Undergraduate Student Experience in a Summer User Design Internship

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Abstract

Makerspaces have become essential components of engineering education, offering students opportunities for hands-on, project-based learning that nurtures creativity, problem-solving, and technical skill development. This study examines the role of an undergraduate student staff member in a university makerspace, focusing on how these experiences contribute to their professional and personal growth. Grounded in Kolb's Experiential Learning Theory (ELT), this research explores how students traverse the four stages of experiential learning—concrete experience, reflective observation, abstract conceptualization, and active experimentation—within makerspaces.

This study investigates the learning processes within these environments through qualitative analysis of reflective narratives and project artifacts from an undergraduate student participating in a makerspace user design internship. The research aims to answer the following questions: *(1) How do undergraduate students engage in experiential learning within makerspaces? (2) How does involvement in makerspaces influence students' technical and interpersonal skill development?*

Findings suggest makerspaces act as dynamic ecosystems where students immerse themselves in project-based tasks, critically reflect on their experiences, and translate insights into actionable strategies for future endeavors. The participant's reflections emphasize the importance of structured project engagement, peer collaboration, and iterative problem-solving in makerspaces. Additionally, the study highlights the necessity of incorporating experiential learning frameworks into makerspace programming to enhance student engagement and educational outcomes. These findings contribute to ongoing discussions regarding experiential learning and its implications for engineering education, reinforcing the argument that makerspaces play a transformative role in students' academic and professional development.

Introduction

This full paper explores how makerspaces have emerged as vital components of engineering education where hands-on, project-based learning is highly valued. These collaborative environments allow students to bridge theoretical knowledge with practical application, fostering creativity and problem-solving by creating physical artifacts (Halverson & Sheridan, 2014). Beyond their role in supporting coursework, makerspaces also provide opportunities for students to develop technical and interpersonal skills, contributing to their professional and personal growth.

A unique aspect of makerspaces is their reliance on undergraduate students, who often serve as users and staff. This dual role not only enriches the learning experiences of their peers but also equips student staff with critical competencies, such as leadership, teamwork, and empathy, while promoting a sense of belonging and community (Barrett et al., 2015; Hunt & Culpepper, 2017; Chambers, 2023). These spaces also align well with Kolb's Experiential Learning Theory (ELT), which emphasizes learning as a dynamic, cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Applying ELT within makerspaces enables a structured exploration of how students navigate and grow through these experiential learning opportunities.

This paper investigates the multifaceted role of makerspaces in fostering creativity, skill development, and community engagement, focusing mainly on the contributions of undergraduate student staff. By leveraging ELT as a theoretical framework, the study examines how makerspaces support experiential learning, promote self-efficacy, and prepare students for future professional roles. Through qualitative analysis of reflective narratives and project artifacts, this study seeks to illuminate how undergraduate participants transform their experiences in makerspaces into actionable insights, providing valuable implications for the design and management of these spaces in educational settings.

Literature

Makerspaces have become increasingly integrated into educational settings, providing students with hands-on engagement and problem-solving opportunities that bridge theoretical learning with practical application (Halverson & Sheridan, 2014). One of the defining characteristics of makerspaces is their reliance on undergraduate students, who serve both as users and staff. These dual roles create an environment where students can explore career pathways while fostering learning and collaboration among their peers (Foster, 2015). Integrating undergraduate staff in makerspaces enhances peer learning and mentorship, reinforcing the argument that these spaces are sites of technical skill development and hubs for fostering academic and social growth (Barrett et al., 2015).

The role of undergraduate students in makerspaces directly contributes to cultivating self-efficacy, further emphasizing the communal aspect of these environments. As Hunt and Culpepper (2017) argue, student staff members play an essential role in shaping the experiences of their peers by supporting technical skill-building and promoting student engagement. Serving as a makerspace staff member enables students to develop technical, interpersonal, and leadership skills (Buckner et al., 2022), strengthening the collaborative nature of these spaces. Chambers (2023) highlights how these student-led interactions foster a sense of community, making makerspaces welcoming learning environments.

The link between makerspaces and self-efficacy is particularly relevant to the undergraduate experience in engineering education. Andrews et al. (2021) describe how collaborative projects within makerspaces influence students' sense of community and inclusion. The scope and perceived value of projects undertaken in these spaces significantly impact students' sense of belonging, reinforcing the argument that active engagement within makerspaces contributes to academic persistence and social integration (Andrews & Boklage, 2023). These findings align with studies demonstrating that hands-on, collaborative learning environments foster greater confidence and engagement among students, particularly in STEM fields (Yamount & Harb, 2023).

