Qualitative Case Study: Faculty Perceptions of the Development and Delivery of Makerspaces at an Urban University

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Introduction

DPW University is a minority-serving, public university in an urban environment. The institution's mission highlights the inclusion of students of all socio-economic backgrounds to partake in a robust and challenging academic experience in order to be well-equipped for a career after graduation. In order to address the evolving and new careers that are becoming available, DPW University realized a need to incorporate a more challenging curriculum to best prepare its students before the begin their careers. Specifically, careers in STEM fields (Science, Technology, Engineering and Mathematics) have been on the rise.

Statement of the Problem

According to the U.S. Bureau of Labor Statistics, employment in STEM field will grow by 18.7% between 2010 and 2020 compared to an increase of 14.3% in all occupations ("What does the S&E job market," n.d.). In order to address this discrepancy, the institution analyzed and took an inventory of its student population. Analysis revealed that the student population consisted of learners with varying self-confidence, critical thinking, literacy, problem-solving and technology skills. Due to the expansion and marketing efforts of the university's programs of study in STEM fields, it has seen an increased enrollment in these academic areas.

DPW University has developed and implemented the Makerspace Program at the main campus' library for all students enrolled in a STEM-related course or program. The intention for this space was to provide students with a disruptive innovation where they have access to a setting where they can transform their learning experience in a more accessible, customizable and creative way (Horn and Staker, 2015). The makerspace environment provides students with an alternative way to interact with the curriculum, assessments and various learning activities in a creative and customizable way according to individual students' needs. The university's

administration approved and provided a space for this initiative within the library. Five librarians were tasked with working with STEM faculty to design and maintain the makerspace environment as well as providing materials (including technology) which are appropriate for the curriculum.

Need and Value

Makerspaces have become popular in K-12 schools and curriculums within the last decade. Schools have utilized makerspaces in order to foster student collaboration, increasing exposure to self-directed learning activities, trial and error, delegating tasks, developing leaders and sharing work or tasks (Oliver, 2016, p. 160). Institutions of higher education can benefit from these qualities and exercises to address the need of supporting creativity and varying learning styles of students in college.

Institutions of higher education are made up of students of varying skills, learning styles, experiences (on and off campus) and interests. Providing a learning environment where individuality plays a part in students' learning and success will introduce instructors to a new way of teaching. Furthermore, students will cultivate skills and strategies which will aid in their professional development post-graduation. This study will analyze the DPW University faculty members' perceptions on student engagement, success and barriers involving a newly integrated makerspace at their institution.

This study will focus on the constructivist theory as the essence of makerspaces involves engagement with peers, instructors and available resources and materials within the space. The previously mentioned components of a makerspace will by studied in order to address the importance of the acceptance and approval of such programs by administrators, instructors, librarians and support staff within an institution of higher education.

The results of this study will provide institutions of higher education insight into the perceptions of faculty involved with makerspaces. This information will aid institutions in the development of environments which provide learners with an arena which fuels student engagement, creativity and academic success. Best practices, gleaned from conducting this research study, will provide a framework for implementing a successful and innovative learning environment.

Research Questions

Research Question:

What are the perceptions of faculty regarding their involvement with the development and delivery of a makerspace at an urban university?

Research Sub-Questions:

How is student-learning impacted while exposed to a collaborative, interactive, and challenging learning environment?

How do students interact with the environment (physical space, software, materials, etc.) in the makerspace?

What are the perceptions of faculty regarding the available support resources available to the makerspace and its users?

What are the obstacles with facilitated instruction and learning within a makerspace?

Review of Relevant Literature

A review of literature on the topic of makerspaces will provide insight on important areas of establishing, developing and maintaining these environments. Recent studies, which analyzed existing makerspaces, will provide an overview of how makerspaces benefit teachers and learners, what obstacles and deterrents facilitators could be faced with, the expectations of makerspaces in the future, and the necessary skills which are required for facilitators of makerspaces. This literature review will provide important information in order to assist in understanding the growing trend and phenomenon of makerspaces in educational institutions.

