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FabLabs, Makerspaces or Third places: Catalysts for University Students' Innovation

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ABSTRACT

The world is changing fast enough that universities are expected to equip students with creativity, intelligence and the tenacity to innovate. Third places are becoming a necessity for this, providing students with hands-on tools in a space encouraging them to work together. These kind of spaces puts students in an environment to be able to flawlessly transcend theory, allowing them to be able write, notepads and think on a higher level. This paper investigates the impact of Fablab on the development of innovation skills among university students. Through a survey conducted at a university in Morocco, we assess students' perceived levels of creativity, prototyping abilities, and confidence in applying theoretical knowledge to real-world challenges before and after engaging with Fablab facilities. The results indicate a notable increase in students' innovation levels, highlighting significant improvements in their problem-solving approach, the development of prototype-based solutions, and their overall ability to think creatively. Furthermore, the study underscores the value of experiential learning environments where students actively contribute to the creation of tangible outputs, bridging the gap between academic learning and practical application.

Keywords: Fablab, Higher education, Innovation, Makerspaces, Student's creativity, Third places.

INTRODUCTION

In an era of rapid technological advancement, universities are expected to do more than simply replicate traditional teaching and learning and "cultivate" creative, problem-solving, and innovative mindsets in students[1]. There has never been a stronger demand for graduates who can engage in critical thinking, prototype solutions, and adapting to complicated challenges. In order to rise to this challenge, numerous higher education institutions are turning toward FabLabs and Makerspaces: constructed collaborative spaces designed to provide access to digital fabrication tools, electronics, and experiential learning opportunities[2]. These spaces act as innovation hubs for students who want to take their brain-based knowledge, or theoretical knowledge, and get into the process of solving real-life problems. Students begin to experience the applicability and depth of their knowledge when starting with design, prototyping, and collaboration, all of which are found in FabLabs and Makerspaces[3]&[4]. Students feel more confident exercising their thinking and knowledge skills beyond 'the school setting.' Most importantly, FabLabs and Makerspaces foster an environment of creativity and entrepreneurship for students to enact their ideas into innovations.

This article investigates the effect of FabLabs and Makerspaces on university student innovation skills. Using survey data from a Moroccan university, we explore how students' creativity and prototyping skills and confidence in applying theoretical knowledge change after utilizing FabLab facilities. The results indicate that improved problem solving, prototype-represented solutions, and overall creative thinking capacity were significant among students after their experience. Additionally, this paper discusses the role of experiential learning environments in connecting academic education to practice. In the end, by considering these findings, this study contributes to the growing

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discourse about the role of FabLabs and Makerspaces in higher education as a value-added support for student-led innovation[5].

STATE OF ART

The FabLabs, Makerspaces or third places in general have become increasingly popular in higher education and has transformed the way students interact with technology, innovation, and entrepreneurship[6]&[7]. FabLabs and Makerspaces have transitioned over the past 20 years from small-scale experimental laboratories to educational spaces promoting experiential learning, interdisciplinary teamwork, and problem solving, which are important twenty-first century skills. This section will discuss the origins and evolution of FabLabs and Makerspaces, the inclusion of FabLabs and Makerspaces into the university environment, and the impact of FabLabs and Makerspaces on student innovation, as well as the considerable obstacles that FabLabs and Makerspaces face[4].

