10th International Conference on Higher Education Advances (HEAd'24)
Universitat Politècnica de València, València, 2024
DOI: https://doi.org/10.4995/HEAd24.2024.17359

Connecting Hand and Mind: Fostering student creativity and confidence through makerspace projects

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How to cite: Sakkal, A.; Harlan L. 2024. Connecting Hand and Mind: Fostering student creativity and confidence through makerspace projects. In: 10th International Conference on Higher Education Advances (HEAd'24). Valencia, 18-21 June 2024. https://doi.org/10.4995/HEAd24.2024.17359

Abstract

This study explored the experiences of undergraduate students enrolled in an interdisciplinary humanities course conducted in a university makerspace. Foundational topics of learning psychology and design of learning environments were combined with activities utilizing design software and maker tools (3D-printing, laser cutting, woodworking, vinyl cutting, and other crafts). The aim was to help students better understand and gain confidence while reducing anxiety in approaching creative projects, as well as apply experiential learning approaches to course content. Qualitative analysis of weekly reports and surveys revealed student challenges in balancing design complexity with limited time, but overall appreciation for creative problem solving. Students also highlighted strengthened social bonds, mentorship, and diminished student-teacher power hierarchies. Significantly, findings showed students valued applying course concepts through hands-on making for deeper learning and personal growth in confidence, communication, and self-awareness. Recommendations include more concerted support for interdisciplinary makerspaces to reach more students outside of STEM disciplines.

Keywords: *Makerspaces; experiential education; student agency; hands-on learning; undergraduate education; collaborative learning.*

1. Introduction

The emergence of makerspaces within educational contexts has garnered significant attention as promising hands-on learning environments that encourage experimentation and learning beyond the classroom (Hoople et al., 2020; Lagoudas et al., 2016). These spaces connect to improvements in design self-efficacy, innovation orientation, and a sense of belonging within the makerspace environment (Carbonell et al., 2019; Soomro et al., 2022; Morocz, 2016). Furthermore, Wilczynski (2015) and Sheridan et al. (2014) underscore the unique attributes of academic makerspaces in fostering complex design and making practices.

Facilitator roles are integral to the maker experience, as Hilton (2018) provides evidence of a positive correlation between makerspace involvement and increased confidence and enthusiasm among teachers. This process is further enhanced through the dynamic nature of proper guidance, as increased faculty involvement helps students achieve higher levels of innovation as they experience failure-based learning (Supraja et al., 2022).

While many of these sources are extremely informative and relevant to numerous contexts, it is worth noting that most of them focus on the STEM fields. This inquiry aims to advance the distinctive potential of makerspaces as interdisciplinary and inclusive environments, beyond the predominant STEM contexts.

2. Methods

2.1. Population & Setting

This study draws on data from 180 undergraduate students at Wake Forest University enrolled in a Learning & Cognitive Science course offered through the Department of Education between 2021 to 2023, with the initial research presented in this paper focusing on the first group of students, made up of 43 students enrolled in 3 sections of the Fall 2021 semester. The course served as a divisional (general education) requirement for the university, with students coming from a wide variety of majors, and having had no previous experience with maker tools. All sections were led by the same professor, from the Department of Education.

The first half of the semester took place in a standard classroom and focused on the more customary topics of a foundational learning psychology course. Classes then moved into the university's makerspace, known as the WakerSpace (see Figure 1), for the second half of the semester. The space has a dedicated staff director and is administered by 25 student volunteers. The revamped course placed a strong emphasis on experiential learning and the design of learning environments. This was achieved by incorporating a significant maker project, fostering an active learning environment that bridged hands-on experience with theoretical concepts.

Figure 1. Facilities and tools of the WakerSpace.

2.2. Study Design

Students first completed laser cutting, 3D printing, and space safety workshops. They were then tasked with designing and creating innovative learning spaces. In small groups, students decided on a theme that tied individual spaces (e.g., preschool, arts high school, university athletic facility, etc.) and also co-created one space together. Spaces measured roughly 16x24 inches.

Within the phases of the project, there was an initial stage for brainstorming, idea creation, and planning. This took on a variety of forms with students choosing whether to sketch by hand, utilize floor planning design software, or create more complex drawings through 3D modeling software (see Figure 2). The next phase required moving plans into the software programs that connect to the maker tools. The final phase involved constructing the models (see Figure 3).

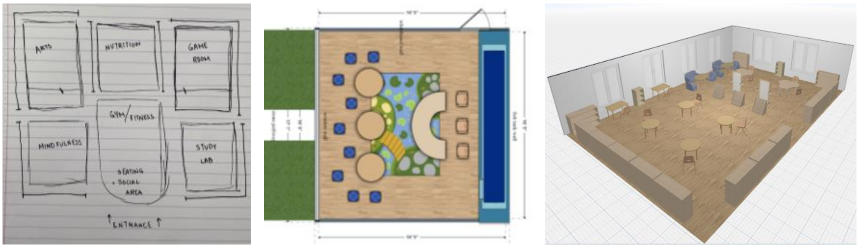

Figure 2. The variety of options for examples selected by students for the initial design stages.

