Exploring Meaning-making and Innovation in Makerspaces: An Ethnographic Study of Student and Faculty Perspectives

Megan E Tomko, Julie Linsey
Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, GA, USA

Robert Nagel
Department of Engineering
James Madison University
Harrisonburg, VA, USA

Melissa W Alemán
School of Communication Studies
James Madison University
Harrisonburg, VA, USA

***Abstract*—In academic makerspaces, students explore innovative practices. Whether they see these spaces as a means to pursue innovation, however, remains to be understood. This paper examines how makerspaces and innovation are connected by the meanings that students and faculty attribute to makerspaces. Ethnographic techniques were used as the methodology to uncover these meanings. The findings presented in this paper are from the Fall 2016 semester where one graduate researcher explored and observed the engineering makerspaces, an elite student group, and an interdisciplinary collaborative research team. Through the field notes, meanings of interaction, functionality, environment, and innovation provide insight into how students and faculty perceive the value and impact of engineering makerspaces.**

Keywords—makerspaces; ethnography; meanings

I. Introduction

Today's engineering students must graduate with greater sagacity than what the standard engineering curricula has to offer them. Industry desires for engineers to have talent and skills beyond applied theory and analytical reasoning. Students must be able to communicate, collaborate, integrate, facilitate, and apply what they have learned in new innovative and unforeseeable ways. More is expected from the graduating engineer. Some students achieve a greater depth through minors, dual-majors, research experience, or internships, which are all essential to developing a broader skillset. However, with at least eight semesters of higher education schooling, numerous initiatives and avenues exist within the boundaries of higher education to expand the repertoire of skills and knowledge that students can acquire. Of these initiatives, makerspaces in particular offer a means for students to begin broadening and solidifying their engineering knowledge through the use of relevant equipment and machinery, emersion in the community, as well as mentorship, individualism, and independence. Yet, there is more to these spaces than simple tools and machinery. These spaces act as a catalyst for innovation and creativity. Invariably, these spaces are a continuous subject to many research endeavors on understanding what exactly is so valuable about a makerspace.

While quantitative research does generate an understanding of makerspaces, it is through qualitative research methods of ethnographic observation and participant interviewing that we can achieve greater insight into the inner-workings of makerspaces. The very act of making in itself can foster a greater sense of self-efficacy as student explore creative avenues, develop expertise, and learn more about engineering concepts [1]. Students feel more accomplished in their work and in their abilities as an innovative engineer . In this work, we are concerned about the meaning of innovation in makerspaces as it pertains to the intersection of creativity, expertise, and learning. In particular, we look to answer the question of "How are innovation and makerspaces connected?" which can be partitioned into three research questions:

1) *What meaning do makerspaces have to the students?*
2) *Do the students see makerspaces as a means to pursue innovative practices or not?*
3) *How does this meaning differ from that of faculty and/or staff?*

This paper presents the findings from ethnographic work studying makerspaces at a large, comprehensive East Coast University. While ethnographic observations were collected over a course of 17 months, the work presented in this paper corresponds to the initial meetings and observations that took place in the Fall 2016 semester by the senior graduate student on the project. Further work will analyze all of the data in order to verify and expand on the findings.

II. Background

A. Makerspaces

Makerspaces, while commonly undefined, are known to be open environments where people are free to explore, create, build, test, and traverse a wide domain of innovative practices through hands-on creations [2]. Makerspaces are an outlet where an individual's creativity is unleashed, and he or she is free to design and create given the resources, tools, and machinery available to them in the space. Examples of some

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common resources found in makerspaces include 3d printers, laser cutters, white boards, and high tables [3]. Across the nation, makerspaces of an expansive variety are promoting collaboration and developing maker communities [4]. Burke [5] posits the question to whether making activities are useful to higher education. Learning is the foundation of education, and education initiatives are aimed at supporting and fostering the learning of students. Learning through making is rooted in the theory of constructionism [6]. Constructionism springboards off of the foundational concepts regarding constructivism and emphasizes how learning and understanding unfolds in a learner as he or she builds a physical and external artifact [7]. The learner furthers their understanding of the artifact through his or her interpretations and meanings behind this artifact [8]. Another form of constructivism at play in makerspaces is multiliteracies. In the context of makerspace, multiliteracies are the ways in which learners communicate meaning via artifacts. Litts [9] proposes that the very combination of these two concepts is what makes the makerspace such an attractive entity to gain insights into learning. She examined different skills and design stances through which learning merged in youth makerspaces.

