

Library Makerspaces and Academic Libraries: An Analytical Study of the Impact of Makerspaces and the Changing Role of Academic Libraries

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ABSTRACT

Makerspaces are collaborative creative spaces that have recently gained significant attention as a means of providing a safe, secure, comfortable, and productive environment for study and work. They also offer access to resources and technology. In this context, the study employs a descriptive-analytical method to explore the changing role of libraries in adopting makerspaces and to assess the importance and benefits of these spaces for academic libraries within the framework of global transformations. The study further derives indicators that suggest the need for makerspaces in Saudi and Arab academic libraries in general, as well as the challenges associated with their implementation and how to address these challenges. Makerspaces present challenges that require rethinking many of the regulations and traditions upheld within academic libraries. They also necessitate changing the library's functions to play a leading role in a changing environment. Therefore, the study recommends promoting a culture of makerspaces among faculty members and beneficiaries, highlighting the benefits of these spaces for them. The study shows that makerspaces are a natural extension of library services, aligning the library's mission to meet beneficiaries' needs with what should be offered through makerspaces. Consequently, libraries are ideal places to adopt makerspaces. The study also recommends that makerspace practitioners develop learning and adaptation skills to facilitate activities within these spaces. For many library specialists, these skills are new, so it is essential to develop their expertise to handle and adapt to makerspaces effectively.

KEYWORDS: Workspaces, Makerspaces, Fab Lab, Tech Shops, The Factory.

1. Introduction

Libraries today face multiple challenges in meeting user needs, particularly in academic libraries, where students learn in a dynamic world with rapidly expanding information. Library programs in schools, colleges, and universities continue to undergo significant changes. With the increasing importance of technology and evidence-based learning, the focus has shifted from the library as a "confined" space to a "flexibly bounded" space that adapts to diverse needs and is influenced by interactive communities. In response to changes in user demand, libraries need to

position themselves as community hubs, providing general needs as well as endless learning opportunities. They regularly evaluate effective space usage, assessing new service locations, and creating makerspaces, which have become a new trend in recent years.

In this context, the study identifies the features of change in the role of the library based on its significant shift in philosophy to address users' needs for technology, teamwork, interaction, social engagement, and knowledge creation. This includes providing spacious shared areas that encourage exploration, creativity, and collaboration among students, teachers, and the wider community. In recent years, several Saudi universities have begun offering workspaces for students as a means to provide a safe, secure, comfortable, and productive environment for study and work, as well as access to resources and technology. In this regard, the study explores the key indicators that make Arab and specifically Saudi academic libraries in need of adopting the idea of creating workspaces, and the requirements for implementing workspaces within Saudi academic libraries.

The Problem statement:

Despite the rapid growth of makerspaces in global academic libraries and the establishment of such spaces in many universities, providing opportunities for meeting and communication and allowing students to access a variety of tools and resources to aid in project creation, similar ideas remain unclear at the Arab level. Academic library services in the Arab world have not deviated significantly from their mission as institutions providing access to information. Most libraries have focused on reading and writing, neglecting other forms of communication, creativity, and the provision of value-added technology.

There is a need for libraries to support and enhance their communities in accessing and engaging with emerging technologies, enabling these communities to participate in an increasingly digital world. Modern libraries need to create spaces that allow users to openly interact with, process, and contemplate information, engage in discussions about it, and develop new ideas, conversations, and opportunities as a result. Thus, makerspaces can be an innovative and appealing way to attract users.

The lack of clear plans and the ambiguous vision of educational institutions in the Arab world regarding modern global trends in educational technology, including Makerspaces, presents a barrier to implementing such environments, compounded by a lack of community awareness and media coverage. Therefore, academic libraries need to better understand the evolving nature of research and learning and enhance experimental scientific communication by providing a strong combination of space and technology.

Additionally, there is a shortage of Arabic research addressing makerspaces, their implementation requirements, and the ability of libraries to meet these requirements and tackle these challenges. Moreover, there is a need to understand how to enhance the use of library spaces, encourage more people to use the library, and create a more comfortable and attractive environment for library users.

Based on this, the problem of our study is to highlight the opportunities and

challenges of establishing makerspaces within Saudi and Arab academic libraries in general. What are the key lessons learned from international experiences and practices?

Based on the above, the following questions can be formulated:

1. What are the benefits of makerspaces, and what is the changing role of academic libraries in the context of makerspaces?
2. What are the obstacles and challenges that hinder the implementation of makerspaces within Saudi academic libraries?
3. What are the requirements and measures needed to activate makerspaces within Saudi academic libraries?

The importance of the research:

The importance of the study lies in presenting the concept of makerspaces and the necessity of adopting them within academic and specifically Saudi libraries. It highlights the integration of makerspaces into library service models to leverage the library's status and establish it on campus as a place for collaboration, learning, and inspiration. This involves adapting the library's infrastructure and services to new forms of technology and training, promoting new patterns of research and learning, and making the library a central location for combining skill sets, creative thinking, and new learning methods in response to global changes.

The recent significant interest in makerspaces has contributed to transforming educational methods and creating new teaching approaches that aim to bridge the gap in traditional education, which often lacks creativity and skill development. This, in turn, affects graduates' ability to meet the growing demands of the job market, especially in scientific and technical fields.

The objectives:

This study aims to highlight the changing role of libraries in adopting makerspaces and to examine the importance and benefits of these spaces for academic libraries within the context of global transformations. It seeks to identify the indicators that suggest the need for makerspaces in Saudi and Arab academic libraries in general, as well as the challenges associated with their implementation and how to address these challenges.

The objectives of the study can be outlined as follows:

- 1- Define the concept of makerspaces and the historical development of the makers movement.
- 2- Assess the importance of makerspaces for academic libraries and the reasons for their need in the context of global transformations.
- 3- Identify the obstacles and challenges that prevent the implementation of makerspaces within Saudi academic libraries.
- 4- Determine the requirements and measures necessary to activate makerspaces within Saudi academic libraries.