Benefits of Makerspaces

The implementation of makerspaces provides institutions with a wide range of benefits. Analyzing existing research on organizations which implemented makerspaces and how they impacted the teaching and learning of students and instructors provides useful information on proper integration and development of such programs. Slatter (2013) explains that a study of existing research exposed an increased likelihood of expanding technical academic programs, improved academic programs and an increase of community engagement at institutions (p. 282).

Traditionally, librarians at institutions of higher education are expected to bring college communities together for the purpose of research, teaching and learning. As makerspaces become infused into libraries, it is incumbent upon librarians to utilize these spaces as incubators for makerspace facilitators. This provides librarians opportunities “to share their skills and for individuals to pursue self-driven learning; as requiring new forms of librarianship and as drawing on traditional skills of librarians as community connectors” (Williams and Willett, 2017, p.1).

Providing teachers and students with an environment where they can collaborate and learn together facilitates opportunities to create solutions to problems existing outside of the

makerspace walls. Moorefield-Lang (2014) conducted a study which exposed instances where 3D printers, which were part of a makerspace environment, provided participants with opportunities to interact with unfamiliar technology which results in creating potential solutions to real-life problems or challenges (p. 592). For example, a faculty member interviewed, had assigned his students to create items for needy children across the globe. Students learned how to operate 3D printers and created bracelets which were shipped around the world (Moorefield-Lang, 2014, p.586). This case study provided insight on how the experimentation with technology in a makerspace provided a service-related outcome and experience for learners.

Deterrents and Obstacles

As with any integration of a tool, resource, program or initiative, barriers and obstacles exist and need to be addressed. Studies have shown the budgetary limitations, parties who are resistant to change and copyright laws are areas which slow down the development and integration of makerspaces (Slatter, 2013, p. 282).

Research has shown that facilitators of makerspaces need to approach and deal with a number of existing boundaries which are inherent to their unique environment. Williams and Willet (2017) conducted a study which showed that makerspace facilitators need to become familiar with teaching learners in a social environment rather than focusing solely providing students with resources for individualized learning (p. 11). They also explain that librarians who facilitate makerspaces must define their roles in the environment and make their roles known to teachers and learners who are interacting with the makerspace environment. Willams and Willet (2017) found that "library staff indicate discontinuities between their role as literacy experts and the perception of the library as providing new maker-based learning experiences…they have reconstructed their role and changed their practice, identifying their new role primarily as

community connectors" (p.11). Providing clarity in makerspace facilitators' role is important for the effective employment of makerspaces.

The learners' actions within Makerspaces are determined by their previously acquired knowledge outside of the environment. As an example, Wang et. al (2013) conducted a research which observed students within a makerspace with engineering material and resources (p.12). It was found that without an adequate prerequisite understanding of engineering principles and collaboration and dialogue with other participants, the environment is not effective. Students without the necessary topic-related knowledge did, however, prove that they were able to exhibit an increased understanding when other learners were involved in the environment. Wang et al. (2013) states that "groups that did collaborate exhibited more engineering behaviors, reached greater depths of engineering behaviors, spent much more time at the exhibit, and completed the activity more fully" (p. 12). The collaborative and social components of makerspaces makes for a successful learning exercise.

In the natural scenario of an effective makerspace, teachers and learners are likely to be exposed to numerous social activities and conversations which they may or may not actively participate in. Bieraugel and Neil (2017) conducted a research study where students were exposed to a makerspace where separate groups of participants were networking, collaborating and tinkering in a makerspace. They found that "the noise, movement distractions, and group work going on nearby" led some participants to find solitary spaces for quiet studying opportunities or individual work spaces (p. 49). Makerspace facilitators can provide various types of stations to address the needs of different learning styles.

Ensuring the safety of students in any learning environment is a commitment of all educational institutions and is mandated by law. Safety is also a concern when operating

makerspaces as learning environments. In order to address this concern, Wilczynski et al. (2017) explain that institutions can "collect a large amount of quantitative data…to monitor and enforce safe operating practices. Databases [can identify] the individuals who are authorized to use the space and departmental affiliation of each user who has been trained and provided access to work in the space" (p. 35). Existing and/or available technologies can be enforced by all institutions to ensure the safety of all makerspace participants in order to ensure the safety as they interact with the environment.