In order to more deeply gauge the development of a student's ability to understand and nurture innovation, critique practices have been used to assist students in the design process and making, which therefore allows students to receive feedback and to make changes to their design [10]. The design process involves identifying a problem, generating ideas to solve a problem, prototyping, building, testing, assessing, revising, and reiterating the preceding steps. In going through the design process, a student is able to recognize causal relationships which can, therefore, resolve inconspicuous misconceptions [11, 12].

The MAKESHOP at the Children's Museum of Pittsburgh aims to provide a comprehensive and engaging learning environment to the children of all ages. Researchers describe that children and families use real stuff (i.e. processes, tools, materials) as a means to engage and interact through making activities [13]. Sheridan, et al. [7] identify how this and two other different makerspaces function as forms of a learning environment via both educational making environments and communities of practice. The learning that occurs in a makerspace combines the learning that occurs within the more formal educational making environments and these more informal communities of practice, where learning is less exclusive to particular people, places, and methods [6]. The community of practice introduces a unique environment where learning occurs through a participatory culture and through the interplay of learning, sharing, and teaching [14].

Even managing makerspaces requires a new level of learning and innovation to take place. For example, libraries have slowly been evolving over the years to include spaces for "making." While the pedagogies in higher education began to be impacted by social constructivist learning theories, libraries began to take on more interactive environments such as learning spaces, learning commons, and information commons [15]. Where newer initiatives are transforming libraries into non-traditional makerspace environments, librarians are formalizing their efforts and concerns in their endeavors to begin to generate workshops and more engaging spaces. As such, librarians are now learning how to work 3d printers, laser cutters, or virtual reality technology [16].

The current movement to introduce making activities in the classroom is not without skepticism. Should the movement undergo scrutiny, results must be produced that showcase the value of making activities and makerspaces [17]. The value can only be elicited from understanding what challenges there are to makerspaces. These challenges include the inability to standardize or evaluate the results, the enormous amount of teacher preparation required to implement making activities, the limited access to appropriate resources and technology, and the wide variety of experiences and interests that students have [18].

B. Ethnography

Ethnography is a qualitative research approach that utilizes observation of an environment in order to understand a specified culture [19, 20]. While ethnographic techniques are the foundation for collecting data in cultural anthropology, ethnographic techniques are widely used in research studies across many disciplines, including education, nursing, psychology, and sociology [20]. While ethnographic research in anthropology often includes researchers living with the people that they are studying over the course of many years, the same cannot be said for education research. More likely, education research does not harbor such benefit and therefore utilizes ethnographic techniques that simply closely follows the lives of those in the culture being observed, rather than living with them [21]. While the challenges of ethnography in educational research persists, educators are making efforts to ensure that qualitative research is recognized, even in the field of engineering [22].

Several studies demonstrate the value of using ethnographic techniques for education. In a longitudinal study, Stevens, et al. [23] use ethnography in order to understand how students make themselves into engineers and how this compares to both formal and informal experiences in engineering education. Another ethnographic study in engineering education took the form of a historic ethnography and sought to understand how engineering education organizations changed in the United States, Europe, and Latin America for over the course of two decades [24]. In another ethnographic approach, two educators expressed the value of transforming STEM (Science Technology Engineering and Mathematics) to STEAM (A for Arts) through an autoethnographic account that showcases stories, experiences, and literature that demonstrate how qualitative techniques and adding Arts as a valued discipline expands and engages students and researcher. Ultimately, educators continue to pursue ethnographic techniques in order to more fully understand the educational and academic culture.

III. Methodology

A. Ethnography

Studying the meanings and perspectives that students and faculty have towards these makerspaces requires a nontraditional approach. In order to capture what meanings are associated with makerspaces, an ethnographic approach was adopted and implemented since more traditional methodologies such as surveys and controlled studies lack the in-depth quality of data that would uncover meanings. In the process of ethnography, a researcher enters into a field site – which in this case are makerspaces and group meetings - and observes and/or participates in what is occurring in that field site. In turn, the researcher removes oneself from the site, creates a thick description of what occurred through field notes, analyzes the written description for reoccurring themes and patterns, and iterates this process until no new themes or patterns can be uncovered in the written descriptions, also known as theoretical saturation [19].

