An Analysis into the Efficiency of Makerspaces

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In the past decade, the emphasis on science, technology, engineering, and mathematics (STEM) within the education system has dramatically reshaped the landscape of teaching and changed the way in which students engage in learning. Within the engineering curricula alone, education has progressed to involve more independent learning and erudition through exploration. One recent example of learning through exploration comes from the Makerspace movement happening in the United States, where makerspaces are being created in the name of STEM in remarkable numbers (Halverson, 2014). But what even is a makerspace? From a purely technical perspective, a makerspace is nothing more than a collaborative environment equipped with fancy tools, like 3D-printers and CNC machines. The goal of these spaces is to harbor creativity and encourage STEM values through hands-on exploration (Avneet, Hynes 2018). The growing makerspace movement within the United States has put makerspaces on a pedestal as a novel approach to boost creativity and innovation - but are they truly effective in what they claim to achieve? Are the intended goals and end results of Makerspaces aligned and are the educational benefits reaped from Makerspaces worth the resources?

As the Makerspace movement grows within the United States, and more cities begin to adopt Maker culture, the need to evaluate the efficacy of Makerspaces becomes pertinent. Moreover, it is paramount that there exists a way to evaluate Makerspaces that considers both the associated resources and benefits. For instance, in regards to constructing a Makerspace within a Smart City, it would be important for city coordinators to consider the utilisation of resources as well as being able to quantifiably evaluate the benefit (or lack thereof). For the most part, the impact these spaces currently have on the surrounding community and the educational system are assumed. In other words, makerspaces are being measured in terms of their potential for impact, not their actual impact (Cun, 2019). Makerspaces are being created in libraries and schools across the nation to boost creativity and innovation, yet no evidence is shown that Makerspaces are anything more than novelty workshops. Furthermore, the resources and cost associated with building and maintaining a makerspace are often overlooked. Through this paper, I begin to layout the framework to evaluate Makerspaces and form an argument regarding their utility as a learning tool within the educational system.

Literature Review

A conceptual framework for dissecting educational makerspaces. To begin, it is important to define the criteria to which we will measure the impact of Makerspaces on the education system. To help better understand the interweavings of Makerspaces and education, I investigated literature pertaining to frameworks to help analyse the socio-technical system. Hira & Hynes (2018) discuss and propose various frameworks that analyse the impact of makerspaces from a nontechnical perspective and use that framework to realize the educational potential of Makerspaces. In one proposed framework, the authors discuss the relationship between people, means, and activities, and then generate the representation of those in the context of makerspaces. The people in a Makerspace, including different groups like teachers, parents, community and students dictate the means, or goals, of the space. The means, then, eventually dictate the types of activities and tools available in the Makerspace. In the conceptual framework, the three aspects of people, means, and activities are interconnected via purpose. Depending on the purpose behind the space, each Makerspace could be focused toward either the people, the means, or the activities of the space, argues Hynes. Furthermore, Hynes argues that Makerspaces tend to sway towards being either people-focused, means-focused, or activities-focused based on the actual purpose of the Makerspace. Essentially, the purpose of a Makerspace shapes which aspects the space focuses on, and in turn, the efficacy and impact the space will have. The author argues that the purpose behind a Makerspace provides weightage to the people, means, and activities involved in the Makerspace. The purpose of a Makerspace could be defined when the space is initiated or can be constantly and continually evolving as the Makerspace changes to its surrounding. Most educational settings design Makerspace with the purpose of meeting educational needs and outcomes before the Makerspace is actually created. Alternatively, community based Makerspaces tend to continuously shift purposes as the context of the space changes within its environment. It is crucial to realize the various instantiations of purpose within Makerspaces, as the purpose shapes the people involved in the space, the means by which the purpose is achieved, and the activities dictated by the goals of the space. All of these aspects have a role in the impact a Makerspace can have on its surroundings. The framework creates the groundings to analyse makerspaces, from conception to present, and further deduce the specific impacts on various actors within the framework. Although the paper makes no firm argument regarding the efficacy of Makerspaces within an educational environment, the framework presented is generalizable and sets the grounds for effectively analysing different spaces from the perspective of purpose.

