanding regarding the impacts of maker programs on industry hiring trends and student career outcomes. This type of data is especially important at community and vocational colleges where makerspaces are increasingly playing a role in providing students with opportunities to develop skills outside of the curriculum and driving curricular decisions. Furthermore, these employment trends could be used to inform educational policy and influence philanthropic support to these programs.

In this project, researcher at UNC-Chapel Hill and Rice University are working on a pair of activities that will develop and implement a framework assessing Maker programs' impact on careers. Our primary activity addresses the immediate need to understand the types of metrics most appropriate to measure career impacts of Makerspace experiences. From these results we plan to develop and calibrate the tool(s) needed to apply the metrics framework for Activity 2. In Activity 2, we will build on the framework to implement a set of tools that stakeholders can

apply generally across design and fabrication studies to assess the relationship between makerspace experiences and career readiness.

In this Work In Progress paper, we lay the foundation for the activities of our project, and share out some preliminary observations based on initial interviews with our target populations. We discuss what we have learned from these initial interviews, which charts a path forward for a refined set of questions, and ultimately a survey deployed to a larger sample size. We end our paper with some next steps for our two major activities.

Methodology

Our working hypotheses and assumptions include the following:

- Robust makerspace experiences, when apparent to prospective employers, increase the candidate's appeal and give the candidate an edge in the hiring process.
- Robust makerspace experiences make the entry-level employee better prepared to enter the workforce.
- Prospective employers see value in the skills gained in the makerspace setting.
- Prospective employers are looking for skill sets in their entry-level employees that are not taught in traditional curricula.
- A new employee with skills gained in the academic makerspace setting is generally able to learn and adapt more quickly to the work environment than employees without this experience.
- New employees with makerspace experience will advance more rapidly than equivalent employees without this experience.

To explore these hypotheses, we will conduct two major activities to identify and apply relevant metrics to capture the impact of makerspaces and then convert those learnings into tools that stakeholders can use for their own benefit.

Activity 1:

Identify metrics that reflect the career impact of Makerspace experiences.

We are applying a qualitative research approach to gather qualitative data from students who have had Makerspace experiences and employers who seek these students. The goal of this strand of inquiry will be to identify parameters that represent Makerspace experience impact on careers. The use of qualitative methods for the initial study phase is justified due to the lack of an existing foundation on the types of skills being developed within students using makerspaces, as well as the lack of data on how student experiences may differ between sites and settings for their makerspaces. Interviews and focus groups are more likely to solicit information on unexpected skills that students may not think to include on a survey or other quantitative instrument without active prompting, probing, and other means of exploratory follow-ups. The <social science research institute> serves as a consultative partner to guide and implement our

research. This will include in-depth interviews (IDI) with at least 40 students, 15 alumni and 15 employers, at least six student focus group discussions (FGD) with 5-8 students per group, and subsequent IDI and FGD transcription and data coding to identify the key metrics that reflect career impact. IDIs and FGDs with students and alumni will utilize a semi-structured interview protocol consisting of open-ended questions relating to their experiences within their makerspaces, the skills they feel that they have developed there, and how they feel that those will (or have) connected to their professional work. The coding process for the IDIs and FGDs will utilize both a priori and inductive codes – some of the codes will be identified and defined based on existing literature on either makerspaces or professional skills, whereas others will be coded as the data are analyzed using an iterative, multi-phase process of open and axial coding. These activities will be conducted using cohorts affiliated with <a large public school in the US East>, <a small private school in the US South>, <two large community colleges in the US East and South> to provide a baseline with which to develop, calibrate, and validate the data.

