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The Role of Makerspaces in Academic Libraries: A Systematic Literature Review

Saira Hayat
Librarian, Govt Associate College for Women Bhagtanwala, Sargodha, Pakistan
sairaalvi.hayat13@gmail.com
Farrukh Shahzad
Chief Librarian, Forman Christian College (A Chartered University), Lahore, Pakistan
arrukhshahzad82@gmail.com
Prof. Dr. Khalid Mahmood
Pro Vice Chancellor, University of the Punjab, Lahore, Pakistan
khalid.im@pu.edu.pk
Muhammad Nadeem Akhtar (Corresponding Author)
Head, Main Library & IT Department, Ayub Agricultural Research Institute, Faisalabad, Pakistan
ch.nadeem@aari.punjab.gov.pk
Sidra Batool
Technical Librarian, Ayub Agricultural Research Institute, Faisalabad, Pakistan
sidra.batool@aari.punjab.gov.pk

ABSTRACT

Makerspaces in the last couple of decades have gained popularity in different types of libraries and academic libraries in higher education institutions are no exception. Based on a hands-on learning approach and peer-to-peer learning, it is generally perceived that makerspaces support in enhancing students' learning and creativity. Therefore, to assess the influence of makerspaces on students' learning and creativity in academic libraries, we decided to adopt a systematic literature review approach. For this purpose, Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) was used as a guideline for the study. Five major scholarly databases including Scopus, LISTA, Taylor and Francis, Springerlink and Google Scholar were searched for the relevant literature. The search literature was carefully assessed to determine eligibility of the studies for inclusion according to predefined criteria in order to answer the research questions. Findings of the study suggested that makerspaces significantly impact student learning and creativity, problem-solving abilities, and interdisciplinary learning while presenting challenges such as resource allocation and faculty involvement.

Keywords: *Makerspaces; Hackerspaces; Fablabs; Academic Libraries; Students' Learning; Creativity.*

Introduction

Technology has greatly evolved over the years with rapid developments taking place affecting every aspect of day-to-day life starting from the first-generation computers, emergence of the internet, WWW, mobile phones and social media. The Internet of Things (IoT) has interconnected the world enabling real-time exchange of information enhancing efficiency of business across various sectors. The twenty-first century has seen groundbreaking advancements in technology such as Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR) and Machine Learning (ML) revolutionizing business, economies and everyday life. Technologies such as nanotechnology, quantum computing and renewable energy solutions are pushing the boundaries of new horizons, possibilities, and a future shaped by intelligent systems, unprecedented levels of innovation and sustainability. This rapidly evolving landscape has also impacted higher education necessitating innovative learning environments that go beyond traditional methods of lecture-based instructions and technology has significantly changed the way students learn (Lee, 2017).

Last couple of decades has seen the emergence of makerspaces in all types of libraries including academic libraries and since then this concept has taken libraries by storm. The term "makerspace" was coined in 2005 with the publication of Make: magazine founded by Dale Dougherty and the launch of Maker Faire, which sparked the 'Maker Movement' and the eventual rise of makerspaces (Okpala, 2016; Wang et al., 2016; Wong & Partridge, 2016). The term maker refers to innovators, artists, engineers, and tinkerers, promoting innovative and hands-on creation whereas "Maker Movement" is a global do-it-yourself (DIY) community that supports merging advanced technology with hands-on creativity (Bean et al., 2015). Makerspace is a specified place for diverse academic and social groups to collaborate on creative work, particularly knowledge-based, sharing ideas, skills, and tools for creating various innovative and knowledge-based products (Chakraborty & Chakraborty, 2021). Makerspaces typically refer to creative environments designed to foster innovation (Zhan et al., 2021).

The proliferation of makerspaces in academic libraries marks a greater change in how libraries adapt their services to new kinds of spaces to offer technologies and resources for learning and research other than traditional print and electronic resource materials (Fletcher, 2020). The increasing adoption of makerspaces in academic libraries to promote experiential learning through maker services (Nagle, 2020). According to Colegrove (2017) makerspaces in libraries represent a contemporary development—an inherent complement that transcends disciplinary boundaries of educational innovation, the integration of formal and informal learning, and outreach and engagement in Science, Technology, Engineering, and Mathematics (STEM).

According to Wong and Partridge (2016) other terminologies for makerspaces are “hackerspaces”, “hacklabs”, and “fablabs” etc. every term highlights different facets, yet all present opportunities for informal, practical learning, usually referring to creative areas meant to inspire innovation. Saorin et al. (2017) mentioned alternative terms such as “coworking spaces”, “innovation laboratories”, “media labs”, "fablabs" or "hacklabs". According to Johnson, (2023) Despite its variation in terminology, makerspace is by far the most indexed term.