Table 1: Makerspace Locations at Saudi Universities

University name	Makerspaces Link
King Abdullah University of Science and	https://kaust-prototyping-lab.iv.navvis.com/
Jazan University	http://centers.ijazanu.edu.sa/iec/Pages/fablab.aspx
King Abdulaziz University	http://www.kaufablab.com
Um Al-Oura University	https://wadimakkah.sa/ar
Princess Nourah Bint Abdulrahman	www.alhavat.com/article/4580892
King Fahd University of Petroleum and	http://fablabdhahran.org
Effat University	https://www.effatuniversity.edu.sa/arabic/research/research-
King Saud University	https://code.mcit.gov.sa/ar/Innovation-Lab/ksu-code-lab
King Khalid University	https://code.mcit.gov.sa/ar/Innovation-Lab/kku-code-lab

2. Methodology:

The study relied on a descriptive-analytical approach to examine and analyze the intellectual production related to the topic, and to derive key concepts used in defining makerspaces and clarifying the changing role of libraries in the context of these spaces. It also aimed to identify indicators that highlight the need for makerspaces in Saudi and Arab academic libraries in general. Additionally, the study utilized content analysis to evaluate the websites of makerspaces at Saudi universities, deriving indicators about these sites, including their goals, tools, and applications used.

Data collection tools:

The research examined several professional journal articles, blog publications, and databases related to makerspaces. The databases included Dar Al-Mandooma, ERIC, JSTOR, Library and Information Science literature, LISA, ScienceDirect e-Journals, ProQuest Research Library, and Web of Knowledge.

The following website was used to list makerspaces at Saudi universities, identifying 20 makerspaces at various institutions. However, the study focused only on makerspaces within Saudi universities, specifically 9 sites, excluding the makerspace at Taibah University as it is under construction: [Fab Labs Directory] (<https://www.fablabs.io/labs>).

Terminology:

- Makerspace: Places that help develop creative interests and imagination by allowing participants to leverage multiple intelligences. It is an effective way to apply knowledge, utilizing new resources for learning (Hayek, 2022).
- Workspace: "Noberg started establishing the first communal workspace, which is a space available for use by any of its users, including office furniture, photocopying and printing machines, meeting rooms, etc. It is available for rental by the hour, day, or month" (Willett, 2016) .

- Fab Lab: Short for Fabrication Laboratory, Fab Labs are open workshops focused on education, innovation, and invention. They offer a range of flexible tools controlled by computers and other materials, allowing individuals to design, develop, and produce custom items that can be achieved through traditional industrial means (Kim B. Y., 2017).

- TechShops: This term was first used in California in 2006. TechShops are for-profit and commercial in nature, allowing people access upon payment of a monthly fee. They focus on community building, providing large spaces and equipment to maximize collaboration, idea exchange, and expertise sharing (Nisha, 2017).

- Makers: Individuals or organizations that design, assemble, and develop products based on creativity and imagination. This term also refers to people engaged in making activities based on their individual ideas, utilizing easily accessible technology, and fostering a shared culture of open-source innovation (Willett, 2016).

Previous studies :

Based on the researcher's knowledge, there is a scarcity of arabic studies that address makerspaces. In contrast, there is significant interest in this topic among many foreign studies.

The study by (Khalifa, 2020), a case study conducted at Effat University in Jeddah, Saudi Arabia, examined the impact of applying the construction and design approach in education on student learning outcomes. This approach allows community members to design, model, and manufacture items using tools that are otherwise inaccessible or unaffordable, such as 3D printers, laser cutters, CNC machines, and CAD/CAM software, through makerspaces. The study found that students learned better and more creatively in problem-solving, actively participated, and mastered skills within the educational process context. (Al-Obaid, 2020) study highlighted the significant impact of Fab Labs in developing intelligence, creativity, and innovation skills among middle school female students in Riyadh.

Osama Damosh's study emphasizes the importance of fabrication labs in public Arab libraries, which have led to massive social and economic changes. The study advocated for the creation of digital fabrication labs within Arab libraries (Osama, 2021). Yasmeen Hafiz's study (Hafiz, 2020) discussed the importance of managing shared workspaces by identifying, evaluating, and developing a set of criteria to be adhered to when assessing and selecting shared workspace management software. The study found that approximately 12 out of 21 software was utilized, and around 15 out of 34 software options received a 75% score for service implementation.

Several foreign studies have provided exploratory insights into makerspaces, aiming to analyze and address some experiences in creating makerspaces within academic libraries. Nisha's study (Nisha, 2017) explored the importance and benefits of makerspaces in Indian libraries, the strategies used to develop and manage them, the modern facilities they offer, and user satisfaction levels regarding makerspaces. The study highlighted that 70% of makerspace users believe these spaces help meet their evolving needs and support their academic requirements. In evaluating makerspaces

within universities, Okpala's study (Okpala, 2016) analyzed the experiences of Australian universities with makerspaces. The study reviewed several Australian university websites and found that makerspaces employ specialists, contain 3D printers and laser cutters, and provide facilities for coursework, personal projects, and collaborative work. The study also highlighted the clear benefits of makerspaces in Nigerian university libraries, with findings indicating a trend among users toward utilizing makerspaces to enhance creativity and innovation. Makerspaces offer rewarding services to students, faculty members, and staff, enabling them to learn new things, collaborate with peers, think of new ideas, explore, repair, and innovate. The study recommended offering training opportunities and workshops for librarians to equip them with the necessary makerspace skills.

Taylor, Hurley, and Connolly (Taylor & Hurley, 2016) identified the additional roles that creative spaces play, such as the social spaces they provide, their role in supporting well-being, addressing the needs of the communities they serve, and supporting access for marginalized groups. The study showed that although not all roles are present in all field-based makerspaces, there is an expectation, given how many spaces respond to the specific needs of their communities, that the desire for makerspaces to be more than just workshops will spread. Smith (Smith, 2013) examined the evaluation of makerspaces in Auckland Libraries, New Zealand, and the public library in Tennessee, USA. The study revealed the overall impact and community value of makerspaces within academic libraries in terms of their perceived value to the communities they are in. Norman (Norman, 2013) emphasized that makerspaces are a place for social integration and interaction with others, describing them as the heart of the community. They play a role in building community trust, as well as contributing to the local economy, supporting local businesses, and providing equitable access to learning opportunities.

The case study conducted by Younghee (2018) focused on the benefits and challenges of providing makerspaces in Australian academic libraries. The study showed that enhancing community engagement, adding value to libraries by providing open and equitable access to emerging and costly technologies such as 3D printers, and assisting in following broader "cultural shifts" (such as increased interest in hands-on work) were among the significant benefits of makerspaces. The study mentioned that one of the main challenges in creating makerspaces is providing dedicated workspace within libraries to facilitate innovation activities.