Origins and Evolution of FabLabs and Makerspaces

About 30 years ago, the American urban sociologist Ray Oldenburg, renowned for his research on public and informal places, presented his book "The Great Good Place: Cafes, Coffee Shops, Community Centers, Beauty Parlors, General Stores, Bars, Hangouts, and How They Get You Through the Day" the concept of Third Places as gathering places, public or private agoras where their users can have discussions and exchange with each other. It refers to intermediate places between the first places (first place), such as the home, and the second places (second place), such as the workplace and the company. Third Places correspond to places of free access for individuals and are characterized by the presence of communities of individuals as a set of people with common interests, projects and ideas. While it is commonly accepted that Third Places constitute intermediate spaces (other than the home or the office), an attempt to define them precisely remains complex because of their variety. There are co-working spaces, places for "working together", which are mainly aimed at freelancers, self-entrepreneurs, sometimes also at job seekers. They allow users, by paying a subscription, to get out of a certain isolation and to benefit from shared resources: an adapted Internet speed, open space workstations, work and meeting rooms, printing possibilities, the famous cafeteria, etc. Beyond that, workers can benefit from the advice of other coworkers and even take advantage of business opportunities. Telecentres are a variant of these "classic" co-working spaces and are rather equivalent to offshore offices. They target an audience of employees to whom they offer a solution to work close to home, once or several times a week. The notion of third locations cannot be limited or restricted to these spaces alone, as is often the case. This also includes FabLabs - a contraction of the English version of "manufacturing laboratory". Open spaces for the creation and prototyping of objects, they are intended for a wide public: families, students, artists, entrepreneurs wishing to test the prototype of a project etc. Created and defined in 2004 by Neil Gershenfeld of the Massachusetts Institute of Technology (MIT)[8], FabLabs, places of "collective intelligence", offer their members numerically controlled machines: laser cutters, 2D and 3D printers, screen printers for antennas and flexible circuits, milling machines for printed circuits and molds, etc. Polymorphous, they can also take on other names depending on whether they are, for example, more computer and technology oriented (Hackerspaces), manufacturing (Makerspaces), repair (Repair Cafés), etc. Such a typology of third places is not exhaustive; for some authors, for example, shared gardens should be included (although less digital)[9].

Integration of third places in Higher Education

Universities across the globe have increasingly adopted FabLabs and Makerspaces as a component of their commitment to experiential, project-based learning[10]. FabLabs and Makerspaces are being implemented in many universities in a very wide variety of settings including engineering schools, design schools, business schools, and social toward sciences and applied sciences. Some of the ways that universities have incorporated different types of third places[11]&[12]:

1. Learning Hubs- FabLabs are used to augment traditional classes so that students learn practical skills side by side with more traditional knowledge of facts. For example, engineering students 3D modeling mechanical systems for prototyping or architecture students 3D printing models of their design.

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2. Interdisciplinary Collaboration Spaces- FabLabs enable cross-disciplinary projects so that skilled students from different disciplines meet and collaborate. Examples are students from business working together with engineers to develop technology that could be commercialized, or students in biology working with computer scientists to devise biotechnology innovation.
3. Innovation and Entrepreneurship Incubators- Most universities employ FabLabs to provide support for student source start-ups, product innovation, and entrepreneurship. Some universities have taken a step further and provided funding and mentoring of university projects in an effort to help the students identify and mentor their projects into viable commercial products.
4. Research and Development (R&D) Labs- FabLabs have also been used by students and faculty for conducting research in areas such as robotics, nanotechnology, and sustainable materials. FabLabs provide opportunities for cross-disciplinary research partnerships with industry and government organizations, which provide opportunities for innovation outside the university.
5. Like Community Engagement Centers:

Many academic FabLabs reach beyond the university campus and engage local schools, NGOs, and businesses in encouraging STEM education and social innovation.

A few examples of universities supporting FabLabs as part of their academic ecosystem include the following:

- MIT (USA): One of the first universities to be involved in the FabLab movement by bringing digital fabrication into their academic courses and research.
- Aalto University (Finland): The Aalto FabLab connects design, engineering, and entrepreneurship.
- Universidad Politécnica de Madrid (Spain): The FabLab enables innovation in architecture, robotics, and sustainability.

Impact on Student Learning and Innovation

Fablabs and makerspaces provide opportunities pursuing endless tinkering to solve a problem, where students try many forms of solutions. This promotes critical thinking, flexibility, and innovative solution finding. This is in contrast to traditional classrooms where a solution to an assignment is fixed, which leads to imagination and creativity being strangled[13].

Third places allow students to develop skills in all sorts of applicable activities, including:

- 3D modeling and printing
- CNC machining and laser-cutting
- Electronics and programming (Arduino, Raspberry Pi, etc.)
- Interenet of Things (IoT) products.

This is vital for future careers in engineering, product design, and the digital manufacturing workforce.

In addition, FabLabs facitilitate the access to students to make prototypes and help them to move to marketable products. In fact, many students can create startups. For example:

- Foldscope from Stanford University, a plastic microscope developed in the university makerspace guided by professor Manu Prakash that cost a fraction of the price of a regular microscope.
- Smart Prosthetics from ETH Zurich, students that were able to create a 3D-printed prosthetic limbs that had sensor based feedback build into them.