Formulating an assessment for Makerspaces. Another article, called *An assessment matrix for library makerspaces*, is extremely pertinent to defining the specific skills Makerspaces are targeting to teach. Aijuan Cun, Samuel Abramovich, and Jordan Smith, in response to the emergence of maker culture, develop an assessment matrix to help assess learning benefit from Makerspaces. Because Makerspaces promote informal learning and usually lack a designed curricula, it is a challenge to create a meaningful yet substantive assessment. To begin tackling the problem, the researchers analysed different theoretical perspectives on assessment, like summative and formative assessment. The authors then implemented a research methodology to iteratively design the assessment process. One of the major goals of the design process was to identify evidence of learning (or lack thereof) available within a library makerspace. Through observation of key values within library makerspaces, data collection, and feedback from librarians, the authors were able to produce a concrete procedure by which to evaluate library Makerspaces (Cun, 2019). As assessment needs change based on the patron, the researchers developed slightly different procedures for children and adults and for first time participants and return participants. This is important to note as the role of distinguished actors is paramount in both literatures, and the actors involved most definitely impact the space. Additionally, the matrix defines key activities present in most library makerspaces, like 3D printers and Virtual Reality, and categorizes them into their potentials for educational benefit. In doing so, the researchers isolated specific learning opportunities and are able to attribute the patron's comprehension to a specific activity. Furthermore, the designed assessment matrix, although specific to library environments, combines both summative and formative feedback to understand the unique learning opportunities provided by making. Although this research is only an initial step into assessing Makerspaces, by understanding the initial goals, the coupling of unique learning opportunities and available activities, and curating a actor-specific assessment model, makerspaces can be thoroughly evaluated.

Theory: Actor Network Theory

In order to systematically understand the impact, and form an evaluation upon these Makerspaces, Actor Network Theory (ANT) was used to dissect the Maker movement. Actor network theory is an approach to understanding the ever changing environment of technology through the identification and interactions of various actors. ANT relates with mainstream sociology when it states that actors have the power to change other actors. In other words, when we act we always interact with others. ANT points out that not only humans, but also non-human entities are constantly influencing technology (Dankert, 2016). To ensure the framework is robust, ANT represents the technology using only actors and their interactions with other actors. By defining these actors and their interaction with other actors, we can more easily understand the shapings and inner workings of a technology. In regards to Makerspaces, ANT allows us to couple the purpose and the outcome of a makerspace and relate it to the interaction of different stakeholders in the environment.

Case: Coupling engineering curricula with a makerspace

To more clearly understand the coupling of Makerspaces and school curricula, I investigated a case study on the impact of Makerspaces and the engineering curricula. Mohammed Galaleldin, in his paper *The Impact of Makerspaces on Engineering Education*, investigates Makerspaces from many aspects, and then concludes with an analysis of the Richard L'Abbe Makerspace in the University of Ottawa (Galaleldin, 2017). The first important observation by Galaleldin is that the objectives of Makerspaces depend on both the support it gets from external actors and the level of success Makerspaces have had until now. The external actors, in regards to ANT and the case study, are the target audience, managerial staff, and the space itself. These actors and their interactions are studied further later when trying to properly evaluate Makerspaces. Additionally, the objective/goals of each Makerspace changes with the target audience. For example, the Makerspaces created at the University of Georgia Tech and Taubman School of Architecture were intended to provide a space where students and faculties from various disciplines could work on projects together. As a result of this, these Makerspaces became more design oriented as both engineers and architects could utilise the space to prototype and innovate. On the other hand, other Makerspaces that emphasised research, like the one within the University of Victoria, aimed at curating a space to support research projects and provide students with research grants. From this case study, it is evident that the objectives of a makerspace, including the intended target audience, shape its construction. Furthermore, these actors, like target audience, are decided prior to the construction of the makerspace and should be paramount in designing the Makerspace (Galaleldin, 2017).