Hong (Hong, 2015) explored librarians' perceptions of makerspaces and suggested guidelines and policies to support makerspaces in academic libraries. The study highlighted the need for integrating creative spaces in academic libraries, noting that 87% of academic librarians see it as essential to establish makerspaces in libraries to diversify the library's role and open new areas of use, such as training creative talents in the era of the Fourth Industrial Revolution and meeting library users' needs. The study also noted that 13% of academic librarians lack space and equipment and have concerns about the increased workload posed by makerspaces and the shortage of qualified staff.

Yoo (Yoo, 2017) analyzed makerspaces in some American academic libraries and proposed characteristics of makerspaces and methods to invigorate cultural content directed towards the makerspace as a creative environment. The study concluded that there is a need for a guide with clear objectives to define the tasks of creative spaces and the need for providing opportunities for universities and private organizations to participate in practical and professional fields under the leadership of public institutions and government.

The concept of makerspaces and the evolution of the makers movement

The definition of worker and makerspaces:

Worker: A worker is an individual or organization that designs, assembles, and develops products based on imagination and creativity. This term also refers to people who engage in making activities based on their individual ideas by applying easily accessible technology and developing technology and culture. The workers' movement is a process of informing and spreading production activities among people who voluntarily engage in creation, modification, and sharing. The main features of workers are "creativity," "motivation," and "information sharing" (Younghee Noh, 2018).

- They are a new generation of web-based inventors, craftsmen, and engineers with skills in computer-aided design, prototyping, and desktop manufacturing tools. They share their own creations spontaneously.

- A person who makes or produces something, thereby impacting their world in a tangible way and making a difference.

The social value of the makers movement is that "individuals can approach making things by expanding the culture of production, and they can regain their initiative while experiencing the joy of creation." Additionally, it will be possible to develop human creativity lost due to the division of labor and also lay the groundwork for developing new technologies in a new era.

The makerspace movement was initially promoted in the United States by MAKE Magazine in 2005 to encourage innovation and DIY (do-it-yourself) projects. Since then, library communities have shown significant interest in the makers movement and culture. Eric Johnson (Johnson, 2016) attributed the increasing interest of libraries in makerspaces to the need to turn creators' ideas into added economic value, recognition of values in informal learning, the spread of participatory culture, and the historical role of libraries in introducing creative technologies. The Institute of Museum and Library Services played a crucial role in supporting the Makerspace movement through its ongoing education initiative with the make-it@your Library project in 2012 (Johnson, 2016).

The makers movement can be traced back to the Arts and Crafts movement of the late 19th and early 20th centuries, which was followed by home crafting in the United States to encourage DIY (do-it-yourself) crafts that thrived throughout the 20th century, particularly in the 1960s and 1970s. This movement was associated with a group of hackers. When we talk about hackers here, we do not refer specifically to those internet pirates in the traditional sense who engage in illegal

practices; instead, hackers here are developers who use the internet in unconventional ways. The term "hacker" originally referred to a group of skilled programmers who challenged and attempted to breach various systems, not necessarily with criminal intent. Douglas Thomas described how these individuals eventually became founders of startups in Silicon Valley, such as the Homebrew Computer Club—a group of computer enthusiasts in the 1970s who later became the founders of Apple (Hayek, 2022).

Many libraries have started developing spaces for design and activities that teach and empower users. Learning in these spaces varies widely from repairing bicycles to using 3D printers to building model airplanes and these spaces are referred to as makerspaces. Defining a makerspace can be somewhat challenging due to differences between spaces and activities, but the focus is on creativity using technology.

While STEM (Science, Technology, Engineering, and Mathematics) education quickly adopted these spaces and technologies, it is important to emphasize that makerspaces are not solely dedicated to STEM activities. They are places where people come together to be creative using technology.

Who uses makerspaces? anyone! Libraries of all types have found ways to create makerspaces. Most of the early makerspaces are found in public libraries, each with different focuses; some work exclusively with children, while others cater to adults. Academic libraries and school libraries are also developing makerspaces. Early experiences show that potential users of makerspaces are not limited to any specific demographic.

Makerspaces reflect the era by investing in library services during economic downturns. They bring people together as a community to repair things in a creative and low-cost manner, continuing maintenance and innovation, including those who lack individual purchasing power. This is the true essence of the library: to accept and assist everyone, together, as a community.

Differences between makerspaces in academic libraries and other libraries: Makerspaces are areas for collaborative creativity, varying from library to library, but generally providing access to a range of creative tools such as laser cutters, 3D printers, sewing machines, bike repair facilities, microcontrollers, circuits, clay and ceramics, etc. They are associated with creating, building, and crafting, offering hands-on experience in activities ranging from woodworking and sewing to computer building and audio-visual recording.

While many public and school library makerspaces may not be highly technical, those in academic libraries often focus heavily on technology. Sometimes, these makerspaces are relatively small, prominently featuring technology like 3D printing. At other times, they evolve into large technical creativity labs within the library. Regardless of size, the success of makerspaces in attracting students to the library is gaining global interest (Mestre, 2020)

Comparing terms for makerspaces:

Several terms are used to describe spaces designated for makers to work together,

including Makerspaces, Workspaces, FabLabs, Hackerspaces, and TechShops. This study has adopted the term "Makerspaces" as it is commonly used in ALA literature (Bagley, 2018).

<https://www.ala.org/tools/article/ala-techsource/what-makerspace-creativity-library>

Makerspaces are environments for collaborative learning where people come together to exchange materials and learn new skills. They serve as centers for creativity, invention, and exploration using a variety of tools and materials to develop specific skills. Hence, library makerspaces are based on the principle of collaborative learning as a guiding framework for library programs and services, enabling the free exchange of ideas and resources through exploration, experimentation, sharing, and interaction among peer groups.

Hackerspaces are community-run workspaces where individuals with shared interests, usually in computers, mass production, science, technology, or digital and electronic arts, can meet, socialize, and collaborate. Hackerspaces are also compared with other community-run spaces with similar goals and mechanisms, such as FabLabs. Founded in 2006 by MIT professor Neil Gershenfeld, FabLabs offers modern tools like electronic devices, laser cutters, routers, etc. Hackerspaces tend to be smaller in size, typically around 1,000-2,000 square feet compared to other spaces. TechShops which Established in California in 2006, TechShops are for profit and commercially oriented. They allow people access after paying a monthly fee and focus on building community by providing large spaces and equipment to maximize collaboration and the exchange of ideas and experiences. Creative spaces are not directly tied to any specific tool, setup, or sponsoring organization. They encompass any space that facilitates innovative learning without being limited by the tools/equipment or the designated area (Nisha, 2017).