The value of makerspaces in higher education institutions is rapidly gaining momentum, keeping in view the advancement of technology. As highlighted by Tomko et al. (2017) makerspaces are crucial for developing future engineers, as they help create independent learners and self-starters who can tackle complex challenges in a world where silos of engineering disciplines are diminishing, ensuring they are equipped to tackle complex problems. The ACRL Research Planning and Review Committee (2024) identified "Makerspaces and Tech Spaces" as a significant trend in its 2024 Top Trends in Academic Libraries, emphasizing that "As libraries persist in evaluating user needs, support for these spaces is becoming increasingly vital."

The significance of the current study is to make a significant contribution and to fill the gap in the existing literature on makerspaces in libraries. As pointed out by Andrews and Man (2017) significant portion of library literature has concentrated on elucidating makerspaces and their establishment, rationales for their integration within libraries and librarianship, operational procedures, particular equipment or projects, and outreach initiatives and relatively little focus has been focused on learning and teaching in makerspaces, creativity and literacies. This study will provide insights into what kind of technologies are being used in the library makerspaces, providing useful input for library administrators and decision makers and assessing the role of makerspaces in enhancing students' learning and creativity in academic libraries. A systematic literature review approach was used to answer the following research questions:

RQ1: What are essential technologies found in academic library makerspaces?

RQ2: Role of makerspaces to support in enhancing students' learning, creativity and innovation in academic libraries?

Methods

A systematic literature review approach was used to provide an insight into the technologies being used in the makerspaces of academic libraries as well as assess the role of makerspaces in supporting students' learning and creativity. For this purpose, preferred reporting items for systematic literature review and meta-analysis (PRISMA) was used as it serves as a guideline to develop protocols for systematic literature reviews and meta-analysis which provides with a minimum set of items for inclusion (Moher et al., 2015; Shamseer et al., 2015). The PRISMA approach is implemented using a four-phase flow diagram encompassing identification, screening, eligibility, and the inclusion/exclusion of publications.

Search Strategy

A comprehensive search strategy was devised in order to retrieve the maximum amount of relevant literature published on the study topic. Therefore, keywords were carefully formulated based on the research questions and title of the study. The keywords used to locate the studies were following capturing different variation in names for makerspaces (makerspace*, , hackerspace*, fablab*) for specifically capturing academic libraries (academic librar*) and finally terms encompassing the essential aspects of research questions (technolog*, learning, and creativity). Truncation "*" sign was used in order to widen the search results keeping in view the various forms of terms such as technolog* may retrieve different variations including technology, technologies, technological.

The Boolean operator "AND" was decided to use where both terms were required in order to retrieve specific results and OR was used to find alternative terms to widen the search criteria. Terms such as makerspace including its alternatives and academic libraries were considered as having special focus keeping in view the topic of the study and it was ensured that both terms appear in the search results. The search was conducted based on the search strategy given below in January, 2025.

Makerspace* OR hackerspace* OR Fablab* AND Academic librar* OR technolog* OR learning OR creativity

This search strategy was used to search for the maximum amount of relevant literature on the topic of the study from the following databases including LISTA, Scopus, Taylor and Francis, SpringerLink and Google Scholar. LISTA was selected on the basis of purely covering published research in the field of Library and Information Sciences whereas Scopus was used to find the overall results from the indexed journals on different fields.

Inclusion and Exclusion Criteria

Appropriate studies pertaining to the research question were identified by means of inclusion and exclusion criteria. If an article satisfied all the inclusion criteria, it was selected for the study; else, it was eliminated.

Inclusion Criteria

The following predefined inclusion criteria was adopted to assess the eligibility of the studies to achieve research objectives:

1. Relevant research papers published in English Language
2. Research papers with no geographical boundaries
3. Studies published between 2015 and 2025
4. Research papers, Reports, Conference Papers
5. Studies focusing on terms such as makerspaces, hackerspaces, fablabs, and academic libraries

Exclusion Criteria

The following predefined exclusion criteria was adopted to assess the ineligibility of the literature to be included in the study.