Outside of the criterion of their attended institution, student-participants were required to be either Juniors or Seniors and were invited to participate in the study based on their tracked, consistent usage of their campus makerspace. This data was provided by existing contacts who acted as collaborators at the selected Makerspace sites, adding elements of convenience and snowball sampling to the recruitment process. For the purpose of this study, the focus was placed on students who were frequent, dedicated users of Makerspaces, rather than casual users – ideally, these students were the most likely to have developed broad and deep skills associated with time spent in these spaces. Current industry professionals were recruited for interviews by convenience, snowball, and criterion sampling utilizing existing contacts at the selected Makerspace sites (typically faculty or staff formally connected to the spaces in an advisory or administrative role). These contacts were requested to provide lists of recent graduates – alumni who have since transitioned into professional roles – who were frequent and dedicated users of their makerspace. The value of this data lies in defining the important universal themes for application across institution types.

Activity 2: Build and Implement Instruments for Stakeholders
In Activity 2 we will iterate on the outcomes of Activity 1 to build a set of quantitative tools that stakeholders can apply broadly across design and fabrication studies to assess the relationship between makerspace experiences and career readiness. Themes and key findings of Activity 1 will be used to directly inform the tool development process of Activity 2: this could mean developing Likert scale survey questions that map on to the specific key themes identified in Activity 1, for instance. We will build the tools to be widely accessible so that stakeholders can apply them to understand and assess the contributions of design and fabrication studios, and academic makerspaces, in particular, to career readiness and workforce development. Activity 2 will also serve to iterate on the data defined in Activity 1 to continually refine and validate the metrics framework. Because of the iterative, multi-phase nature of this study, the exact form of the tool(s) in Activity 2 are to be determined.

Results and discussion

This work-in-progress paper addresses our progress on Activity 1, and some impressions from early interviews. Five interviews were conducted with individuals who have used makerspaces as students. Interviews responses were sorted based on emergent categories of information based on quotes from the students. Here we share some of these key responses and themes.

Interviewees mentioned a number of professional skills that they learned while working in a makerspace. These skills included: Problem-solving, creativity, teaching/communication, time management, project management, confidence-building, patience with experimentation, documentation of processes and sharing work effectively.

Emergent themes that we picked up on from talking with the students included the following:

- Self Confidence / Communication
- Social / Collaboration / Peer Learning
- Creativity / Problem Solving / Experimentation
- Active Learning

Self confidence / Communication

Students consistently highlighted the impact of their makerspace experiences on selfconfidence and practical skill development. Through hands-on work and teaching roles, they gained not only tangible, quantitative skills but also a sense of authority in discussing their experiences. Students felt that the makerspace served as a transformative environment, providing them with invaluable experiences to build confidence, enhance their resumes, and succeed in job interviews. The focus on the hands-on design process proved instrumental in securing internships and multiple job offers, underlining the direct link between makerspace engagement and professional success. Moreover, the students emphasized the transferability of the learning process, highlighting the development of skills not only in using specific machines but also in the broader ability to learn new things—a crucial asset for future employment.

> "I'm more comfortable talking about my experiences and speaking with authority based on my abilities…I have tangible, quantitative skills from my time in the makerspace."

> "The makerspace was invaluable to me: a place to build confidence and get experiences that I could put on a resume or talk about in an interview: I can talk about the hands-on design process. I know that got me an internship – and multiple offers every summer. Now I have a job lined up – I could only have those from the makerspace."

> "You learn skills and gain confidence in yourself and know how to learn new things. That is something – a process – that is transferable to employment, beyond knowing how to learn specific machines and tools."

Social / Collaboration / Peer learning

Responses underscored the collaborative nature of makerspaces, emphasizing the inherent teamwork and social aspects integral to the space. Students feel that the makerspace served as a focal point in their college experiences, providing a space for like-minded individuals to connect and collaborate on both curricular and co-curricular projects. The value of collaboration extended beyond academic projects, contributing to a social experience that facilitated networking and job opportunities. The EDGE teaching model, characterized by explaining, demonstrating, guiding, and enabling, was actively employed in the makerspace, fostering a learning environment where peers shared diverse approaches to using different machines. The sense of community was a defining aspect, with the makerspace becoming a second home, a space to not only gain diverse experiences but also to share and learn from the projects of fellow community members.