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Finaly, through mentorship programs, competitions, and industry partnerships, FabLabs help bridge the gap between academia and the business world, equipping students with entrepreneurial skills that are valuable in the job market.

MATERIAL & METHODS

To understand the role of third places like FabLabs and Makerspaces in the northern part of Morocco, we conducted a survey targeting a diverse group of university students. The goal of the study was to capture the different levels of FabLab participation from students whose profiles included frequent users, students who had never heard of a FabLab, and students who had only recently started going to a FabLab. The survey contained a series of questions to understand students' perceptions regarding their creativity, innovation, and even problem-solving skills, as well as their confidence in their ability to apply theoretical knowledge to real world problem-solving. The survey collected information for each student about their experiences, confidence, attitudes, and self-reported skill development related to their participation in FabLab. We focused on the Fablab of the Faculty of Science and Technology of Tangier since at that stage, it was the one and only third place available at the Abdelmalek Essaadi University. This FabLab known as “GreenLab” was founded in 2013, it has been leaded by students since its inception. The students chosen to be part of the FabLab’s organization team have various responsibilities (see figure 1), which allow them to manage this space.

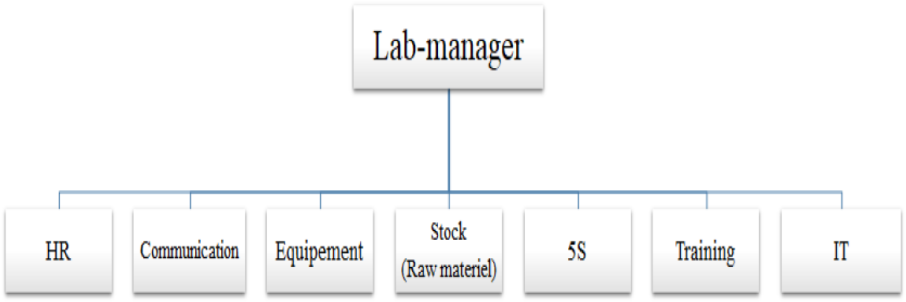

Figure 1. FabLab’s Organization chart

In an attempt to get some ideas on the role of third places in fostering innovation among students, we did a survey of approximately 150 northern Moroccan university students. The survey was administered both online and in-person to get a representative sample.

RESULTS & FINDINGS

Out of the 150 students invited, 123 complete responses were obtained, which provided us with an 82% response rate. The participatory rate reflected the students' interest to the topic and was a solid premise for investigating FabLabs and Makerspaces' impact upon their learning process. The responses collected were consequently cleaned and evaluated with the objective of establishing patterns towards creativity, problem-solving capabilities, and utilization of abstract skills in practical form among different types of students.

In Figure 2, we see the gender ratio of FabLab members. The results show that 68% of the users are male and 32% are female. These results point to the existence of a gender gap in FabLab membership, consistent with research on gender and other areas of engagement with STEM and technical spaces.

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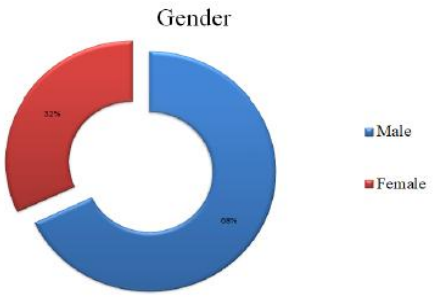

Figure 2. Fablab members' Gender

Figure 3 provides data regarding the level of education among the users of FabLabs. The majority of respondents (64%) are engineering students, as can be expected from the technical nature of FabLabs and the emphasis on prototyping and digital manufacturing. Bachelor's (Licence) students account for 15%, while Master's students account for only 7%. What is surprising, however, is that doctoral (PhD) students account for only 6% of FabLab users, which means that the facilities are being used primarily by students at early stages of study.