Figure 3. A collection of final learning spaces created by students.

A foundational aspect of the design of the project was the recognition that this was not an engineering course, where students might be expected to master the software and tools for academic and professional environments. With most students coming from the humanities, the design and scoring of the project required an alternative structure. Therefore, the framework for the study was created with the intention of moving beyond simply serving as a grading rubric, instead capturing the genuine process of project creation (see Figure 4). As such, the first stage, *Ideas*, was intended to allow for students to experiment, take risks, and make mistakes, all foundational aspects of experiential and maker learning. Similarly, *Participation* can often be an elusive aspect to assess. This was primarily captured by the instructor taking notes throughout all class meetings and the use of weekly reports and surveys for capturing progress and logging of use of time. *Support* materialized in a variety of ways within this project, with students repeatedly accounting for the narrative reasoning behind their designs. Lastly, *Process* was included to encourage the skills at the heart of sustained inquiry that are desired throughout the academic and professional careers of students.

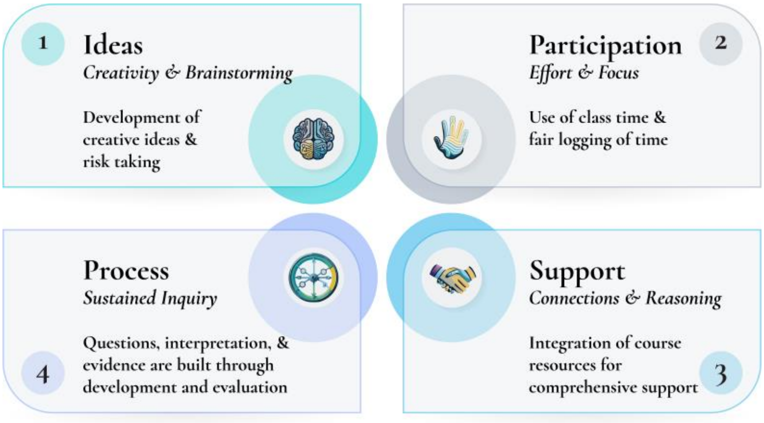

Figure 4. Study Design, Process, and Rubric.

2.3. Data Collection & Coding

The data driving this research came from five weekly reports and surveys that were assigned to students over the eight weeks of the project. Reports consisted of open-ended questions documenting use of time, reflections regarding the learning experience, connections to sources, and extensive inclusion of images to capture the making process. Surveys mainly consisted of Likert-scale questions capturing student sentiments regarding workload, stress, time management, and excitement as compared to experience with past learning environments, with some open-ended questions for clarification.

A qualitative analysis of the data was conducted through thematic coding (Gibbs, 2013), utilizing MAXQDA 2022 as the coding software. The codes derived in order to assess student learning experiences in makerspaces included: design process (time challenge and problem solving & flexibility), learning (deep learning and maker tool learning as well as self-realization and motivation), and relationships (student to student and student to instructor; see Figure 5). It is worthwhile noting there is a fair degree of overlap between these codes, and as such, some responses were double-coded. In those cases, the researchers distinguished between primary and secondary codes for the specific segments.

Figure 5. Coding Scheme.

3. Analysis & Findings

The analysis revealed three overarching themes: the design process, academic and personal growth, and relationship dynamics within the context of the makerspace. All themes are discussed in more detail below, arranged by their frequency of occurrence.

3.1. Creativity is liberating… but takes a lot of time!

Reports and surveys captured frequent reflection regarding the design process. Specifically, students addressed how they balanced attention to detail and kept the larger picture in mind by planning accordingly, frequently addressing time. Analysis of the coded segments revealed a broad consensus that time was constraining in many ways. For one, many students noted how hard it was to coordinate scheduling, for both group and individual components, with one student expressing how finding time to print… was "proving to be a challenge because of my busy school schedule and the guess-work that went into showing up to the makerspace and hoping there was room available." Facility hours often posed challenges for students, forcing them to compromise elements of their project.

Similarly, worry was also prevalent among students. Worries largely revolved around how time-consuming the project was. One student wrote in an early report, "I felt as though I was racing the clock and it was consistently winning." Another striking example from a student's first report noted their "brief mental breakdown… because it really hit me how much time this project was going to take to complete." However, in their final report, the same student expressed feeling "so proud" of the work they had accomplished, suggesting an overall positive evaluation of the experience, despite the initial immense worries.

