MadaFabLab: an inclusive STEM and fabrication environment for creativity and innovation and its impact on persons with disabilities

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Abstract –

Fabrication laboratories (FabLabs) are utilized to materialize concepts. They can improve cognitive and creative abilities when used in a design-learning situation. Numerous studies have attempted to comprehend the relationship between makerspaces and creativity in a variety of disciplines, with the capacity to generate innovative consequences in makerspaces dependent on creativity. However, a comprehensive study that provides a holistic perspective on the contributions of labs as inclusive places that stimulate creativity for people with disabilities is absent. In order to address this study gap, the paper that follows provides an overview of FabLabs, makerspaces, and creativity and introduce the first of its kind MadaFabLab, as the first inclusive fablab in the world designed and tailored for innovators with disabilities "MadaFabLab". The studies revealed that fablabs contribute to the development of creative person, product, physical, and social surroundings, as well as creative process. In addition, the MadaFabLab, a novel inclusive idea, fosters problem-solving, collaborative, and communication skills, and offers appealing locations and tools for the development of creative solutions to real-world challenges and needs identified by people with disabilities. We identified and analyzed five important themes pertaining to technical skills, technological and environmental factors, STEM learning, and skill development, and focused on their significance for fostering creativity in an inclusive FabLab.

Keywords: Fablab, MadaFabLab, STEM, Inclusive Education, Creativity, Innovation

Introduction

A FabLab is defined as "a creative, uniquely adaptable learning environment with tools and materials, which can be physical and/or virtual, where students have the opportunity to explore, design, play, tinker, collaborate, inquire, experiment, solve problems, and invent" [1]. In FabLabs, a greater emphasis is placed on the use of often-predefined equipment (e.g., 3D printers, laser cutters, or electronic workbenches) and the breadth of training related to this equipment. This technology enables computer support and subtractive manufacturing, design and rapid prototyping, as well as the simple materialization of highly customized products. Digital fabrication technology is regarded as an integral component of FabLabs, invention studios, and, personal fabrication setups. Schmidt [2] coined "open creative labs" as a catch-all term for all labs mentioned in the literature: entrepreneurship, public libraries, design education, higher education, science, technology, engineering, and mathematics (STEM) education, medical practices, and sustainability [3]. The majority of research conducted on FabLabs characterized them as creative, built environments that assist students, engineers, designers, architects, and healthcare professionals in developing innovative solutions to real-world problems. In this regard, the stimulating atmosphere and environment promotes the development of creative ideas and solutions. There is evidence of a growing impact of workspace environments such as makerspaces on innovation and creativity [4]. It was discovered, for instance, that the quality of the physical environment positively affects individual and team creativity. In contrast, negative characteristics of the physical environment can inhibit creativity [5].

Digital fabrication technology utilized in FabLabs influences users' thinking, ideas, creation skills, and ability to produce creative solutions in a wide range of domains, including art, science, and engineering. A study conducted by Saorin et al. [6] in makerspaces concluded that digital editing tools and 3D printers contributed to the development of engineering students' creative ability. In addition to fostering the development of creative skills, makerspaces are beneficial for fostering collaboration, problem-solving, and communication in STEM (science, technology, engineering, and mathematics) fields [7].

This article seeks to comprehend the influence of built environments, such as FabLab, on creativity according to person, process, product, (physical and social) environmental characteristics, and collaboration aspects, with a focus on people with disabilities. Four findings were outlined in the present article and a dedicated section for Mada's initiative to establish an inclusive Fablab called "MadaFabLab".

Learning and Skills Development in STEM Education

Fablab plays a significant role in helping students with disabilities develop their creative thinking, communication, and collaboration skills, particularly when the "learning by doing" approach is implemented. The type of pedagogy utilized in Fablabs was another factor that contributed to the development of the students' creative abilities. Students' motivation to learn, think, and act creatively was primarily influenced by their enjoyment of the learning process and the availability of a technologically supportive environment. Exploration, inquiry, and examination of materials were also found to foster creative outcomes from an experiential standpoint. Additionally, research on FabLabs examined the motivation for creativity in STEM education. Smith demonstrated that Fablabs in STEM can be utilized to improve creative skills and abilities such as critical thinking, problem solving, and design collaboration. In this regard, material artifacts and discarded materials found in makerspaces can have significant implications for learning how to foster creativity. Particularly, FabLabs foster conducive learning environments where prototyping and other design activities are essential for the development of creative thought, problem-solving, and collaborative skills.