1. Research papers not in English Language
2. Research papers not available in full-text
3. Studies discussing makerspaces in academic libraries but not addressing important aspects to answer research questions such as types of technologies and components, learning and creativity.
4. Book chapters, review articles, editorials etc.
5. Studies published before 2015

Study selection and data extraction

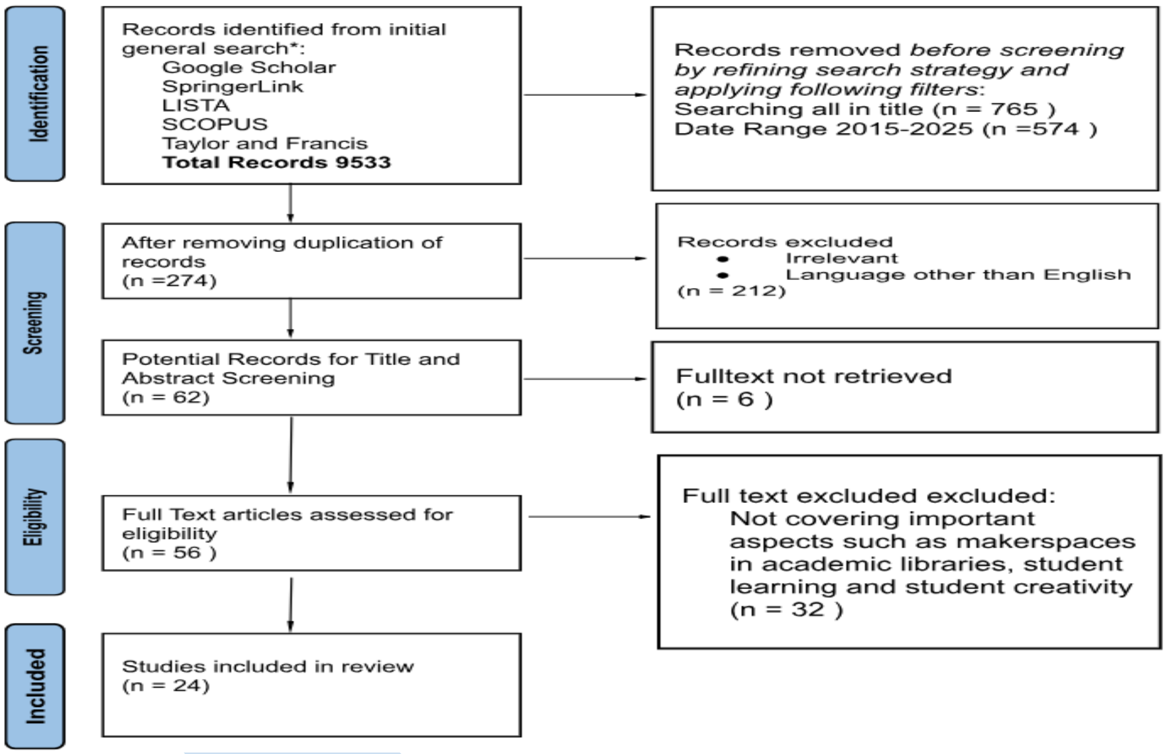
The process of identification, screening, determining eligibility and final inclusion is shown in Figure 1. The screening process, at two stages, title/abstract and full text—yielded 26 studies for inclusion in this review. Author names, country, year of publication, technologies or equipment, learning and creativity supported by makerspaces were extracted from the studies included. These fields were selected on the basis of fitting the objectives of the study.

Results

A comprehensive search strategy was devised to ensure retrieving the maximum amount of relevant literature. The search results from five databases including LISTA, Scopus, Taylor and Francis, Springerlink and Google Scholar yielded a total of 9,533 results. Searching the keywords in title and applying the date range filter to retrieve results of the studies published between 2015-2025 filtered the results to a total number of 574 studies. After initial screening and excluding duplicate results, language other than English and irrelevant articles, a total number of 62 studies were considered eligible. After applying the final inclusion and exclusion criteria 24 studies were finally considered eligible in every way for inclusion in the study.

The summary of the extracted data on themes covering the research questions is shown in Table 1. Author(s) is shown in the first column, while country where the research study was conducted is shown in second column, third column is the indication of year of publication. The technological equipment and components used in the makerspaces reported in the studies are given in the fourth column of the table, whereas the fifth and sixth column of the table shows learning, creativity and innovation respectively. Most of the selected articles were from developed nations, as the makerspace phenomenon is relatively novel to academic libraries and has been embraced in academic libraries within the developed world. Resultantly, there is very little, or no research produced on this topic from developing and third world countries as the concept and adoption of makerspaces is still very rare considering the costly nature of technology, maintenance and sustainability factors. Maximum number of publications on makerspaces were from countries like USA, UK, China, Australia and Canada.