Unknown Future of Makerspaces

In order to properly assess the continued success of any innovation in the future, it is necessary to analyze empirical evidence and research. As Slatter (2013) explains, there is lack of empirical evidence to suggest that makerspaces will or will not continue to be a strong and popular movement (p.282).

As universities consider integrating makerspaces into the landscape of their physical campuses, they must be cognizant of their mission of this type of project. As makerspaces are utilized as outlets for innovation, creativity and collaboration, adequate technologies to infuse into these environments is necessary. As Wong and Partridge (2016) explain, a modern makerspace environment may include 3D printers and laser cutters (p. 155). In order to properly plan for a creation of makerspaces in the future, institutions will need to assess the rapidly changing inventory and technical innovations which become available to teachers and learners. The future landscape of makerspaces in educational settings is unknown due to the nature of rapid technology development (Wong and Partridge, 2016, p.155).

Training of Makerspace Facilitators

In order to effectively implement makerspaces at educational institutions, trained facilitators of these programs are necessary for effective outcomes from students. As many makerspaces are situated with libraries at institutions, librarians and designated support staff need to have proper training on pedagogical best practices and how to facilitate interactions among participants and resources. Moorefield-Lang (2015) states that librarians are limited to online resources and peers who are involved with creating, maintaining and facilitating makerspaces in order to become adequately trained on such programs (p. 107).

Facilitators of makerspaces require a specific toolkit of knowledge in order to facilitate an effective makerspace environment. Kyungwon and Abbas (2015) explain that makerspace professionals should have competencies including an "(1) ability to learn, (2) ability to adapt to changing situations, (3) ability to collaborate, (4) ability to advocate for the Learning Lab or Makerspace, and (5) ability to serve diverse people" (p. 119). In addition to these competencies, Kyungwon and Abbas (2015) suggest that these professionals also need to be trained on how to manage others, how to develop programs, grant writing, fundraising, technology and learning theories (p. 121). The aforementioned characteristics outline the necessary skills and training requirements for effective makerspace professionals.

The sharing of knowledge among makerspace facilitators can improve the future of existing and new makerspace environments. Tucker-Raymond et al. (2016) shares that "Makers are interdependent because they need and expect others' expertise just as they know that they should contribute their own" (p. 210). The same is true of professionals who are involved in the delivery of these spaces. Tucker-Raymond et al. (2016) explain that sharing information will provide other professionals with information that can be leveraged to distribute knowledge and facilitate a community which "relies on exchanging knowledge and providing social support to

achieve each member's goals" (p. 210). The sharing of knowledge in the area will advance the development and improvement of the makerspace phenomenon.

Learners and educators bring their own levels of knowledge and expertise to makerspace environments. It is important for makerspace facilitators to have access to and be able to reach out to community members who may assist in the learning activities as needed. Lock et. al (2018) conducted a study that observed makerspaces where various learning needs were exposed. In one case of the study, a "technology instructor called on 3-D printing experts to assist" (p.15). In another case study, students did not want assistance using *Makey Makey* with available instructional videos. Instead, they preferred to "mess around with the kit; they demonstrated a sense of pride and accomplishment when they were able to prototype a solution themselves" (Lock et. al, 2018p.15). Makerspace facilitators must be willing and able to determine when and when not to provide assistance for learning to take place.

This literature review provides an introduction to this research study of the perceptions of educators who facilitate learning in makerspace environments. The information in the literature review is relevant to this study as it provides important information on current and effective practices of makerspaces. The findings of this study, the perceptions of faculty involved with makerspaces at an urban institution of higher education, will address the topics covered in this literature review.

Methodology

A qualitative case study design will be used to analyze faculty perceptions of their involvement with the development and delivery of makerspaces at DPW University. The study will utilize interviews of the faculty members involved in a makerspace environment and observations of the physical makerspace environment where student and faculty interactions take place over a period of time. A case study design will be used for this study as the researcher is focused on performing an in-depth analysis of an environment which is restricted by the time and location where the makerspace activities are taking place (Creswell, 2014, p.14). Interviews of the faculty and observations of the makerspace environment will provide a variety of data collection types in order to collect detailed information on the phenomenon (Creswell, 2014, p.14).