Fostering Individual Creative Competence

Creativity is necessary for success in numerous fields, including design, and engineering. It is essential to develop innovative alternative solutions to a problem. According to a study in the field of engineering, makerspaces equipped with digital editing tools and 3D printers stimulate creativity [7]. Similarly, Duenyas and Perkins demonstrated that makerspaces that facilitate engagement with a variety of tools and materials help users develop creative competencies such as self-awareness, self-esteem, the ability to cope with negative emotions, and the ability to form positive relationships [8]. Similarly, Taheri et al. [9] demonstrated that FabLabs contributed to a strong sense of community, self-confidence, and entrepreneurial abilities for engineering courses, in addition to fostering creativity. In addition, they increased their problem-solving, communication, and teamwork skills. Hoople et al. [10] discovered that the presence of experienced practitioners and explicit rules of engagement were crucial for both formal and informal creative competency development inside makerspaces. In conclusion, FabLabs and makerspaces play a crucial role in the development of individual creative skills, notably in engineering fields.

Creative Product Development

Creative products must not just be creative and distinctive, but also useful, practical, and/or functional. The development of creative products is regarded as a complicated endeavor needing multidisciplinary teamwork with the necessary instruments. In this sense, interdisciplinary collaboration enabled using digital fabrication technologies in FabLabs can stimulate the inventiveness of the outcomes (i.e., prototypes and products). According to research in nursing and engineering, collaboration in a FabLab environment helps uncover real-world challenges, produce innovative ideas, and develop commercially viable prototypes. Other studies have also highlighted the favorable role makerspaces play in the conception and development of sustainable, creative, and viable goods [11]. According to the reviewed articles, FabLabs and makerspaces should be deemed ideal environments to produce creative outputs. As settings that support built environments, these places seem to have the right physical conditions and resources for developing and making real ideas into unique and long-lasting goods.

Fostering Creativity through Motivational and Inspiring Learning Environments

When supported by proper means, such as digital fabrication tools, makerspaces can be viewed as dynamic learning environments where users engage in creative endeavors [12]. As a learning setting, makerspaces enable individuals to express themselves, hence increasing the likelihood of developing creative solutions. Trahan et al. discovered that providing a learning environment in which students and teachers were permitted to fail encouraged them to experiment and explore without fear, as well as to include other participants in their creative activities [13].

Forest et al. [14] investigated the effect makerspaces have on self-perception. They discovered that 90% of users believed makerspaces as learning settings encouraged them to pursue occupations requiring creativity, design, innovation, and invention. In addition, their research revealed that design-build education fosters innovation, creativity, and entrepreneurship in engineering. Studies have demonstrated that FabLabs and makerspaces have a good impact on the self-expression, inspiration, motivation, and creative capacities of their users through the provision of encouraging and supportive physical and social environments [15].

MadaFabLab

Fablabs have the potential to alter fabrication patterns, promote science, technology, engineering, and mathematics (STEM) skills, create enterprises and jobs, and stimulate economic growth and productivity. They accomplish this by allowing virtually any member of the general public with creative ideas to participate in the design, production, and distribution of goods and services. An expanding global network of Fablabs has established an altogether new arena of opportunities at the local level to drive creativity, invention, and applied research across industries. As stated in the introduction, however, just as the internet has not been distributed consistently or inclusively to everyone, some Fablabs around the world have made the same error. Their approach disregards inclusive design in favor of cooperation, resulting in "one size fits one person" as opposed to the "universal design" dictum of "one size fits all."

Incredibly, the process that Mada Center has been creating to construct and deploy the world's first Fablab intended exclusively for persons with disabilities and become a global standard named “MadaFabLab” (https://fablab.mada.org.qa) supported through the Mada Innovation Program [16]. Since not only its space and furniture will be suggested for the integration of people with special needs, but also their content will be designed with the same strategy, combining assistive technologies and online courses with digital manufacturing. This strategy will facilitate the process of altering social norms, beliefs, and attitudes, as well as addressing unconscious prejudices and stigma, and establishing policies and procedures in training centers that are in line with these changes. In a world where change occurs at an ever-increasing rate, driven by science and innovation, inclusive education and training must utilize technology to promote universal access and increasingly individualized learning.

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