For qualitative research, specifically ethnography, the background of the researcher impacts the study itself. For these purposes, it is important to understand the ethnographic researcher that collected data for this study. The ethnographic researcher is a 24-year old white female graduate mechanical engineering student. Her undergraduate studies lacked hands-on work and the institution did not have a makerspace during her time there. She grew up in the Northeast of the United States, is native born, and is attending graduate school for her graduate degree in Mechanical Engineering. Her fieldwork was completed in parallel to and for a course on qualitative research methods. Her qualitative research lens most closely aligns with an interpretive paradigm.

The ethnographic work presented in this paper was completed during the Fall 2016 semester at James Madison University. The graduate researcher dedicated over 60 hours to fieldwork and approximately 90 hours to constructing over 200 pages of single-spaced typed field notes. This paper only examines and presents findings from the first fourteen observations, which consists of over 15 hours of fieldwork that resulted in the construction of 63 pages of single-spaced field notes. These observations occurred in multiple locations at James Madison University.

B. Participant Observation

In ethnography, the researcher may choose to be a participant observer which is where the researcher partakes in the activities of the culture that he or she is studying. For this research, three different groups or entities were studied and the level of participation depended on the entity. These entities included an interdisciplinary elite group of students focused on space and innovation, an interdisciplinary collaborative research team, and the makerspaces on campus. The degree of participation in each group, Figure 1, ranges from high participation for the collaborative research team to low participation in the student team.

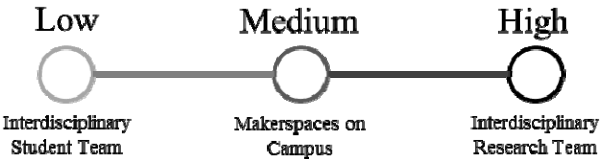

Fig. 1. Degrees of participation via the different observed communities

1) Elite student group

The interdisciplinary elite group of students was formed through a nomination and interviewing process. This group of students met twice a week for six weeks and then once a week following this six-week period. The students worked together to generate ideas and draft an experiment that would help to promote innovation for the engineering space on campus. The student group consisted of one senior graphic design student, one senior architect student, one junior engineering student, and one sophomore engineering student. The group worked in conjunction with two other groups on campus. For this group, the graduate researcher sat in on the meetings and observed and recorded the students' activities. The researcher would share ideas if the students invited her to speak and she would talk to the students during the meetings so as to develop a friendly relationship, trust, and rapport.

The elite student team met at various places on campus, depending on the accessibility and timing. For example, for the first meeting, the students met at the graphic design and architect building since two of the students worked there. The next meeting occurred in the engineering building since the other two students were engineering students. Other locations included the library, study rooms on campus, and makerspaces on campus.

2) Research team

Moreover, the graduate researcher participated in, observed, and recorded the weekly meetings for the research team who was studying the makerspaces using ethnographic methods. This interdisciplinary group consisted of an engineering faculty member, a communication studies faculty member, one graduate female engineering student researcher (the ethnographer of this study), one senior male engineering undergraduate student researcher, and two sophomore female engineering undergraduate student researchers. This group focused on looking at makerspaces through an ethnographic lens. The communication faculty trained and guided the undergraduate and graduate student researchers in their research on makerspaces using ethnographic approaches. The senior undergraduate student researcher had been using ethnographic methods for two years and the other undergraduate researchers were brought onto the project during the Fall 2016 semester. In these meetings, the group would discuss recent observations, research directions, and potential themes that were evolving from the ethnographic fieldwork of the students.

The research team maintained a consistent meeting room located near the faculty offices of the engineering building. The room held a conference table, eight chairs, a 50 to 60 inch wall-mounted television monitor, a window with blinds,

a whiteboard, and two abstract pieces of artwork. Also in this room, the walls were painted a dark purple color – one of the few walls with color in the engineering building.

3) On-campus makerspaces

Furthermore, the graduate researcher observed the makerspaces and the users on the campus. The initial work corresponds to when the engineering makerspaces were undergoing renovation and were not open for use. During the Fall 2016 semester, the engineering makerspaces were opened mid-semester, and the graduate researcher observed the space as the students began to make their way into the space. The engineering makerspaces are centralized to the first floor of the engineering building where the making room, workspace area, fabrication studio, and machining center are all made available to the students. A lab manager and trained engineering students oversee the spaces during open hours. While access to each space is dependent on the space, students are able to receive additional training on the tools and machinery of their choice.