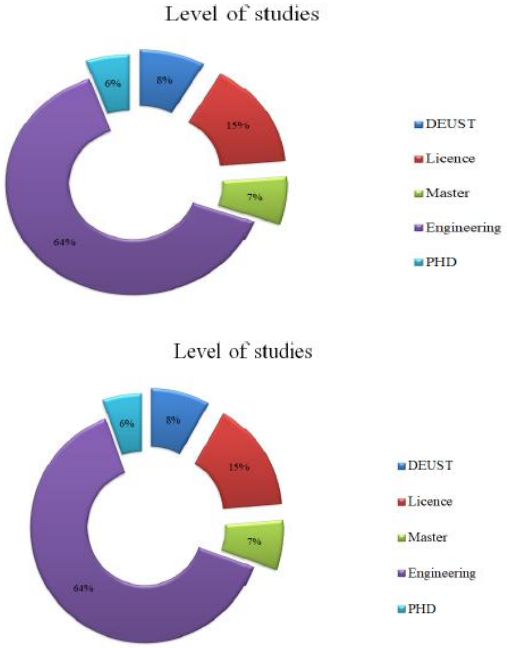

Figure 3. FabLab members level of studies

The substantial student population ratio of engineering shows that FabLabs maintain close connections with applied and technical sciences. However, the relatively poor turnover from other levels of studies and other disciplines is a concern for interdisciplinary activity. Encouraging students from other disciplines—business, social sciences, and arts—to work in FabLab facilities can help develop cross-disciplinary approaches and broaden the horizon of innovation.

Understanding the genders and the academic background contribute to a fundamental understanding of who is using the FabLab and how it fits within the environment of the university. Next, it will be important to investigate how these distinct profiles of students use the FabLab, their perceived effects on their creativity and problem solving skills, and whether there is a divergence in experiences, feelings and skills between heavy users, newcomers, and students who have never used a FabLab.

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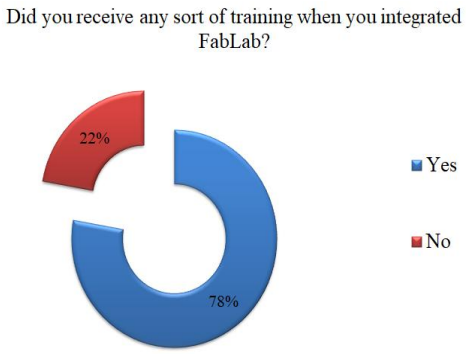

Figure 4. Training proposed by FabLab

Figure 4 shows that 78% of students indicated they received training when they joined FabLab, while 22% did not receive any training. These findings imply that FabLabs typically provide structured learning experiences that assist students in understanding the different tools and technologies. Although, the 22% of students who did not participate in training may signify a gap in onboarding practices and could inhibit their confidence in operating FabLab equipment. If all new members received training, it may support engagement and skill-building, especially for students who might not be familiar with digital fabrication technologies.

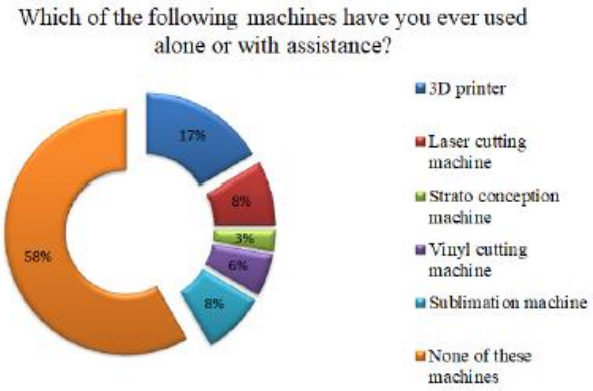

Figure 5. Machines used by FabLab members

Figure 5 shows how frequently students use different types of FabLab machines. The data reveals that:

- 17% of students have used a 3D printer,
- 8% have used laser cutting and sublimation machines,
- 3% have used a vinyl cutting machine,
- 58% of students have never used any of these machines.

The result that over half of students in the survey (58%) reported never using FabLab equipment poses important questions about accessibility, awareness, and level of engagement. This could be the result of being unfamiliar with the technology, lack of hands-on use, or students simply feeling they could not use any of the machines away from an instructor.

Figure 6 reveals that 79% of students have made use of FabLab machines for academic projects, while 21% have not. This implies that FabLabs are successfully functioning as learning spaces, in which students apply knowledge to practice. Though, 21% of students who have not incorporated FabLab tools into their studies may be considered barriers, including: Lack of knowledge about the potential for class projects the FabLab may serve Limited faculty encouragement to use FabLab resources Limited hands-on training to operate machinery.