Makerspaces and the changing role of academic libraries

The concept of academic libraries as a place is evolving. These institutions now encompass "a variety of spaces that cater to the diverse ways students and faculty conduct their work—quietly and privately, in groups, with their own technology, and with technology provided by the library." This represents a much broader approach than the traditional model of academic libraries as merely "a place to store books." Many view technology-focused makerspaces as a central feature of the contemporary academic library, positioning them as hubs of creativity for the 21st century. This broadening of the academic library's space and function aims to enable the library to "accommodate functions that support academic success and provide opportunities for faculty and students from different disciplines to mingle."

In this new concept, the library is more than just a space where students can access and train on technology, driving new patterns of research and learning forward. It becomes a crucial location for combining skill sets and creative thinking needed to achieve new research outcomes and learning in innovative ways—essentially, a place to support students who wish to experiment with new methods of research communication and collaboration. Makerspaces and other creative and collaborative spaces are emerging forms of experiential learning that are becoming increasingly popular in many colleges and universities. According to the NMC Horizon Report:

2018 Higher Education Edition, "Incorporating the maker culture into higher education has made students active contributors to the knowledge ecosystem, learning through experimentation and creativity, and demonstrating newly acquired skills in more practical and innovative ways" (Becker, 2018).

Mark Hatch, in his book *The Maker Movement Manifesto*, refers to makerspaces as the "new industrial revolution," linked to human resources and focusing on educational methods, enhancing creative thinking skills, and adapting to the future industrial society based on information technology, including online education, robotics, virtual reality, and artificial intelligence, among other tools. These tools have a positive impact on future education trends and planning based on the creative economy, investment in national manufacturing activities, and their role as creative economic hubs to foster scientific talent and enhance the ability to utilize necessary technologies for the new industrial revolution (Hatch, 2014). In this field, Bagley sees a favorable opportunity to prepare students for future jobs by taking bold actions necessary to develop globally competitive talents and providing such developmental programs to young people (Becker, 2018).

Benefits of makerspaces for academic libraries

As a central location on campus, libraries are uniquely positioned to foster evolving partnerships that may be essential in developing experimental approaches to scholarly communication for students and others. As academic units, libraries bring expertise in delivering information and research across disciplines and practices, which can clearly guide and teach such experiences.

There is promising potential in utilizing library services in new ways, as libraries have become increasingly valuable for their spaces and the opportunities they create for the community, such as supporting education, providing access to modern technologies, and assisting local businesses. When considering the space needed for these services, Petra Paraschiv mentions four important spaces that every modern library should accommodate to meet diverse needs and attract a wide range of visitors: a social space for interaction and knowledge exchange, a quiet space for reflection, an innovation space, and a neutral and reliable public use space. A significant expectation from users is to create more space for them, not just for books. Beneficiaries not only want to develop new skills and learn how to use modern technologies but also to share their experiences with others. Therefore, libraries are attentive to user needs and strive to accommodate these demands, making makerspaces a trend in recent years (Paraschiv, 2020).

Creating a makerspace in academic libraries is particularly beneficial for students. The creative space provided by the makerspace opens a new world of resources and exploration for students. Since projects completed in the makerspace are student-centered inquiries, this makes them ideal for implementation in educational environments. Besides the academic benefits of the makerspace, students are also trained to develop a mindset focused on teamwork, problem-solving, and innovation.

A makerspace can also serve as a springboard for developing entrepreneurial skills in students. Entrepreneurship includes many competencies that students are expected to develop. Many believe these shared goals can be achieved through entrepreneurship,

with placing entrepreneurship at the heart of the makerspace helping students connect their learning to future rewards.

Universities are continuously evolving, adding new facilities, resources, and programs to better serve students, faculty, and staff. Over the past decade, many universities have added academic makerspaces to their campuses. Makerspaces within academic libraries provide a development that allows individuals from across the university to come together for collaboration, design, manufacturing, and learning in shared spaces. By allowing students to design prototypes, we help them learn problem-solving, and by enabling them to manufacture, we provide them with essential skills for future jobs. Moreover, allowing students to access the university makerspace exposes them to the latest technologies, which can help them find work and gain experience with technologies involving open-source software. It also allows for self-learning, fosters dynamic collaborative learning, enhances interdisciplinary thinking, and enriches the learning environment by enabling students to work collaboratively with their peers—engaging in collective sharing, collaboration, self-learning, prototyping, and problem-solving. This makes them more creative, experimental, and explorative in understanding how things work and troubleshooting. Additionally, it benefits students by providing access to services and resources that may otherwise be difficult to obtain.

Community is a vital aspect of the success of the modern maker movement, and many successful academic library makerspaces actively cultivate interdisciplinary communities of practice, allowing users to share knowledge and ideas in informal, low-risk environments. Especially in a university setting, students may not have many opportunities in their courses to interact with students outside their disciplines, making "a group of peers who can help them through roadblocks to graduation" important for students (Wilczynski, 2017).

Curricular Integration: Faculty partnerships also allow for the integration of makerspace topics into the curriculum, often enhancing the library's mission as a center for learning and ensuring a broad impact of library maker services. Academic libraries are increasingly recognizing their role as facilitators of this type of interdisciplinary experiential learning. Many case studies highlight specific applications of maker topics in the curriculum. For instance, a case study of the Marston Science Library at the University of Florida provides several examples of integrating 3D printing technology into academic research and teaching in biology, computational biology, and engineering. At Stetson University Library in Florida, faculty from chemistry created tangible molecular models as three-dimensional teaching aids (Okuonghae, 2022).

Challenges of creating and managing makerspaces in academic libraries:

Despite the rapid growth of makerspaces in academic libraries and many studies highlighting the positive achievements of this trend, it is inevitable that such a focus on technology comes with a significant cost. For example, the AI lab at the University of Rhode Island (URI) relied on a grant of \$143,000, in addition to undisclosed additional funding from participating colleges and URI's office of the provost. Such costs are often beyond the budgets of libraries, leading them to seek alternatives like grants or corporate sponsorships (Burke J. , 2015).