The campus has other makerspaces, besides those housed in the engineering department. Other makerspaces on campus supported collaboration and innovation through spaces well-equipped with 3d printers, high-resolution display monitors, virtual reality equipment, laser cutters, and meeting rooms. While most makerspaces are discipline-oriented, the campus is home other makerspaces that are open to all disciplines to pursue personal projects, independent study projects, research projects, or class-oriented projects. These makerspaces offer student-led extracurricular classes to allow students to learn how to use the different equipment available in the makerspaces.

C. Analysis

Ethnographic data analysis is an iterative process. Fieldnotes and transcripts were constructed removing all identifying characteristics of participants to protect their confidentiality. Names of participants provided in the exemplars from the data in the following section are pseudonyms. In effort to develop grounded theory, the field notes were coded for common themes and patterns through constant comparative methods of analytic induction. Resulting from this process, the research questions (what meaning do these makerspaces have to the students, do the students see makerspaces as a means to pursue innovative practices or not, and how does this meaning differ to that of faculty and/or staff) were able to be identified and the field notes were then coded and analyzed further for themes and patterns corresponding to meanings and seeing makerspaces as a means to pursue innovation. For this study, the first fourteen observations included the first six observations of the makerspaces, the first four collaborative research meetings, and the first five elite student group meetings which were coded through two rounds of coding for themes of meanings of makerspaces. In this first round, the engineering faculty member and the communications faculty member coded the datasets. The research team discussed the findings and themes in the data. In the second round, the graduate researcher coded the datasets under the direction of two engineering faculty and the communications faculty members – the communications faculty member further developed the codes of the graduate researcher.

IV. Findings

A. Meanings in Makerspaces

All three sets of ethnographic data demonstrated that students and faculty find makerspaces to be meaningful educational and relational spaces for exploration and learning and community building. The flexibility and openness of makerspaces are key to how the students make sense of their instrumental and relational value. The following themes showcase the meanings constructed in makerspaces: (1) makerspaces as places to explore; (2) makerspaces as places to build community; (3) makerspaces as flexible for functionality; and (4) makerspaces as open.

1) Makerspaces as places to explore

Students found meaning in the interactions with the makerspaces and with other people therein. Interactions with the space came in the form of having a space or place where the students could eat, sit, and work (both on school work and personal endeavors). On multiple occasions, the students were found eating during their group sessions to work on assignments:

> *Occasion 1*: Ken pulls out a square bit of Tupperware that contains a green and cream colored dish that causes my stomach to grumble at the smell. It apparently sparked Bob's curiosity, for he asked what Ken was eating. Chicken and broccoli casserole. Ken also pulls out baked Lays chips, and peaches. I find it almost welcoming that he feels comfortable eating with the rest of us here. Johnny starts with business, passes around his phone for everyone to type their emails into, and adds us to the Google drive.
>
> *Occasion 2*: Everyone besides Mav pulls out their laptops. Mav is hacking away out a bowl of leafy greens. The team reiterates that all that they have to do is the work on the tool as their assignment.

Although there were no rules that indicated weather eating was allowed within the spaces, the students felt comfortable in the space to eat while working on their assignments with their group. The students incorporated simply eating, sitting, and working on assignments as a way to explore what they were allowed to do in a space.

Further, while the space consisted of machinery and equipment, the students were able to explore the use of and interact with the different types of equipment for their projects. Types of machinery and equipment available to students including 3d printers, laser cutters, lathes, mills, and tools such as drills and screwdrivers. The layout of this machinery and the types of a projects that students create using the machinery, Figure 2, impact the students' ability to explore the space. While in these beginning phases of the newly developed space, the students are wary to engage in the space, yet even having the resources available to them thereby presents an opportunity – one of which they would