Beyond fostering community and belonging, makerspaces also play a crucial role in developing STEM skills and essential interpersonal competencies. Yamount and Harb (2023) argue that makerspaces uniquely enhance skill development by integrating technical tasks with social interaction, reinforcing that learning in these spaces is not limited to technical proficiency alone. The ability to communicate effectively, collaborate with diverse teams, and demonstrate empathy are all critical skills increasingly valued in engineering and technical fields (Buckner et al., 2022). These interpersonal competencies make makerspaces particularly valuable within higher education, ensuring that students leave with practical expertise and the ability to work effectively in professional settings.

By enabling hands-on learning and fostering interpersonal skills makerspaces significantly contribute to student's academic and personal development. Integrating undergraduate staff further enhances these benefits, creating an environment where student mentorship and collaboration drive technical and interpersonal growth. Collectively, the literature underscores that makerspaces are not just places for project-based learning but essential ecosystems that shape the educational landscape by combining creativity, professional development, and community building.

Theoretical Framework

This study applies Kolb's Experiential Learning Theory to explore how participants navigate complex, project-based learning environments. The framework provides a systematic method for analyzing participant reflections, enabling a deeper understanding of how experiences are processed and transformed into actionable insights. By situating individual narratives within the ELT framework, the study identifies dominant learning styles and stages, highlighting areas of strength and opportunities for growth. Additionally, insights derived from the ELT analysis contribute to the design of experiential learning programs, ensuring that activities and support structures align with the learning cycle while accommodating diverse learning preferences.

Kolb's Experiential Learning Theory (ELT) provides a theoretical framework for examining the learning processes within makerspaces. ELT conceptualizes learning as a cyclical process involving four interconnected stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation, see figure 1 (Kolb, 1984). This iterative cycle emphasizes the transformation of experience into knowledge through a dynamic interplay of action and reflection, making it a powerful tool for analyzing experiential learning in engineering education.