Student views were predominantly positive and attributable to the creative and flexible aspects of the design process. Many students elaborated on problem-solving, utilizing trial and error, and anticipating future challenges effectively. One student noted how they "had to erase and redraw the tables for their design many times before coming to a final design," going on to acknowledge, "it did not decrease or increase the value of your ideas," but was rather valuable to the design process. This embrace of learning and growing from errors is powerfully reflected in one student's recognition that "the execution of this project taught me a lot about being open to change and learning to embrace opportunities for growth." Such an open mindset and appreciation of creativity coalesced with students growing in confidence throughout the project. The journey from apprehension to excitement was characteristic of the many student commentaries regarding growing empowerment and confidence.

3.2. Relationships matter

The importance of collaborative interactions and genuine relationships amongst students and between students and instructor were revealed throughout the data. Almost every student highlighted positive aspects of their group dynamics by recognizing peers as resources. One student noted that their classmates were "helpful in walking me through certain steps because I tend to forget certain things when working on the software," addressing the shift they experienced moving from self-doubt to self-confidence. Other students addressed the role of their peers as sounding boards and motivators, with a student expressing gratitude that their group members "used techniques and design elements that I hadn't thought of" because they "gave me inspiration and pushed me to try new things."

Many student noted the makerspace environment providing unique opportunities to cultivate friendships with their peers, with one student articulating they "really felt like part of a community in the maker environment in being able to form connections with new people that I wouldn't otherwise have gotten a chance to talk to." Another student remarked on the conducive nature of the space for allowing "more casual and deep conversations while also working on our projects that helped to build relationships."

Similar themes emerged with student-instructor relationships, with reports often citing interactions that fostered meaningful connections. One student noted the importance of the instructor as a resource saying, "there were times when I doubted whether or not I would be able to make something, but with the help of [the instructor], I found a way to do it using the tools." Another student discussed how the setting allowed for "more opportunities to get to know the professor and understand his level of commitment" on a personal level.

Power dynamics were often addressed by students noting how the traditional student-teacher hierarchy was less prevalent. One student remarked how "it was a collaborative space where I felt like the professor was working with me to learn, develop my ideas, and succeed together." A few students even commented that the power hierarchy shifted towards the students, with one student saying, "It became an environment where we were more in control and the professor was there to help when needed," capturing greater levels of student autonomy.

3.3. The power of hands-on learning for academic and personal growth

Students experienced both academic growth and personal development through the context of hands-on learning. In regard to academic growth, students experienced deep learning of the course content. A prime example of this came in a report that lauded how "being able to truly put.. readings to use in a synthesized way not only helped me to retain more information from them, but also just made me more interested in them in general." Others echoed similar points, with one student noting they were "confident that the concepts I learned and proceeded to utilize within my model will not soon be forgotten… because rather than just memorize the information, I actually put it to use and interacted with it in ways that I have not in any other class thus far in college."

Hands-on learning in the space fostered personal growth beyond academics. One student's reflection stands out: "This project told me I am too hard on myself... I am going to try to be nicer to myself not just in school but in all aspects of my life." Another realized, "I need to be a little bit less impulsive." Students vocalized their intentions to apply their new maker skills beyond this project, into other academic and social contexts. These reflections demonstrate how the makerspace experience helped students balance short and long term goals, adapt calmly to changes, communicate effectively, foster relationships, and enhance self-awareness.

4. Study Insights & Moving Forward

The study findings highlight many of the powerful and unique elements of makerspaces through the voices of participants, while also capturing the realities that can often lead to many individuals never experiencing makerspaces. As Budge (2021) argues, makerspace integration requires acknowledgment of their complex and often messy ecosystems. This insight calls for more adaptable instructional and institutional policies. Supporting the unstructured, creative chaos of makerspaces and fostering creativity in lieu of conventional, compartmentalized approaches means instructors must allow sufficient class time for nurturing an authentic and sustained learning process. Institutional roles here can contribute by housing makerspaces in interdisciplinary locations, bridging formal and informal learning (Hoople et al., 2020).

There are also significant costs attached to creating makerspaces that can often inhibit access. While most university makerspaces are available at little or no cost to students, supplies (e.g., 3D filament, wood, or vinyl) are not always provided. The maker machinery can also be extremely expensive, with the medium-sized WakerSpace containing two laser cutters ($25K), ten 3D printers ($60K), a CNC router ($17k), as well as woodworking tools, vinyl cutters, sewing and embroidery machines, a podcast room, circuitry and soldering stations, as well as extensive arts and crafts (costs listed in USD). These machines are complex and require constant maintenance and specialized knowledge, making the dedicated staff director and the 25 student volunteers pivotal to the success of the space. While there is a large diversity of specialized institutional academic makerspaces (Wilczynski, 2015; Sheridan et al., 2014; Hoople et al., 2020; Forest et al., 2014), access for more students of diverse backgrounds and academic interests is key to ensuring the success of makerspaces.

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