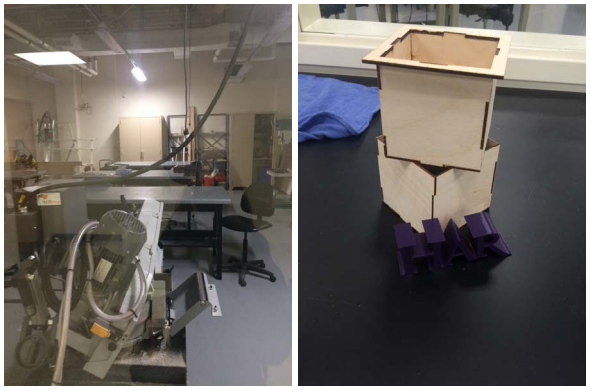

Fig. 2. Machinery and example projects in the makerspaces

not have without the makerspace. A student's interaction with the space depends on what was included in the space, whether that be high work tables with rolling adjustable chairs or a small study room with a whiteboard which allow for interaction with other students:

> Tara writes on the whiteboard "How might we…?" with the bullet points below it "1) support students 2) advertise support 3)" Jillian interjects "Where are you finding these?" Tara says that "I'm just looking at our interviews." She is looking at the interviews on the Google drive and pulling out the themes to write about. Bob presses that "we need to figure out a good 'how might we' and brainstorm 30 ideas for that." He wants a really good 'how might we' question. Once we have a good 'how might we' question then we can easily brainstorm ideas. Jillian wonders if "maybe we should summarize our interviews… Ooooo there was a comment." A person on the website ended up giving them feedback on their work.

Even more, students interact with other students in the space as they explore new conversations and new ideas with a space that has seemingly less restrictions than their classrooms. New insights and new pathways are explored while the students immerse in these conversations with their peers in makerspaces.

2) Makerspaces as places to build community

Students viewed campus makerspaces as important sites for building community with others like them and thus the importance (and meaningfulness) of the spaces were dependent on the opportunity to interact with other people, including faculty, other students, or staff. They identified the space as one of which they could interact with others through schoolwork, projects, meetings, or simply casual conversation. Makerspaces as places for community and relationship building was an important theme across the data, as students indicated they felt more comfortable in the makerspaces when they knew others in the room. Further, the spaces themselves were closely connected with the students' identities as "engineering students" and were experienced in somewhat territorial ways, as noted by a student in the elite group:

> There is only one or two places on campus where people can mingle. Engineering students stick with engineering students. There are few places on campus where interdisciplinary collaboration occurs.

Interestingly, major-specific makerspaces such as those in engineering can be perceived as limiting cross-disciplinary collaboration while also building a strong sense of in-group, in this case disciplinary, identity.

Not surprisingly, the meanings of community-building are complex and fraught with contradictions. For example, students appreciated the potential for interactions with faculty in one of the makerspaces due to the proximity to faculty offices, while also simultaneously felt intimidated by their watchful gaze. One engineering student commented:

> Although the fact that the room is right next to the faculty offices – I'm not sure how I feel about that. At least in regards to setting up camp and working there. On one hand, it's good to be nearby faculty. On the other, faculty can be very intimidating and might make me feel watched almost.

While this student's comment might suggest that students then would turn away from using the makerspaces adjacent to faculty offices, the space was usually occupied by students throughout the day.

Thus, the students wanted a place where they can interact with other students and faculty from engineering to build community and their sense of identity as engineering students, while also desired an opportunity to interact with students in other majors. The engineering-specific makerspaces coupled with the university-wide makerspaces allow for these potential relationships.

3) Makerspaces as flexible for functionality

Makerspaces are viewed as flexible spaces that fulfill multiple instrumental and relational needs, thus must cater and adapt to the different spectrums of functionality: casual space to working space and an individual space to meeting space.

First, students viewed and used makerspaces as both a casual space and a working space. Students could find themselves chatting casually in the space, and moments later, they would be immersed in the trenches of a project. The spaces are constructed with formal work tables and hard plastic chairs while also included an area for comfortable seating (see Figure 3). For example, one student noted, "Really, I have seen students laying on couches in this room." In another instance, students have been seen "pulling a whiteboard through a set of double doors and into an enclosed room with stacks of books and seating areas." Indeed, in the course of ethnographic observations, the researcher observed the multifunctionality of the spaces where students combined social conversation about their weekend and classes, with project-specific work in a short period of time.