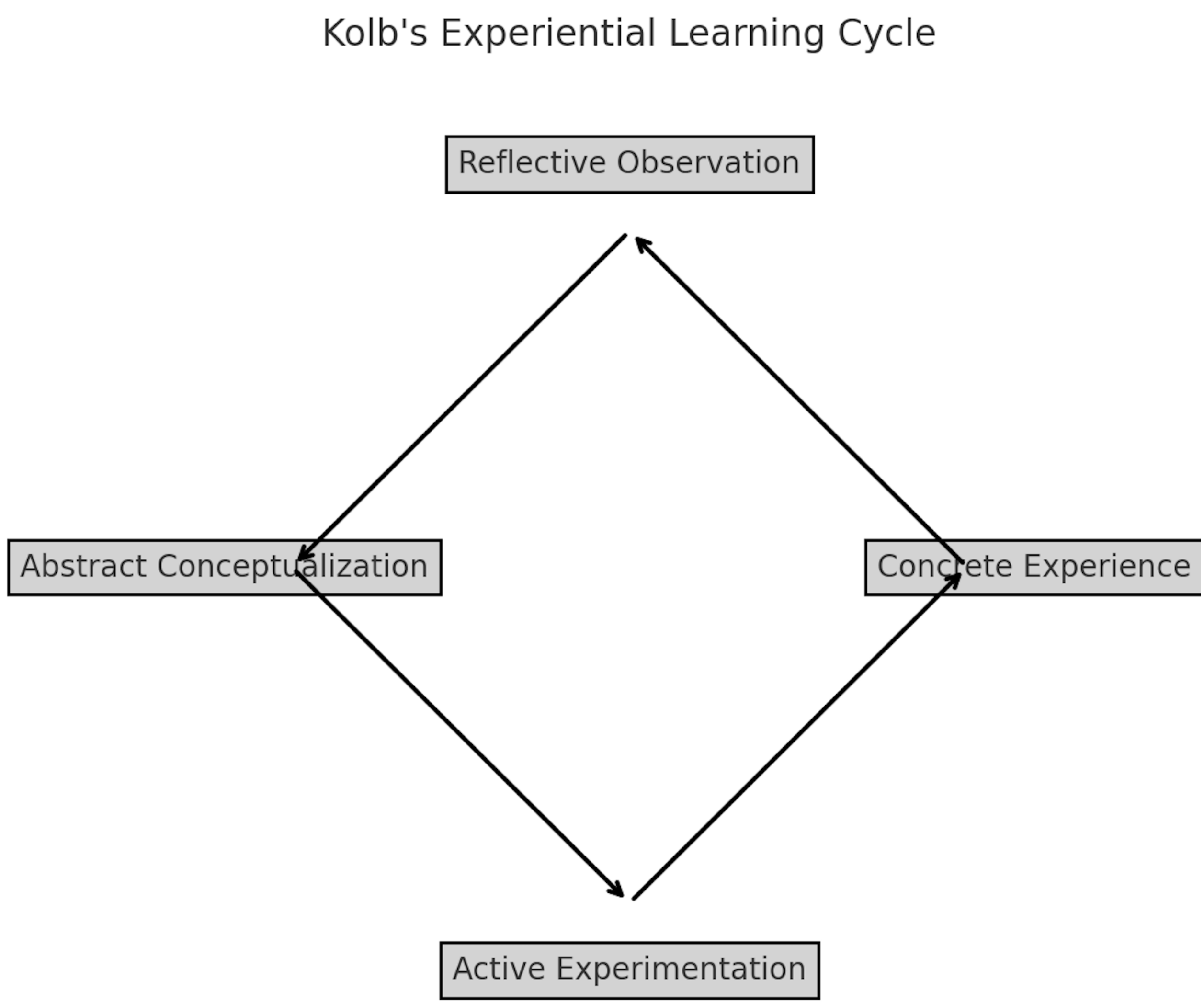

Figure 1: Experiential Learning Theory

Experiential Learning Theory (ELT) has been widely integrated into engineering education to bridge the gap between theoretical knowledge and practical application (Kolb, 1984; Felder & Brent, 2003; Prince & Felder, 2006). Research indicates that inductive learning approaches such as project-based and problem-based learning enhance students' ability to apply engineering concepts in real-world scenarios (Kolmos et al., 2016). Active learning strategies in STEM disciplines have been shown to improve comprehension and retention compared to traditional lecture-based instruction (Waldrop, 2013).

Experiential learning principles underpin the design of project-based learning courses, internships, and design labs, where students engage directly with engineering challenges, reflect on their experiences, develop conceptual understanding, and apply new knowledge in iterative cycles (Mills & Treagust, 2003; Prince & Felder, 2006). These applications highlight how ELT fosters problem-solving skills, teamwork, and adaptability—key competencies for engineering students navigating complex learning environments.

Makerspaces exemplify ELT in action by allowing students to integrate theoretical concepts with hands-on experimentation. Students cultivate technical expertise through direct engagement with projects while developing leadership, collaboration, and communication skills (Buckner et al., 2022). The reflective and conceptual phases of ELT further support the integration of diverse knowledge areas, reinforcing the interdisciplinary nature of engineering education (Dym et al., 2005). By engaging in structured experiential learning cycles within makerspaces, students refine their problem-solving abilities, enhance critical thinking skills, and develop a stronger connection between theory and practice. Applying ELT in makerspaces fosters more profound learning, professional growth, and innovative problem-solving approaches in engineering education

Methods

This study involved a single participant, a junior undergraduate student, who completed an internship during the summer of 2024 in a university makerspace at a large public university in the American Southwest. The participant was recruited in accordance with university IRB protocols and voluntarily participated after a researcher on the project approached the summer internship class and explained the project. The primary data source consisted of reflective narratives written throughout the internship during the summer of 2024.

Data analysis followed a qualitative approach, employing a combination of a-priori coding and open coding techniques (Saldaña, 2015). The research employed qualitative methods to analyze the collected data. A research team member conducted the initial coding process using apriori codes derived from ELT principles, categorizing reflections according to the four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Open coding allowed for identifying emergent themes beyond the predefined categories, ensuring a comprehensive understanding of the participant's experiences. Emergent codes included learning through hands-on engagement; self awareness; iterative learning; research skills; project management;and leadership.

To ensure the robustness of the analysis, these codes were triangulated with additional data sources, including artifacts such as meeting agendas, digital project management tools (e.g., Miro boards), and physical creations produced in the makerspace. This triangulation process facilitated a comprehensive understanding of the participants' experiences and interactions while enhancing the credibility of the findings. The participant's status as a junior undergraduate played a significant role in shaping data collection and analysis. As an individual still in academic and professional development, their reflections offered valuable insights into how makerspaces support skill acquisition and personal growth. However, this also introduced limitations, as the findings are based on a single perspective and may not fully capture the diverse experiences of other students in similar roles. Future research could expand on these findings by incorporating multiple student perspectives and additional data sources, such as interviews or direct observations.

Findings

The participant's reflective narrative was analyzed using ELT as the framework. ELT's four-stage cycle—concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation—provided a structure for interpreting the reflective data. This approach facilitated an understanding of how the participants engaged with, reflected upon, and synthesized their project experiences to inform future actions.