Next, Galaleldin explores the various financial models, key partners, and management structures adopted by different Makerspaces and how these decisions shape the impacts on both the educational curricula and the community. These non-human actors also play a big role in the success of a Makerspace. At most of the university Makerspaces surveyed within the paper, the funding came from grants and were maintained by students and faculty. The financing for the longevity of the Makerspaces was handled by specific department heads. Furthermore, the various objectives of the individual Makerspaces correlated with the key partnerships that they intended to form. The research-oriented makerspace at the University of Victoria, for example, formed partnerships with research professors and centers within the university and continuously searched for support from external research foundations. Finally, Galaleldin listed the different management structures of the surveyed Makerspaces and correlated them to the different values and goals that they intended to achieve (Galaleldin, 2017). The management ranged from spaces that were run by a single professor, to a student body, to externally hired full-time staff and a complete board of directors. Generally, the Makerspaces that had management bodies that included more professors were more research-oriented and coupled closely with the engineering curricula. Alternatively, the Makerspaces that were run by student bodies were more design-oriented, and provided a greater selection of tools and equipment to innovate with. Another contribution made by Galaleldin that is relevant to my research comes from his analysis of the Richard L'Abbe Makerspace in the University of Ottawa. Galaleldin, through the analysis of the engineering curricula in place at the university, identifies key skills that are important for 21st century engineers to know including communication and team work skills, investigation skills, design skills, entrepreneurial and management skills, and problem solving skills. These skills were derived from the engineering curriculum and students who utilised the Makerspace were surveyed about their improvement in these areas. Galaleldin, after surveying the participating students, found that students claimed to have gained competency in these umbrella skills after using the Makerspace for months. Although the paper is limited by the credibility of self-evaluation on the side of the students, the derivation of these umbrella skills from the engineering curricula seem valid for the overall evaluation of Makerspaces.

Case: Makerspace or Waste of Space

To fully comprehend the impact of Makerspaces, it is important to consider both the positive and negative outcomes. In *Makerspace or Waste of Space*, a study is conducted using Brinkerhoff's Success Case Method to identify the factors that "successful" Makerspaces have in common (Benjes-Small, 2017). The general process of the method involves identifying various spaces, surveying the spaces to identify success and nonsuccess, and then interviewing the cases to find commonalities. After identifying 64 Makerspaces within the United States, the researchers developed and distributed a comprehensive survey to each space. The questionnaire developed involved responses that were both qualitative and quantitative, and the results were tabulated and then aggregated prior to further investigation (Benjes-Small, 2017). Furthermore, the questionnaire sought to seek insight into the goals, support systems, utilization, and tools in the Makerspace. The researchers cleverly designed the questionnaire to differentiate perception and fact, allowing an analysis that is unbiased and lacks “perceived” results. It is very interesting to note that the first question involved defining the purpose of the makerspace, as this has been shown to profoundly shape the Makerspace as a whole. Moreover, the last question provoked participants to consider their own makerspace, and self identify it as a success (or not). This methodology, Success Case Method, allows “success” and “nonsuccess” to be defined by the surveyees, which in this case are the users of the Makerspace, instead of any other actor. Although this choice may be less credible as the participants and auditors of makerspace are one and the same, the primary-source opinion of the surveyees provides invaluable insight.

The results of the survey indicated three main factors that lead to the Makerspace being identified as a “success”. The first and most important factor was having a purpose for the space prior to construction. This has been emphasised in almost all research into Makerspaces; purpose shapes success for Makerspaces. The purpose of the Makerspace shapes the interactions between the participants and the activities, and a concrete purpose, whether that be centering on teaching and learning, engineering, or equitable access to technology, is a key to success. The second important factor among successful makerspaces is having a supportive staffing model. These actors seem to play a key role in the longevity of the Makerspace and their involvement in the space seems to play a role in the success. As the staff interacts with the patrons of the space, they are able to identify how to better the experience for the users and overall increase the efficacy of the Makerspace. Finally, the last factor that was attributed to Makerspace success was developing the space around community. Relationships play an important role in a successful makerspace. A core community of enthusiastic users and a strong partnership between faculty and the patrons also lead to the success of many makerspaces (Benjes-Small, 2017).

Discussion

The question of how to evaluate Makerspaces is one that is difficult and not popularly explored. Much of the hype around the fad of Makerspaces is due to its potential, but when it comes to the true gains as an educational tool, much is still left to be explored. From one aspect, tying the makerspace to a curriculum has been shown to be an effective way to teach specific skills and abilities. Evaluating makerspaces then becomes slightly easier, as the Makerspace is designed to cater to specific skills emphasised in the curriculum, and formal methods of assessment can be used. Furthermore, a makerspace with a concrete purpose, is likely to have a greater and more identifiable impact than the ones that are built “in the name of STEM”. Additionally, through realizing the success cases within makerspaces, the criteria through which to evaluate the space becomes more evident. Evaluating a makerspace is contingent on the purpose of the makerspace, and hence there cannot exist just one form of evaluation. The frameworks presented in this paper as well as the analysis of cases using Actor Network Theory feed to the discussion of realizing the impact of Makerspaces.

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