Second, the makerspaces could transform to be both an individual workspace and a meeting space for groups, as there are multiple tables that allow one person to work at one table and other tables to be filled with a group of students on a project. It is typical to find spaces serving multiple needs

Fig. 3. Variety of functionality of the spaces as the range from comfortable spaces to working spaces.

simultaneously and students will modify the spaces to serve their purposes:

> The group decided to revise their plan to meet at Main Hall due to an event that was taking place there. Instead, they chose to return to their original intended meeting place – the Design Center. When we get there, someone is sitting in the main lobby area where we had met last time. The main lobby area is open, has no desks, and has student projects displayed throughout. After discussing where we could potentially sit down, pull out our laptops, and sink into the work that we have to do, Jillian perks up and motions for us to follow her. She scurries into a hallway at her gaze falls upon a door that has a keypad on it. Her instinct tells her to type in some numbers in the keypad. She presses on the door handle and pulls open the door much to her surprise. She exclaims that there were rumors about what the code was for the door and that it worked. We enter into a room – a studio room.

In the ethnographers work with the elite group, it was commonly observed that the group sought out spaces that would work for their purposes and the fact that the group met in makerspaces across campus highlights the multifunctionality across those spaces. As shown in her field notes, "The group agrees to find a study room on the third floor. Jillian was itching for a table so that she could put her computer on it and work. The rest of the group had the same desire not to be doing work on their lap."

Ultimately, the flexibility of the space to cater to the students' wants or needs was meaningful to the students. Students found ways to make a space work with their needs despite the intention or purpose of the space being for another need. During the time of the observations, the engineering makerspaces were being renovated; thus, the functionality of those makerspaces was unknown and abstract to the students. Students saw the new spaces with uncertainty and were unaware of the intentions of the spaces beyond the knowledge that the spaces are "theirs" (for engineering students) and will help them build their engineering skillsets. While the new spaces themselves did offer flexible and modular workspaces, the uncertainty of each makerspaces' purpose may have led to even greater flexibility by the students.

In sum, the functionality of the space caters to multiple student activities. In one room, the students have a sitting area, tables to work at, and books to utilize, while other rooms may include high-top wooden tables, whiteboards and others machinery. Students notice the small elements of the room that may enable and encourage their use. For example, a student noted: "I personally really like this room – the mix between the sitting area, the tables, the colors, the books, and the wall décor." While these makerspaces allow for a variety of activities ranging from a study space or a workspace, students will craft their own use of the space, such as using the space to take a nap in.

4) Makerspaces as "open"

A makerspace environment is commonly articulated as being "open." While there is still much more to be investigate the "openness" claims of makerspace, openness does heavily emanate from the words that students use to describe the spaces. Moreover, there are numerous ways that this openness manifests in the makerspace design and built.

First, the physical built and structure of the spaces are open. Open doors, windows, and clear paths into the spaces are important to students expereinces of the spaces. A well-articulated pathway to get to the space was also important. For example, signage was one means that students looked to find the makerspace. A space that was accessible and visible provided an open space. Further, the space being physically wide and spacious with windows to the outside informed a level of openness to the space, see Figure 4.

Second, the idea that the makerspaces did not look like typical classrooms and were places for them to pursue their work and goals was important to students' experience of these makerspace as open. In these spaces, students feel free to choose what they want to work on in an environment that does not constrict their endeavors. Importantly, the makerspaces were not uniformly discussed as "open," but were evaluated for their character as more or less open. For example, a makerspace can feel welcoming to the students while also feeling uninviting depending on the amount of activity that was in the space and who was in the space. This demonstrates the close intersections between all of the themes regarding the meanings constructed in the makerspaces. The instrumentality, community building, and flexibility of the spaces all connect with students' understandings of the spaces as more or less open at any given time.

Fig. 4. Open spaces in the makerspaces.

Through student conversations and ethnographic interviews, students discussed the spaces that were welcoming and inviting. The fact that a space was "open" manifested through feelings of warmth and inspiration. For example, one student noted, "It makes me feel welcome. Warm. Inspired. That work can be enjoyable… Still, the whole set up is very inviting."

Physically speaking, the space promoted openness by the attributes of being spacious and bright. In contrast, even a space with windows can give students a sense of confinement. Evidently, windows themselves do not signify openness in a space. There is more to the desire to have an open environment than just windows and open doors. Jillian, a member of the elite student group, highlights the multiple meanings of openness including the size of the space, access to natural light, and its' association with a particular student identity:

> Jillian likes to work in the Design Center since she personally likes to be more isolated and they give seniors some space. She also likes the Main Hall as well. It is really bright and is a big space. She can see everyone going around and if she had to work in a room like this then she would be very anxious (the one that we are in. It is a closed in room. One wall is floor to ceiling glass windows that is open to the hallway of engineering building on the third floor. The rest of the walls are white. One of them has a whiteboard on it. The table is in fact four tables. Two rectangular ones next to each other along their long edges – this makes up the center of the table. On the ends are trapezoidal tables. Overall, it makes a hexagonal shape for the table). This room is almost too confining. She would want to be able to see outside.