Makerspaces are environments where new intellectual property is created daily through the fabrication of previously non-existent items. The same equipment used to create these innovations can also be used to infringe on others' intellectual property rights through illegal replication. Libraries need to address these important intellectual property issues in their makerspaces through policies and practices. Librarians can leverage their expertise in copyright to help users protect their work (Kim b. , 2019).

Although makerspace services align with the mission of academic libraries in many ways, new and innovative services often face resistance. Organizers of library makerspaces frequently find themselves defending unconventional library services, sometimes against internal staff.

Establishing strong policies is crucial to ensure that makerspace services function effectively and meet user needs. Policies should address various aspects such as cost determination, user identification (students, faculty, community members), service specifications, and intellectual property and trademark issues. It is also important to address any restrictions on space use, operational hours, and training for users. Policies and procedures should evolve as the spaces develop to meet the needs of their users, requiring continuous and accurate evaluation (Mathuews, 2018).

A major challenge in implementing makerspaces is balancing the desire to remove barriers for users with the need to ensure their safety. The most common obstacle observed in maintaining makerspaces is upkeep and enhancement, including setting up 3D printers, understanding electrical networks, and implementing safety policies. Communication skills also require specific expertise.

Finding staff with the technical skills to work with users and facilitate their learning is another challenge. Makerspace practitioners need skills in learning, adapting, collaborating, facilitating, and advocating to manage activities effectively. For many librarians, these diverse skills are new, necessitating further development.

The effectiveness of makerspaces depends on the consistency between the work done in the space, the size of the tools and area, and the value the space provides to the community. Practitioners highlight the challenge of maintaining practical skills in makerspaces, which can be forgotten if not regularly practiced. Repeating activities, documenting, task division, and gradual expansion are essential for transforming new activities into processes.

Another challenge is helping the public and stakeholders understand the value of makerspaces to secure continued funding. Misunderstandings can lead librarians to avoid implementing makerspaces. Researchers emphasize strategies for building partnerships with community members and external agencies to understand community needs and advocate for the value of makerspaces (Okuonghae, 2022).

A final challenge is determining how to reconfigure existing spaces within and outside academic library walls to reflect this new reality. Access to technology that enables this is crucial.

The following indicators highlight why makerspaces are essential for improving the image and activating the new roles of libraries in a changing environment (Osama,

2021).

- **Weak Adaptation to New Technologies:** Libraries may struggle to control and implement new technologies. While some libraries use technology professionally, they are few.
- **Interest in Technology:** Many professionals need to develop their skills through self-education to keep up with current practices. Sometimes, technology is acquired merely as a tool or because it is available, neglecting the social perspective necessary for understanding user needs.
- **Lack of Control over Digital Technology:** There are risks related to intellectual property, privacy, and freedoms due to the dominance of external technology providers.
- **Overwhelming Amount of New Technology:** The sheer volume of new technologies, applications, and associated practices and terminologies can create confusion and hinder professionals' understanding of digital projects.

Key considerations in designing makerspaces in academic libraries

The potential benefits of leveraging library services in new ways are significant, with libraries becoming increasingly valuable for their spaces and the opportunities they create for the community, such as supporting education, providing access to modern technologies, and assisting local businesses. When considering where these services should be provided, Petra Paraschiv (Paraschiv, 2020) identified four essential spaces that every modern library should include to meet various needs and attract a diverse range of visitors: a social space for interaction and knowledge exchange, a quiet space for reflection, an innovation space, and a neutral and reliable space for general use. One important expectation from users is the creation of more space for them, not just for books. Users not only want to develop new skills and learn how to use modern technology but also to share their experiences with others. Consequently, libraries are addressing these needs, leading to the rise of makerspaces in recent years.

1. Social space for interaction and knowledge exchange

A recent report from the Pew Research Center on library attendance in the United States highlights an interesting trend: Millennials are the most frequent visitors to public libraries. In 2016, 53% of survey participants aged 18-35 visited a public or mobile library. Millennials, representing a younger generation (Rendina, 2015), are social and consume and disseminate knowledge during their social interactions. This is why modern libraries also need to create spaces where users can interact openly with information process it, reflect on it, discuss it, and develop new ideas and opportunities as a result.

2. Quiet space for reflection

For centuries, libraries have represented a sacred space for consuming knowledge. Reflection was central to traditional library services, focusing on gathering as much knowledge as possible. Today, with continuous access to information, libraries are no longer the sole source of knowledge consumption. However, when inquiring

about library patrons, it is observed that 3 out of 4 respondents believe it is "very important" for the community that libraries still provide quiet study spaces (Pew Research Center survey) (Rendina, 2015). Thus, people still value having a quiet space to read a physical book or digital resource, or to organize their thoughts and work without the distractions of modern society. There is ongoing debate about whether libraries should become places of interaction and lose quiet spaces. Both options can be provided in a modern library, making the library a gathering point for everyone, regardless of how they consume knowledge. Providing a quiet space in addition to a social space is equally important. Creating a "social section" in the library can simply reduce complaints about noise by allowing users to choose their preferred area based on their needs.

3. Innovation space for makers

Users expect libraries to provide spaces that foster innovation and creativity, not just book storage. Libraries are increasingly focusing on maker spaces that allow users to develop new skills, learn to use modern technologies, and share their experiences. These spaces have become a significant trend, responding to the growing demand for hands-on, practical learning experiences.

Interactive Library Walls: Interaction between virtual and physical spaces is crucial for effective library design. Many libraries are now incorporating interactive elements into their physical spaces, such as digital displays that engage users with library resources in new ways. For example, Avedøre Library uses interactive walls to present books in engaging formats, integrating physical books, videos, digital content, and physical objects, with changing themes throughout the year (innova, 2021).



Figure 1: Communication Wall at Avedøre Library.

The Ørestad Library in Denmark is also an example of a public library that continually strives to offer integrated services through virtual communications. It features screens at the entrance to display the building's general functions and provides touchscreens distributed across bookshelf fronts to describe the resources available on each shelf (innova, 2021).



Figure 2: Touchscreens on the sides of bookshelves at Ørestad Library

The libraries in Christchurch also feature the Discovery Wall, the largest interactive touchscreen wall in New Zealand. This digital wall represents the city of Christchurch, allowing users to explore images, videos, and texts related to the city's unique history and identity. Users can upload their own photo collections, share their family histories, add comments to photos and videos, and send postcards via email (innova, 2021).