> "[In the makerspace] I got all of the experiences, but I also got to be part of a community to share what I'm working on and learn about projects that other people have done"

> "You are always working with someone in the makerspace: it is inherent to the space"

> "A place you can go and be with other people who are interested in the same things as you…that's what I was looking for"

Creativity / Problem solving / Experimentation

The overarching theme revolves around the makerspace's role in teaching practical skills, adaptability, and problem-solving, providing a foundation for success in real-world scenarios. Students spoke to the makerspace's role in fostering critical thinking about project goals and tool selection, and encouraging them to evaluate the most effective tools for specific projects. Low fidelity prototyping emerged as a key aspect, teaching students to streamline designs after brainstorming using cost-effective materials like post-it notes and popsicle sticks. The experience taught the entire process of prototyping and the appropriateness of toolchains, transitioning from brainstorming to physical creation. Students reported that the makerspace offered freedom for experimentation, allowing them to dive into projects, learn to utilize resources, and acquire hands-on experience, sometimes lacking in a classroom setting. The emphasis on taking a project from conception to completion, understanding realistic timelines, and building adaptable problem-solving skills highlighted the practical knowledge gained in a judgment-free space, proving valuable for securing jobs and internships.

> "The ability to dive in and figure out the tools you need to solve it…you might not learn it in the classroom. Hand-on projects give you the experience and teach you to utilize resources rather than sitting in a classroom. Being able to do that on your own is important."

> "The makerspace taught how to learn new things and how to adapt…I know how to tackle problems I might initially know nothing about"

> "It teaches you how to take a project from conception to completion and what a realistic timeline looks like"

Active learning

Students express a heightened focus in the makerspace due to its hands-on and active nature, contrasting it with traditional lecture-based learning. They reported that their experiences fostered confidence and a versatile learning process transferable to employment, extending their learning beyond specific machine or tool proficiency. Students believe the makerspace is viewed as invaluable for building confidence, and providing hands-on design experiences applicable to resumes and interviews, resulting in internship and job opportunities. The student narrative underscores the transformative journey from entering the makerspace with minimal skills to gaining expertise in 3D modeling, 3D printing, laser cutting, and various other techniques. Workshops are mentioned as essential for learning tool basics, aiding individuals with limited initial skills.

> "I felt more focused in the makerspace. There was always something hands-on and active to be doing. In a classroom I might doze off. It is easier to go to a class where you learn how to use a drill than listen to a general lecture for an hour. It felt more conducive to learning in my opinion."

> "I had almost no skills going into the makerspace at first. I had to get out of my comfort zone and explore new things, like learning machines. Skillset wise, my internship in the makerspace taught me 3D modeling, which I was proud to learn on my own. Also my freshman class in the space taught me know to 3D print, laser cut, plasma cut, spray paint, learn power tools, molding/casting, and so much more. I even learned how to go through the steps to these things really well: there's a difference in knowing how to do something and knowing how to do it really well."

Future work

These preliminary interviews have highlighted the strengths of makerspaces as reported by students who have spent significant time in the makerspaces. Our future activities include increasing the sample size of the interviews we conduct as well as initiating the interviews with other categories (employers, multiple universities). While our activities focus on academic makerspaces, we plan to validate our data against the breadth of design and fabrication studios, including a variety of Makerspace operational structures in public/private institutions, community, and vocational colleges. After concluding both Activity 1 and 2 we will develop a final report providing useful guidance on the value of investments in design and fabrication studios for organizations who make education investment decisions.

The tangible outcomes of this study – such as the specific forms of the developed tools for assessing makerspaces – will be more fully realized as the project develops, given that these tools will be developed iteratively from the findings of Activity 1. However, the purpose and ideal impact of these outcomes is to pave the way for makerspaces to more quantitatively justify themselves in terms of student skill development and long-term career successes. Having a more formalized and grounded means of evaluation for these spaces should allow for more robust grant proposals, compelling fundraising pitches, and alluring recruitment communications for prospective students, which would all contribute to the long-term financial sustainability and overall thriving of campus makerspaces.

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