Jillian's preferences also highlight the value of multiple makerspaces with different environmental features and designs to cater to a diverse student population with different needs and identities. Focusing on the meaning-making of the student body showcases that there is not a singular understanding of what constitutes "openness," yet flexibility seems to be a key feature associated with its meaning.

B. Makerspaces and Innovation: Student-Faculty Comparisons

Both students and faculty see space as a means to innovation, answering our second research question with a definitive "yes." To the students, innovation is spurred from the support that faculty and/or the institution provide by making an effort to make spaces conducive for the students. Innovation, to the students, was inspired by spaces that are designed well and where interactions can occur between people.

1) The limits and possibilities of "re-purposing" space

Students were able to identify when a space was built for one function but was being used for a different function. For example, one student talks about the spaces on campus,

> *A lot of spaces are not designed with student interaction in mind. A lot of spaces on campuses that were not originally designed for the purpose that they are being used currently. Like welding in an old biolab – doesn't really work out.*

When the researchers on the project read over this statement, one member stated that while they and the other people whom they worked with tried to make the classrooms function, the classrooms still appear not to be doing their function. This brings up an interesting contrast and tension, for while the students are desiring spaces that intentionally crafted to inspire innovation and interaction, authority figures were trying to utilize and make-do with the resources available to them. On the other hand, while the engineering makerspaces are being renovated with the intention of creating the spaces that inspire an engineering identity, the students still used the space for other purposes or even would manipulate a space to fulfill their need for the moment.

Further, students felt letdown by renovations, expecting a new building, but experiencing an update on older spaces. One student observes:

> They [the students] got all excited thinking that they were getting a new building, but all they did was slap some paint on the walls.

Faculty too recognize when the design of a space fails to meet expectation and inspire innovation. For example, one faculty member noted that it is important to look at what is not working in a space: "Look at the space and the problems of what happens when instead of a space inspiring creativity, it does the opposite."

2) The need for spaces to create a "buzz"

For students, innovation in space also came in the form of a "buzz," an *in vivo* code in our analysis. While articulating what this "buzz" is was a challenge, the students found that certain areas with a buzz were attractive and places that they wanted to be. For example, one student notes:

> The engineering building is a trauma ward, there is nothing exciting. The front door is like an airport lounge where people are just sitting there by themselves, listening on their headphones, and not talking. It's not a space that is conducive for working. One would think that a space that focuses on technology would be a place that is alive and exciting when you walk into it. **The exciting part about the business building is that it creates a buzz about the major. Perhaps, the fact that the engineering building doesn't have that buzz then people feel that they can just walk in.** Or that it is a just a long hallway that needs more outlets and tables.

The importance of this buzz allows for the engineering identity to be cultivated in a space that aims to inspire an engineering culture. Such a buzz would, in theory, allow for innovation to occur. For the students, the frustrations on their current spaces were very apparent, especially the lack of having an engineering space.

3) Makerspaces as vehicles for innovation

Faculty view the makerspace as a direct means to inspire innovation. The makerspaces were being designed intentionally such that spaces could provide the students with

a variety of resources while also attempting to cater to students' needs and the curriculum. Even more so, the makerspace is also an avenue to understanding innovative practices. In this way, the makerspaces became a space to research, and this research informed the design and transformation of the space. In this direction, questions begin to arise: how does the space make you feel, how are you engaged differently than previous years, what are you doing in absence of the makerspace (for when the spaces were not accessible since they were being renovated), how do people communicate and learn, etc. The understanding of innovation came from understanding the interaction of students with each other and with the space. Overall, faculty saw this space as a means to understand and inspire innovation in their students. This led the faculty to have a more inquisitive and analytical view of the space and how it functioned for the students.