Figure 3: The Discovery Wall at Christchurch City Libraries

DLib Wall is a custom application developed by the University of Nevada, Las Vegas (UNLV) Libraries to create a physical and engaging presence for digital library collections. It can display visual resources (such as images and videos) in various formats designed to engage passersby who may not have prior knowledge of or awareness of these resources. The application is designed to be user-friendly for patrons of any age or technical skill level.

According to Samanta Roslund, makerspaces represent a physical location where people come together to share resources and knowledge, work on projects, network, and build. A makerspace can range from a repurposed book cart filled with arts and crafts supplies, to a table in a corner with LEGOs, to a full-fledged Fab Lab equipped with 3D printers, laser cutters, and hand tools (council, 2022).

For example, the Guldborgsund Libraries in Denmark recently opened a Fablab with the primary goal of empowering invention by providing free access to digital manufacturing tools. In this way, the Fablab becomes a community resource that everyone can access. According to Jan Holmqvist, the project has been a real success: "It also attracts new people and has already been a great success in terms of

increased attendance."



Figure 4: The Fablab at Guldborgsund Libraries

4. Neutral and Trustworthy Space for Public Use:

As noted in research from the National Archives, libraries reach a much broader range of age groups and social backgrounds compared to other types of cultural activities. Therefore, the library represents something different for each of us. It can be a quiet place for professionals to work, a playground for families, or even an information hub for those with limited resources, and much more. However, one aspect that everyone agrees on is that the library is a neutral and safe public space.

Analysis of the Reality of Creating and Managing Makerspaces within Saudi Universities

In recent years, many Saudi universities have begun providing makerspaces for students to create a safe, secure, comfortable, and productive environment for studying and working, as well as providing access to resources and technology. This section of the study will discuss an overview of the makerspaces available in Saudi university libraries, their objectives, and the challenges associated with providing them.

The popularity of indoor makerspaces has increased in Saudi Arabia as a means of providing a secure and safe working environment. These makerspaces are typically established by companies or institutions to offer a space for working, often funded by the institution itself. They provide a range of services, such as creating a comfortable and secure environment for users to work in and offering access to resources and technology.

The Fab Lab Dhahran, which opened in January 2014, was the first digital fabrication lab on the eastern coast of Saudi Arabia, specifically at King Fahd University of Petroleum and Minerals. It provides opportunities for collaboration and networking, enabling innovators in Saudi Arabia to find a well-equipped space for local creative programs. Peter Routke, a research scientist at the Visual Computing Center and Maker Space Group Coordinator, explained that the Maker Space Group at King Abdullah University of Science and Technology was the result of collaborative efforts from community members. He added, "We want to empower people to build all the projects in their minds, whether for themselves or for the

benefit of the King Abdullah University community (Fab Labaan, 2023).

The following site was used to list the makerspaces at Saudi universities, identifying 20 makerspaces at various locations. However, the study focused only on the makerspaces at Saudi universities, specifically 9 locations, excluding the makerspace at Taibah University as it is still under construction. <https://www.fablabs.io/labs>.

Table 2 shows the names and addresses of the makerspaces at Saudi universities, the entities responsible for managing these spaces, and the different terms used to describe them.

Table 2: Names of Makerspaces in Saudi Universities

University	Name of Makerspace	Responsible Entity	Location	Year Established	Link
King Abdullah University of Science and Technology	KAUST Prototyping Lab Makerspace	University	Building 24	2018	https://kaust-prototyping-lab.iv.navvis.com/
Jazan University	Fab Lab Jazan	College of Science	Innovation and Creativity Unit	2018	http://centers.jazanu.edu.sa/iec/Pages/fablab.aspx
King Abdulaziz University	Innovation and Prototyping Center Makerspace	Innovation and Creativity Center	Building 534	2015	http://www.kaufablab.com
Umm Al-Qura University	Fab Lab Wadi Makkah	Innovation and Entrepreneurship Institute	Innovation and Entrepreneurship Institute	2015	https://wadimakkah.sa/ar
Princess Nourah bint Abdulrahman University	Fab Lab Princess Nourah University	Deanship of Scientific Research	Deanship of Scientific Research	2021	www.alhayat.com/article/4580892
King Fahd University of Petroleum and Minerals	Fab Lab Dhahran	Deanship of Scientific Research	Deanship of Scientific Research	2014	http://fablabdhahran.org
Effat University	Fab Lab Effat University	Scientific Research	Scientific Research	2014	https://www.effatuniversity.edu.sa/arabic/research/research-labs/fabrication-lab/pages/default.aspx
King Saud University	KSU Code Lab Makerspace	Digital Entrepreneurship Center	Digital Entrepreneurship Center	2022	https://code.mcit.gov.sa/ar/Innovation-Lab/ksu-code-lab
King Saud University	KKU Code Lab Makerspace	Digital Entrepreneurship Center	Digital Entrepreneurship Center	2023	https://code.mcit.gov.sa/ar/Innovation-Lab/kku-code-lab

From the previous table, it is evident that different terminologies are used to describe makerspaces. Some universities use the term "Makerspace," while others refer to them as "Fab Lab," which is the most common and widely used term among Saudi universities. Additionally, the table highlights the recent establishment dates of these

makerspaces within universities.

The table also indicates that the responsibility and management of makerspaces in Saudi universities have been handled by entities other than university libraries, even though libraries are ideally suited for creating and managing makerspaces. This idea is supported by several researchers:

Dale Dougherty, editor and publisher of *Make* magazine and the founder of the Maker Movement, notes that libraries are among the best places to integrate makerspaces due to their greater flexibility in space, programs, and knowledge resources. Libraries can attract young people seeking to enhance their learning environment through a Do It Yourself (DIY) approach, allowing them to learn lessons in a setting different from their academic environment—the library. Makerspaces offer opportunities for people of all ages to engage with maker communities by sharing their work and experiences, creating a compelling social experience based on relationships (Partridge, 2016)

In addition to the neutrality of academic libraries, which makes them an ideal place for democratizing access to technology and fostering interdisciplinary collaboration, Burke and others (Burke J. &, 2018) describe the library as "the heart of the university." Libraries have a unique ability to make a significant impact and leverage relationships with students, faculty, and staff, providing users with a space for creativity beyond academic activities.