A similar study, by Moorefield-Lang (2014), utilized a qualitative case study design which has been highly cited by other research (as noted by *Google Scholar*). The study, which analyzed faculty perceptions of the effectiveness of resources available in a makerspace environment, analyzed areas concerning "their maker spaces, how long 3D printers and maker areas had been a part of their libraries, training techniques, funding, challenges, and successes with the technology and learning space, as well as favorite projects and products" (Moorefield-Lang, 2014, p. 585). Interviews and observations were utilized as data collection tools.

Social constructivist theoretical framework is used in this research study. The essence of the makerspace environment is defined by the subjects interacting within the space, therefore, the social nature of makerspaces falls within the realm of analyzing what is constructed in the environment by "makers" and their perceptions of the environment. Patton (2015) explains that with this theoretical framework, the researcher will analyze "the multiple realities constructed by different groups of people and the implications of those constructions for their lives and

interactions with others" (p. 121). Creswell (2014) explains that in social constructivism, individuals, such as faculty members involved in makerspaces, are able to share their perceptions of the scenario in which they are engaged with (p.8). This research study will examine (by way of interviews and observations) the perceptions of faculty, who are involved in makerspace environments, regarding the engagement of learners in the makerspace environment in order to develop an understanding of the effectiveness of makerspaces.

Population and Sampling

Purposeful sampling will be used in this study for selecting faculty members at DPW University who are facilitating makerspace environments for their students. Purposeful sampling, as explained by Patton (2015), is utilized in order to study a case of participants from a specific environment "because they are information rich and illuminative, that is, they offer useful manifestations of the phenomenon of interest" (p. 46). Purposeful sampling, using a criterion-based case selection method, provides the researcher with subjects who are involved in a current makerspace activity within DPW University (Patton, 2015, p. 267).

Based on the criteria for the purposeful sampling, one faculty member from each of the following academic disciplines where a population of active makerspace facilitators exist at DPW University: Physics, Geoscience, Mathematics, Computer Science, Educational Technology and Security Studies. With prior IRB approval, the researcher acquired an inventory of participating makerspace facilitators and faculty members from the Library Director. E-mails, requesting voluntary participation in the study were disseminated to the prospective participants. Upon receipt of a consent of participation, observations and interviews were scheduled with the sample. A highly cited qualitative case study, as per Google Scholar, studied facilitators' perceptions of makerspaces resource availability and effectiveness, which involved interviews

with six makerspace facilitators (Moorefield-Lang, 2014, p. 585). This related study was referenced when designing the sample population for this study.

Procedures

This qualitative research study was designed in a certain in order to effectively deliver and analyze the data with time and resource limitations in place. The procedures of the study involved flexible interview and observation schedules to compliment the schedules of the participating faculty and their makerspace activities. Upon IRB approval, permission was granted from the Library Director, to conduct the study in the makerspace environment; the Director is the manager of the physical space on campus. The researcher began the process of recruiting participants from a population of faculty members who facilitate makerspace activities at DPW University during the first week of the Fall 2018 semester.

From a population list provided by the Library Director at the institution, one faculty member from each of the following academic disciplines were sent an email which requested their voluntary participation: Physics, Geoscience, Mathematics, Computer Science, Educational Technology and Security Studies. The research utilized purposeful sampling by selecting one faculty member from each academic department who was currently actively facilitating a makerspace activity. Consent forms were distributed and signed by all students who were involved in each of the makerspace activities.

Upon receipt of the participation agreements, the researcher conducted observations for each of the six faculty members' makerspace environments during the first five weeks of the semester. The observation sheet (see APPENDIX B) was used to collect qualitative data on the engagement opportunities taking place in the makerspace environment as well as any noticeable obstacles, proficiencies, interactions, collaboration and available resources that were present.

After the collection of all observational data, the researcher coded the data which provided themes on what transpired within the physical environment.

During the eighth week of the Fall 2018 semester, interviews were scheduled with the participating faculty members which took place between the tenth and twelfth week of the semester. The interviews (see APPENDIX A for the set of interview questions) were video-recorded using video capture software installed on the researcher's laptop. The video format of the recorded interviews provided an effective approach for coding the data.