4) The challenge of interdisciplinarity

As noted in previous themes regarding community building, fostering innovation is viewed as connected to interdisciplinarity. Yet, campus cultures often constrain cross-disciplinary interactions. Major-specific makerspaces are one of the ways that limit the potential of engineering students innovating with students outside their major. While this functions to enhance students sense of in-group disciplinary identity, it may impact and challenge innovation practices. For example, a faculty member noted this challenge: "Now the classic makerspace is intended to be interdisciplinary in bringing in people of all different majors – but that's not usually how spaces work."

Likewise, students noted the cultural and administrative constraints to cross-disciplinary interactions:

> Mav [one engineering student] says that you can't use Computer Science computers in the CS Lab unless you are that major. This indicates exclusiveness.
>
> But then Bob [the other engineering student] replies that there is a reason for that. Those computers have programs on them. Our computers [the engineering computers] are our private computers. Programs (as in administrators for engineering) pay for those computers.

The tension between developing identity while also encouraging the cross-disciplinary interactions between students emanates within the makerspace environment. Students themselves crave both an identity and pride within their major while also having the opportunity to explore the challenges and opportunities that come with interdisciplinary collaborations.

V. Discussion

Throughout the ethnographic observations, makerspaces are noted to provide a variety of meanings to the students. The spaces fostered meanings of exploration, community, functionality, and openness. These meanings showcase the importance of having spaces that inspire students to be able to interact with each other and with faculty, having spaces with adaptable and multi-functionalities, having spaces that are open, and having spaces where innovation is encouraged. Yet, such meanings have to be carefully considered in the development, design, and implementation of makerspace. Even so, these meanings to students are not necessarily without contradiction and tension. As demonstrated in the datasets, the students want a space that caters to their needs, yet such spaces may be difficult to build when individual students do not all desire the same thing in a space. Even creating spaces with multifunctionality, the manner in which a multifunctional space is designed can impact the ability for students to build community and explore the space. It is important to consider that these meanings are not exclusive and can greatly impact the make of the makerspace and how students interact within and with the space.

While several meanings can be extracted regarding the students view on makerspaces, both students and faculty also found makerspaces to be spaces to pursue innovation. Students and faculty recognized the limits and possibilities to the spaces, the need and desire for the space to create a "buzz", the space as a vehicle for innovation, and the challenges within such spaces for developing identity and interdisciplinary. Students wanted these several attributes to the space and felt that such spaces were provided to them through the institution. These students felt that faculty was on their side in regards to desiring innovation, but there was more on the institution to supply such spaces. Nevertheless, the faculty, whether seeking innovation or not, had greater knowledge on how institutional support for such facilities was provided. This led faculty to explore the spaces through research initiatives in order to understand how to create valuable spaces for the students and to see how students used the spaces provided to them. This lead to the ability to juxtapose what students said about makerspaces, how they used the space, and what faculty were capable of doing with the space. This juxtaposition showcased the variety of perspectives between students and faculty on makerspaces and what challenges and desires existed on the student and faculty viewpoints, which are both equally important and valuable in the design of makerspaces. Amidst the wide-ranging tensions and attitudes highlighted in this work, there still remains much to uncover regarding the meanings to makerspaces.

VI. Future Work

This paper presented the initial findings regarding meanings in the first fourteen sets of field notes. Future work will be to examine all of the field notes and continue to complete the iterative process identifying the meanings various individuals prescribe to engineering makerspaces. This process is allowing for the meanings of engineering makerspaces to be captured through the renovation of engineering spaces at a single East Coast University. Additional studies at other university makerspaces will allow for comparison of prescribed meanings leading toward broader comparisons and understanding. Additionally, these findings will be triangulated with the several student researchers who have worked to capture the spaces through ethnographic work. While the meanings presented here demonstrate that makerspaces are more than just a space to

make things, there is more to discover in the qualitative data analysis of the current data that has been collected.

VII. Conclusion

Students develop inherent meanings to the studied makerspaces. Across the board, the students do not have the same meanings to the space. This research demonstrates that there are meanings of interaction to the space – that students see these spaces as places where they can interact with others. Understanding the meanings that students are identifying with makerspaces can act as a springboard for understanding makerspaces and what students are learning and how they are benefiting from these spaces. Students make meaning in these spaces and when something has a meaning then that greatly impacts someone's ability to learn. While building and testing are evidently very prominent in makerspaces, in understanding the meaning behind why someone builds and uses a makerspace, we can help to create environments where meaning supports and guides the learning that students undergo in makerspaces.

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