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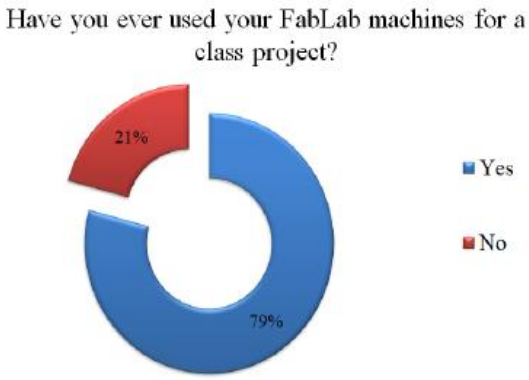

Figure 6. FabLab machines used for class projects

Students who are given hands-on training on lab equipment are much more likely to embrace FabLab tools in their education. Hands-on training helps reduce technical limitations, build confidence, and create a comfort level with equipment available. When students learn to use 3D printers, laser cutters, or CNC machines, they not only acquire the necessary skill but also cultivate an attitude of experimentation and innovation.

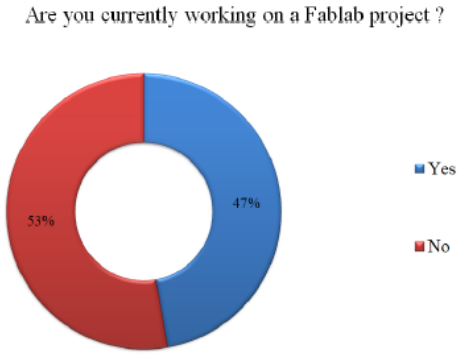

Figure 7. Members working on FabLab projects

According to the data (See figure 7), 47% of participants are participating in a FabLab project, while 53% are not. This nearly 50-50 split shows that while a considerable membership is involved in FabLab projects, slightly more are not involved at this time. Reasons for lack of engagement could stem from lack of time, lack of money, lack of interest, etc. Further investigations are warranted.

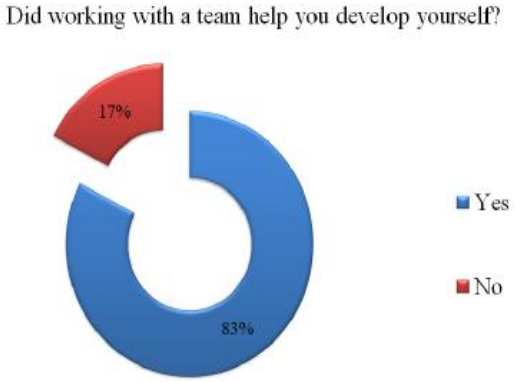

Figure 8. Impact of Teamwork on Personal Development

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An overwhelming 83% of participants indicated that working as a part of a group benefited their own growth, while 17% indicated otherwise. Such a positive experience shows benefits of teamwork to one's capabilities on skills like problem-solving, communication, and collaboration, all of which are essential skills for a technical and innovation-based workspace like what FabLabs provide.

These two charts (Figure 7 & 8) are interpreted side by side to show an interesting relationship; while moderating FabLab engagement (47% of members are active), greater numbers of members who worked collaboratively within the context of a FabLab recognize the developmental potential of the work (83% of members).

The research results indicate that levels of engagement in FabLab projects are associated with opportunities for development in others when working together. In applied terms, the findings suggest that a more collaborative approach to projects (i.e. working with teams as part of projects, or programming for a FabLab, such as mentorship) may lead to higher levels of engagement and maximize the development opportunity for the members involved in it.

The most important part of the survey is the part which consists on understanding the role of FabLab in enhancing innovation and creative thinking of the students. The figure 9 represents the impact of FabLab Experience on Creativity.

According to the findings, 78% of participants said their experience in the FabLab inspired them to feel more creative, and 22% of participants disagreed. This overwhelmingly positive response implies the participants were in an environment that encouraged creative thinking and problem-solving. The nature of FabLab projects is hands-on and experimental, thus likely leading the participants to be able to explore their ideas, engage in an iterative design process, and utilize interdisciplinary knowledge in creative ways. From an academic and professional perspective, creativity is a key area for implementing innovation and technological progress.