The analysis of participant reflections using Kolb's Experiential Learning Theory revealed a structured learning process that aligns with the four stages of experiential learning. The participant engaged in project-based learning experiences within the makerspace, demonstrating a deep connection between hands-on engagement and skill development. The participant identified key patterns and challenges through **reflective observation**, particularly concerning interpersonal dynamics and project structuring. This aligns with prior research by Hunt and Culpepper (2017), who highlighted the role of undergraduate staff in shaping peer experiences and contributing to community development. The participant expressed frustration with the lack of initial structure, stating, *"I was honestly expecting more structure with our project and the check-ins to have deadlines and clear expectations of what needed to be done per week."* Additionally, they recognized a divergence in goals, explaining, *"An early problem that I saw arose were the two different goals that my partner and I had versus what our professional staff wanted."*

Concrete experience was evident as the participant actively participated in the research, interviews, and data collection, reinforcing findings from Halverson and Sheridan (2014) that makerspaces provide an environment for bridging theoretical learning with practical application. The participant noted, *"The first week we reviewed research papers with similar issues and questions that we wanted to investigate for our own space."*

The participant transitioned into **abstract conceptualization** by synthesizing insights from their experiences and formulating strategies for improved project execution. They reflected on the impact of different project components, emphasizing, *"The interviews were probably the most interesting part of the whole project. It truly felt like we were getting really valuable information from both the students and the student staff."* They contrasted this with the limitations of their observational data collection, humorously noting, *"The one part that I found a little funny was our observation week. I sort of felt like a stalker and an investigator trying to find clues."*

As part of their data analysis, the participant encountered inefficiencies that affected workflow. They described their experience as follows, *"At one point, we were organizing sticky notes on the Miro Board, then we would get paused and re-routed to a different organizing tactic, then that would get paused, and we would go back to our sticky notes to make them more detailed, then paused and re-routed again."* This frustration underscores the need for streamlining qualitative data analysis in student-led research projects. Despite these setbacks, the participant successfully applied their reflections to refine project outcomes, stating, *"In the end, we were able to share our data and come up with 'how might we statements' that best defined and refined the goal for our project."*

Active experimentation was evident in the participant's evolving approach to project management. They emphasized, *"If I were to do this project again, I would want to set those deadlines for myself and balance out the grace that I gave myself and Even for our expectations."* Their learning experience culminated in practical applications as they prepared for the project's next stage, noting, *"As of right now, we are in the prototyping stage and I am extremely excited to see where we go for the fall!"*

The findings reinforce that makerspaces are transformative learning environments that foster technical competency, leadership, and collaboration. The participant's experiences align with prior literature that emphasizes the value of makerspaces in promoting a sense of belonging (Chambers, 2023) and professional skill-building (Yamout & Harb, 2023). Moreover, the participant's iterative engagement with the project supports the argument made by Prince and

Felder (2006) that experiential learning techniques contribute to deep understanding and long-term knowledge retention.

Conclusion

This study demonstrates that makerspaces cultivate a holistic learning process wherein students engage deeply with project-based tasks, reflect critically on their experiences, and translate insights into actionable strategies for future endeavors. Through the lens of Kolb's Experiential Learning Theory, the participant's experiences illustrate how makerspaces facilitate a structured learning cycle that integrates concrete engagement, reflective assessment, conceptual synthesis, and iterative application.

Kolb's theory is particularly suited for analyzing experiential learning in collaborative and project-based settings, like makerspaces, as it bridges theoretical knowledge with practical application. Its adaptability has been demonstrated across educational disciplines, from engineering (Mills & Treagust, 2003) to leadership training (Kayes et al., 2005), making it a robust framework for understanding how individuals learn in complex, real-world environments. By adopting ELT, this study contributes to ongoing conversations about experiential learning, highlighting its applicability to contemporary challenges in education and professional development.

The findings indicate that makerspaces serve as immersive learning environments that extend beyond technical skill development, fostering collaboration, leadership, and self-efficacy. The participant's reflections reveal that structured engagement in research, interviews, and project work led to meaningful learning experiences, aligning with literature that underscores the role of makerspaces in enhancing both technical and interpersonal skills (Barrett et al., 2015; Yamout & Harb, 2023). By participating in project-based tasks, students refine their ability to navigate complex problem-solving scenarios while developing essential competencies in teamwork and communication.

This study reinforces the argument that makerspaces foster students' self-efficacy. The participant's reflections demonstrated that engagement in structured tasks and collaborative learning environments contributed to a stronger sense of ownership and confidence in their work. These findings align with research by Andrews and Boklage (2023), which highlights the importance of peer interaction and mentorship in student-led makerspaces.

By linking experiential learning theory with real-world applications in makerspaces, this study contributes to ongoing discussions on experiential education's impact on student learning and professional preparedness. Institutions seeking to maximize the benefits of makerspaces should consider integrating structured reflection practices, providing mentorship opportunities, and embedding experiential learning assessments into their programming. One of the more interesting findings from this study is the identification of the iterative nature of Kolb's experiential learning cycle. The participant currently has plans to participate in the summer internship again in 2025, and future research will study how their next iteration of concrete experience supports new learnings, which are built on their previous experience in the makerspace. Future research should also explore the long-term impacts of makerspace engagement on career readiness and interdisciplinary collaboration, further solidifying the role of these spaces in shaping the future of engineering and STEM education. Ultimately, this study affirms that makerspaces are more than creative workspaces; they are transformative learning ecosystems that prepare students for the complexities of academic and professional challenges.

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