Some studies suggest that makerspaces are a natural extension of library services. The mission of libraries to meet the needs of users aligns well with what makerspaces should offer. Providing access to emerging technologies on campus, such as 3D printing, aligns perfectly with the objectives and goals of academic libraries (Brown, 2014). Makerspaces support student-centered learning and can offer students opportunities to develop problem-solving skills, creative thinking, innovation, and communication in a supportive environment.

Brown and Ficioni (Brown, 2014) describe that one of the vital aspects of the success of modern maker movements within academic libraries is community. Many successful academic library makerspaces actively foster interdisciplinary communities, allowing users to share knowledge and ideas in low-risk, informal settings. This is especially valuable in a university environment where students might have limited opportunities to interact with peers outside their disciplines.

Tools and Equipment Used:

Makerspaces within Saudi universities provide a range of advanced digital fabrication tools, including both simple and complex hand tools. As the complexity of the equipment increases, so does the number of training sessions required to explain the use of the equipment and its software, which aids in completing students' projects. The laboratory management team communicates with faculty members to understand students' needs and develop their skills, offering consultations to choose the most suitable equipment for students interested in creating 3D models and achieving the desired results while maintaining the highest quality standards. This includes educating students about different types of materials and their properties

and selecting the appropriate material for their project.

Table 3 outlines the tools and equipment used within the makerspaces.

University Name	Tools and Equipment Used in Makerspaces												
	Vinyl Cutter	CNC Milling Machine	Laser Cutter	Circuit Production	CNC Milling	3D Printer	Router Machine	Robots	Wood Cutter	Radio	Roland MDX-20	3D Body Scanner	Varios Small Parts
King Abdullah University of Science and Technology	✓		✓	✓	✓	✓						✓	✓
Jazan University	✓		✓		✓	✓		✓					✓
King Abdulaziz University			✓			✓	✓	✓					✓
Umm Al-Qura University		✓	✓	✓		✓							✓
Princess Nourah Bint Abdulrahman University			✓			✓		✓	✓				✓
King Fahd University of Petroleum and Minerals	✓		✓			✓			✓			✓	✓
Effat University		✓				✓	✓						✓
King Saud University			✓	✓	✓	✓					✓		
King Khalid University			✓			✓	✓				✓	✓	✓

Makerspaces provide expertise, technology, and a creative environment for the general community, including students, staff, faculty, and startups. The previous table indicates that the most commonly employed tools within makerspaces in Saudi libraries are 3D printers, vinyl cutters, laser cutters, plastic printers, robots, and radios. Additionally, various traditional tools are also utilized, such as drill presses, air blowers, pneumatic presses, and circular saws, among others.

Examples of Equipment and Tools Used in Saudi University Makerspaces

The QventAid device emerged as a response to the COVID-19 pandemic. In a humanitarian initiative, and with national design and production from Qatif, the QventAid disaster assistance ventilator was developed. This device is a Saudi-made product that helps provide an adequate amount of oxygen for patients in non-critical conditions.

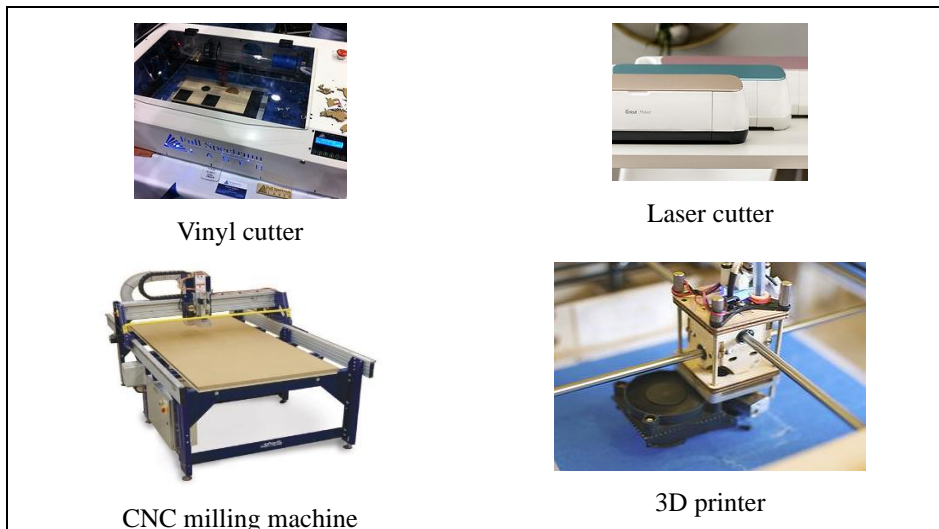


Figure 5: Examples of Equipment and Tools Used in Makerspaces at Saudi Universities

Objectives of Makerspaces at Saudi Universities:

Makerspaces at Saudi universities are designed with a set of goals, including:

Empowering Students: They enable students to execute their projects using digital design tools, 3D printers, laser cutters, and other advanced technologies. These labs were established to keep up with the latest technologies in contemporary crafts and modeling, aligning with Saudi Vision 2030.

Transforming Ideas into Reality: The concept of makerspaces revolves around converting ideas into tangible results. Planning, designing, producing, and manufacturing all occur in a single, safe location, providing the ideal environment for creativity and turning the ideas of the new generation of architects and designers into reality.

Providing a Safe and Comfortable Environment: Makerspaces are equipped to ensure student safety by offering a space with all necessary comforts and needs, including natural light and excellent ventilation. Students are allowed to use the facilities after completing an introductory workshop on the services of the makerspace, equipment usage rules, and safety systems.

Ensuring Health and Safety: All technicians responsible for managing the makerspaces are trained to ensure the health and safety of students.

Summary of objectives of makerspaces at Saudi universities:

Redefining the Role of Libraries: Makerspaces aim to rediscover the library's role as an interactive community space, not just for consuming information but for experimentation, creativity, and knowledge sharing.

Collaborative Learning Environment: They provide a collaborative educational environment where community members, mentors, and library staff can learn from each other while working on projects or using available technology.

Space for Experimentation and Creativity: Makerspaces are places for experimentation, play, and creativity. They bring people's imaginations to life and allow individuals of all ages and skill levels to create and implement their ideas, supporting hands-on learning.

Equitable Access to Information and Technology: They aim to provide equitable access to information and technology by extending this access to new and costly digital or manufacturing technologies, such as 3D printers and robotic machines.

Fostering Entrepreneurial Spirit and Skills Development: Makerspaces help cultivate an entrepreneurial spirit and develop useful general skills such as teamwork, public speaking, professional networking, time management, and project management.