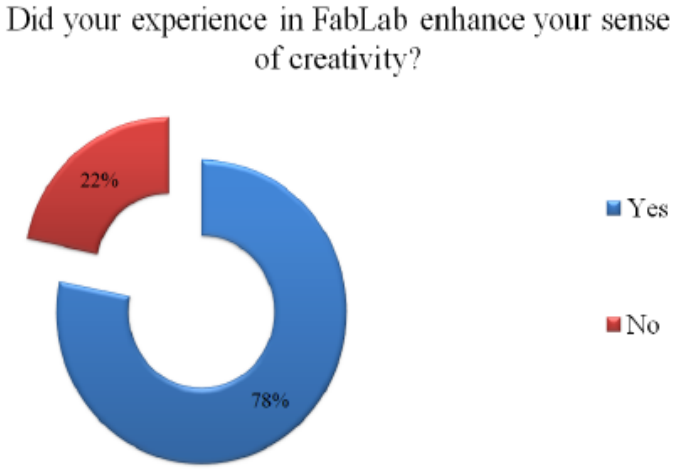

Figure 9. Impact of FabLab experience on students' creativity

In the last figure 10, the data showed that 63% of participants said they were introduced to the notion of "innovation" activity related to a FabLab project, while 37% of participants said they did not connect their experience with "innovation". While it is evident that the participants perceived such experience in relation to their exposure to innovation based on responses of a majority of participants (who acknowledged that the FabLab activities introduced them to innovation), the 37% of participants did not link their experiences with working to introduce innovation suggests areas as to how FabLabs promote and communicate the innovation process needs addressed.

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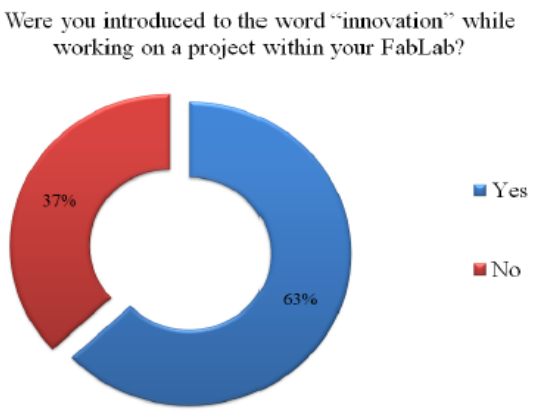

Figure 10. Introduction to Innovation Through FabLab

Innovation is a key component to advancements in technology and industry. Innovation is not just about creatively solving problems but also the ability to take an idea and make it a reality that has an impact on others. The fact that nearly two-thirds of participants linked the FabLab experience to innovation suggests that the FabLab successfully provide students with experiences that relate to real-world applications of the creative thinking process and technological development. Strategically discussing types of innovation processes, providing case studies, and presenting structured challenges to innovate could potentially engage a larger group of participants to link their experience to innovation.

FabLab is therefore a place of sharing, of learning that can be considered as a succession of the class, which allows learning by doing. In addition to all this, the FabLab is a place for rapid prototyping and having it within the university campus brings students closer together and allows them to carry out their projects. Some authors discuss the impact and the importance of those spaces in university since they could have a lot of advantages for students, we have listed the most important ones:

- A place where open-mindedness reigns
- Learning by doing space
- It is an enriching place to meet people
- A place where we can innovate

CONCLUSION & PERSPECTIVES

The research illustrates the relevance of FabLabs as third spaces where students in universities can develop creativity, innovation, and experiential learning. The results in the research show that FabLabs indeed improve students' technical skills and problem-solving abilities but also facilitate collaboration and experiential learning. By connecting theoretical limitations to real-world opportunities, they provide students with the tools to test ideas, create prototypes and deliver innovation-based projects. Furthermore, the findings around FabLabs shows the importance of third places for education; settings outside of the classroom that play a pivotal role in learning development and professional development. Third places provide crucial spaces for students to "try things," take risks, and create an entrepreneurial mindset that prepares them for the complexities of the changing job market.

To maximize the promise of third places like FabLabs, universities and educators may want to enhance the structure of innovation training, mentoring programs, and interdisciplinary collaboration. Future research might then assess which activities within FabLabs bolster mobility towards creativity and innovation, and how the learnings might be applied in future efforts at other third places within different educational and professional contexts. Institutions can strengthen the denotation of third places and cultivate a generation that is adaptable, creative, and forward-thinking for the future.

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