Figure 1 *PRISMA Flow Diagram for Studies Selection*



Technological components and equipment in makerspaces

The results of the study indicated a variety of technological components and equipment being used in academic library makerspaces based on the size and budget of the library. Low-tech activities in makerspace included such as knitting, embroidery, crocheting and weaving (Wong & Partridge, 2016) alongside high-end activities with tools such as 3D Printers, Scanners, CNC machines and Microcontrollers (Andrews & Mann, 2017).

Table 1: *Summary of the extracted data on Makerspace technology, learning and creativity*

Author	*Country*	*Year*	*Technology Components*	*Supporting Students Learning*	*Supporting Students Creativity*
Andrews, Camille E.	USA	2017	3D Printers, Microcontrollers, CNC Machines,	Informal learning by doing, Collaborative and Peer-to-Peer Support Different approaches of	**Through uTEC model, using tinkering, experimenting and creating**
Andrews et al.	USA	2021	3D Printers, Filaments, SLS and Metal, Full Spectrum Laser Cutters, CNC Milling Machines,	Formal and Informal STEM Learning, Experiential Learning, Working collaboratively with	**Students reported gains in collaborative skills and creativity, Creativity through**
Bell et al.	Australia	2023	3D Printes, Laser Cutters, 3D Scanners, Autodesk Fusion 360,	Active collaborative learning rather than passive classroom learning,	**Technology is connected with creativity, Makerspace fosters**
Cao et al.	China	2020	3D Printers, Daijiang Drones, Google Glasses, VR Devices, Laser cutting, Robotics	Learning by doing approach, makerspace as a place of experiential learning, encouraging	**Developing the makerspace to support innovation and creativity**
Childrey, Cynthia	USA	2025	3D Printers and Scanners, Sewing Machines, Virtual and Augmented Reality Devices.	Makerspaces encourage social, hands-on and contextualized.	**Makerspaces promote creativity by design thinking, creative problem solving and**
Colegrove, Patrick Tod	USA	2016	3D printers and scanners, laser cutters, Mindstorms Robotic Toolkits, Hummingdoc,	Active learning, problem based learning, cultivating curiosity, constructivist learning, technology	**Creative collaboration, drives innovation and entrepreneurship, 21st century**
Curry, Robert	UK	2017	3D Printers, Arduino	Experiential learning, Self-efficacy through social learning, self-directed learning, learning in	**Self-efficacy in creativity and innovation, fosters innovation and creativity**
Johnson, Paula C.	USA	2023	3D Printers, Robotics, Laser cutters, Button and Jewelry making equipment, Sewing and embroidery machines, Raspberry	Self-directed learning, hands-on learning, collaborative and experiential learning, informal project driven learning,	**Centers for creative making, makerspace as a creative outlet,**

Author	***Country***	***Year***	***Technology Components***	***Supporting Students Learning***	***Supporting Students Creativity***
Lam et al.	UK	2021	Machines, Textiles, Workbenches,	Idea sharing, peer learning, mentoring, co-design activities enhance learning	Fosters creativity through co-design, promotes collective creativity throughout the design
Lee, Rebekah J.	USA	2017	3D Printers	Facilitates physical learning, Provides multi-sensorial learning environment, interactive learning,	Provides a less structured and creative environment, Enhances creative thinking and innovation
Lv, Jinyu	China	2016	3D Printes, Laser Cutters, Circuits Programmable Robots,	Learning through constructing and formulating own ideas,	Catalyze innovation, A place for creative exploration
Melo et al.	USA	2023	3D Printing, Laser Cutters, 3D Scanners 3D modeling, Photo editing and web development	Low and High-tech communal learning environments,	Facilitate creative thinking and innovation
Michalak, Russell and Rysavy.	USA	2019	3D Printes and Scanners, Drilling, saw machines, Sewing Machines, laser cutters, maker	Experiential learning, supports learning, place to learn actively and collaboratively, teaching and	Originated as creative places, encourage and catalyze innovation, encourages students to innovate
Nagle, Sarah Beth	USA	2020	3D Printers and Scanners,	Facilitate experiential learning, inclusive peering learning, improved learning and engagement learning by making	Spirit of creativity, 3D technology improved student creativity, low risk creative space, creative thinking and problem solving skills
Okpala, Helen Nneka	Nigeria	2016	3D Printers and Scanners, 3D Modeling VHS Conversion softwares, soldering iron,	Supports informal and shared social learning, collaborative learning environments, inter-	Open environment for creativity and innovation, fosters creativity
Osawaru et al.	Nigeria	2020	3D Printers and Scanners, Robotics, Soldiering Irons, Sewing Machines, Scissors, Projectors	Facilitates group learning, collaborative learning environment, interest driven learning, critical thinking and	Cultivates creative interests and innovation, makerspaces fosters creativity and innovation, An open environment for creativity, fosters