In order to validate the results from the coding of interview and observation data, the researcher scheduled meetings with the faculty members during the thirteenth week of the semester. The themes which emerged from the coding of the qualitative data were shared with the participants and the results were confirmed without amendments or additional themes.

The researcher is a full-time professional staff member and adjunct professor at DPW University. These positions present potential bias on the research study as the researcher regularly interacts with faculty members with unrelated projects. Furthermore, the researcher's role as an adjunct professor may include bias with participating students as they may have been enrolled in the researcher's courses.

A potential risk which was present during the research study was unexpected verbal or physical conflicts during the observations of the makerspace activities. This potential risk did not occur during the study. Another potential risk was having students not consent to the observational exercise. This did not occur during this research study.

Timeline for Completion

July 2019	Apply for IRB approval in order to initiate the research study
August 2019	Request and receive permission, from the Library Director, to conduct the study in the Makerspace housed in DPW University's library.
August 2019	The researcher completes an extensive literature review of the research topic.
September 2019	Request permission from a professor from the Physics, Geoscience, Mathematics, Computer Science, Educational Technology and Security Studies academic departments (the list of Makerspace facilitators is retrieved from the Library Director).
September 2019	Consent forms are distributed and signed by all students who were involved in each of the makerspace activities.
September-October 2019	The researcher conducts observations for each of the six faculty members' makerspace environments during the first five weeks of the semester.
November 2019	Interviews are scheduled with the participating faculty members.
December 2019	Interviews are conducted with faculty members from the tenth and twelfth week of the semester.
January 2020	The researcher analyzes, synthesizes and codes the data from the interview and observation data.
January 2020	The researcher validates the emerged themes from the data analysis by meeting with the participating faculty members.
March 2020	The researcher produces the report of the findings.

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Appendix A

Interview Questions

1. Describe the Makerspace activity learning objectives if they exist. If learning objectives do not exist, how do you assess your students' involvement in the activity?
2. How do your students engage with the makerspace environment (technologies, materials, collaboration with peers, etc.)?
3. How would you describe the effectiveness of the Makerspace environment in your course?
4. What do you believe, are the necessary support systems that are needed for an effective makerspace environment (technical, academic, etc.)?
5. What skills are necessary for makerspace facilitators to be successful in conducting makerspace activities?
6. How do your makerspace activities impact student learning outcomes?
7. What obstacles or deterrents have you experienced when designing and facilitating makerspace activities?
8. What recommendations do you have for instructors who wish to incorporate a makerspace activity into their existing curriculum?

Appendix B

Observation Checklist

Course Title:

Date of Makerspace Activity:

Room Number:

Number of Students Observed:

Observation	Possible Codes
Enthusiasm Level of Students	EXCITED – a high level of enthusiasm or excited BORED – disengaged and limited amount of participation
Types of Engagement Among Students	LEADER – taking a leadership role in the environment. PARTICIPANT – accepting the direction from others. SOLO – working alone and not taking direction from others.
Types of Support Resources Present	TECHNICAL – The IT Helpdesk is present to assist participants OSS – The Office of Specialized Services is present to assist students with disabilities. ACADEMIC – Subject matter experts or tutoring services are present. INSTRUCTOR – the instructor or facilitator is assisting students.
Types of Teacher-Learner Engagement	GUIDANCE – Teachers are assisting and guiding students with the activity. OBSERVE – The teacher has a hands-off approach and is overseeing their work.
Materials Utilized During Activity	SOFTWARE – Computer software applications are being used. HARDWARE – Computer Hardware, such as mice, keyboards, microphones, and speakers are being utilized. WIRES – Wires to connect different resources are being used. TOOLS – Materials such as cloth, computer chips are being used.
Technologies	PROGRAMMING – A programming language is being used in the creation of a product. DESIGN – Design software, such as Photoshop or InDesign, is being used to create a product. SOCIAL MEDIA – Social media platforms, such as Facebook and Twitter, are being utilized in the making of a product.
Presentation of Student Work	DURING – Students present their work during the makerspace session. SCHEDULED – Presentation are scheduled with the instructor during the makerspace session.