Empowering Student Innovations: They enable students to prototype their innovations, test their effectiveness, and refine them based on results. Makerspaces assist students in obtaining patents and support research and innovation skills, aiming for active participation in local and global conferences with high-quality industrial models. They also encourage those less interested in creativity and innovation to experiment and discover.

Integration of STEM Skills: Makerspaces utilize STEM skills to integrate science, technology, engineering, and mathematics. This includes scientific knowledge, skills, creative and decision-making thinking, and technological applications related to scientific, engineering, and computer sciences.

Organizing Conferences and Workshops: They hold conferences, workshops, and courses related to new technologies (e.g., 3D printing, laser cutting). For example, on 26/7/1442H, workshops were organized at King Abdullah University labs to enable people to prototype their ideas.

Services provided by makerspaces:

Makerspaces in Saudi Arabia typically offer a range of services to their users. These services include providing a comfortable and safe environment for staff to work in, as well as access to resources and technology. Additionally, these spaces often offer training and development opportunities, along with other services such as catering and transportation.

Most tools used in our daily lives can be designed and manufactured in makerspaces, ranging from artistic designs printed on clothing or any conceivable surface to furniture, plastic items like keychains, eyeglass frames, mobile phone cases, and both static and moving components of electronic devices and mechanical machines, all in various imaginative shapes and colors.

Makerspaces generally provide a range of equipment and software necessary for creating these products. This includes laser cutters for engraving and carving on metals and wood, vinyl cutters, and 3D printers. These 3D printers allow users to produce three-dimensional parts made from various materials with different

mechanical and physical specifications, which can be assembled into a single product. The 3D printing process involves layering special materials based on CAD design software.

All of this equipment, among others, is managed and coordinated by precise CNC (Computer Numerical Control) systems, which are operated and supervised by the team using the workshop and utilizing its resources to bring their ideas to life.

Challenges facing makerspaces:

Makerspaces in Saudi Arabia face a range of challenges:

- **Security and Safety:** Ensuring the security of the makerspace and providing a comfortable, safe environment for staff to work in are critical challenges. Makerspaces must also guarantee access to necessary resources and technology and provide training and development opportunities.
- **Space Constraints:** Finding suitable space within university libraries for makerspaces can be challenging. Additionally, equipping these spaces with the necessary resources and technology can be costly. Ensuring that makerspaces are used appropriately without disturbing other library users is also a concern.
- **Cost and Resource Shortages:** Many universities in Saudi Arabia lack the financial resources, space, and equipment required to establish makerspaces. Creating such spaces can be expensive, and not all universities may have the budget to invest in this initiative.
- **Cultural Resistance:** There is cultural resistance to the idea of makerspaces in academic libraries in Saudi Arabia. Some view them as distractions from the core functions of academic libraries.
- **Regulatory Issues:** Establishing makerspaces in universities requires approval from the Ministry of Education and other government entities, which can be difficult to obtain.
- **Lack of Awareness:** Many students and faculty members are unaware of the potential benefits of makerspaces and may be hesitant to embrace them. Suha Al-Salehi points out that a common challenge is the limited view of makerspaces as only 3D printing areas, while the concept is much broader (Al-Salehi, 2019).
- **Lack of Expertise:** Faculty members or library staff may lack the technical expertise to effectively use and manage a makerspace.

3. Requirements for establishing makerspaces in academic libraries:

1. **Adequate Seating Space:** University libraries should provide comfortable seating for students and faculty to study and work.
2. **Access to Technology:** Libraries must provide access to computers, printers, and other technologies to support research and learning.

3. Access to Resources: Libraries should offer a variety of resources, including books, journals, databases, and other materials.
4. Quiet Study Areas: Libraries need to have quiet areas for students to work without distractions.
5. Group Study Areas: Libraries should provide group study spaces for students to collaborate on projects and assignments.
6. Access to Reference Materials: Libraries should have reference materials such as dictionaries, encyclopedias, and other reference books.
7. Access to Library Staff: Libraries must ensure access to staff who can assist with research and other library-related tasks.
8. Library Services: Libraries should provide access to services such as interlibrary loans, document delivery, and other services.
9. Facilitate Administrative Procedures: Streamline government and administrative procedures for establishing makerspaces in academic libraries.
10. Training for Library Staff: Train librarians on how to manage and use makerspaces effectively.
11. Promote Makerspace Culture: Increase awareness among students and faculty about the benefits of makerspaces and the advantages they offer.

4. Summary:

- Makerspace Culture in Libraries: Makerspace culture has taken root in many American and European libraries. Although such concepts are not yet widespread in the Arab world, it is likely that Arab libraries will adopt this culture soon to remain relevant and interactive with a diverse audience different from what they have known in recent years.
- Importance of Innovative Models: This study emphasizes the importance of new innovative models known as Makerspaces, which transform libraries into community hubs for sharing, innovative forms of service and education, and laboratories for ideas and inventions. The study also highlights the need to benefit from international experiences to implement makerspaces in Saudi academic libraries.
- Challenges and Adaptation: Makerspaces within libraries present numerous challenges that require rethinking many existing regulations and traditions. They also necessitate changing the role of libraries to play a leading role in a changing environment. Additionally, there are challenges related to the perceptions of beneficiaries who view libraries solely as places for books and reading. Therefore, it is crucial to promote makerspace culture among faculty members and users and demonstrate the benefits of makerspaces to them.
- Natural Extension of Library Services: Makerspaces are a natural extension of library services. Libraries' missions to meet users' needs align with what they should offer through makerspaces. Thus, libraries are well-positioned to adopt makerspaces

as new technologies require new skills, and libraries are in a position to help develop those skills.

- Skills Development for Makerspace Practitioners: Makerspace practitioners need learning and adaptation skills to facilitate activities within makerspaces. For many library professionals, these skills are new, so their expertise must be developed to handle and adapt to makerspaces effectively.

- Economic and Social Impact: Makerspaces bring about economic and social changes. They help mitigate the risks of uncontrolled technology and its production rather than just consumption, which could strain budgets. Additionally, many companies producing this technology own citizens' data.

- Funding and Resource Challenges: The success of makerspaces depends on the ability to secure necessary funding for financial resources, space, and equipment. Establishing a "makerspace" can be costly, and many universities may not have the budget needed to invest in such an endeavor.

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