Author	*Country*	*Year*	*Technology Components*	*Supporting Students Learning*	*Supporting Students Creativity*
Paul et al.	USA	2025	3D Printers and Scanners, CNC Milling machines, Vinyl cutters, Binding Equipment Sewing	Experiential learning, Learning by doing, learning through building knowledge, Project based learning	Promotes creativity and innovation, teamwork creativity, community creativity
Radniecki et al.	USA	2016	3D Printers and Scanners, Laser Cutter, Printed Circuit Board, Vinyl Cutters, heat press, Sewing	Stimulated active learning, outside the classroom learning, Self-directed learning, supplemental	Catalysts for unseen innovation, encourages innovation and creativity
Saorin, et al.	Spain	2017	3D Printers and Scanners, laser cutters, CNC machines in wood	Promotes Project/Problem based learning, Social learning, creativity	Creativity through divergent thinking ability, Stimulates
Sharma and Shrivastava	India	2024	3D Printers, Laser cutters, Vinyl cutters, Waterjet cutters, Computer Numerical Control	Learning and intellectual exploration, learning by doing, hands-on learning, experiential	Encourages creativity and innovation, acquire skills in more concrete and creative way,
Tomko et al,	USA	2018	3D Printers, Woodshops, Laser Cutters, Waterjet, Coding Arduinos, wide-format	Collaborative learning in informal and formal ways, self-directed learning, makerspaces offers	Creativity through interactions with peers, Interplay between expertise, learning and creativity.
Wang et al.	Canada	2016	3D Printers and Scanners, Laser cutters, Computer Assisted Design (CAD), Robotics, CNC	Learning is best achieved by doing, peer lead and shared learning, encourages playful learning,	Fosters imagination and creativity, collaborative creativity, Transform creative ideas to
Wong and Partridge	Australia	2016	3D Printers, CNC Machines, Laser Cutters, Power and Hands-on Tools, Computers, soldering	Makerspace offers informal hands-on learning, Problem based learning, Flexible learning programs	Makerspaces encourages creation and creativity, student-driven making and learning
Zhan et al.	China	2021	3D Printers, Laser Cutters, Building drones or robots at makerspaces,	Informal learning environments, transforming knowledge based learning into creative leaning, improving students learning	Aas places for students creativity, develops creativity and innovation, Provides creative wisdom, Creative problem

All the studies except (Lam et al., 2021) reported that the makerspaces were having 3D printers as an essential technological equipment and Saorín et al. (2017) termed it as a “characteristic technology for makerspaces”. According to Johnson (2023) 3D printers were the starting point of many makerspaces. Okpala, (2016) described that 3D printers are devices specifically engineered to produce three-dimensional objects and are initially developed using suitable software prior to being printed, while Wang et al. (2016) mentioned 3D printers as cutting-edge technology of great interest for public in makerspaces. Radniecki et al. (2016) argued that 3D printers are operated by the staff until the students learn how to make and print 3D shapes with these printers.

Along with the 3D printers, many makerspaces also maintain 3D scanners to scan artifacts in 3D format (Radniecki et al., 2016) to build prototypes of the real-world objects (Wang et al., 2016). 3D Scanners availability in the makerspaces along with the 3D printers were reported by (Bell et al., 2023; Childrey, 2025; Colegrove, 2017; Melo et al., 2023; Nagle, 2020; Okpala, 2016; Osawaru et al., 2020; Paul et al., 2024; Radniecki et al., 2016; Saorín et al., 2017; Wang et al., 2016).

Other popular technological equipment or components reported in the studies are laser cutters as it provides an avenue for artistic, decorative work leading to prototyping different shapes on cardboards and it is mostly used in STEM makerspaces specially for engineering students as they can prototype shapes such as drones with the help of laser cutters beside being used as decorative and artistic work on cardboard or wood materials (Radniecki et al., 2016). Laser cutters along with Computer Numerical Control (CNC) drilling and milling machines and Vinyl cutters are among other popular technological equipment being used in makerspaces (Andrews et al., 2021; Johnson, 2023; Paul et al., 2025; Radniecki et al., 2016; Saorín et al., 2017; Sharma & Shrivastava, 2024; Wang et al., 2016)

Besides the above-mentioned technological equipment various other types of generic equipment such as power and hand tools, sewing and embroidery machines, saw, button and jewelry making tools, needles and other supplies are usually part of makerspaces (Radniecki et al., 2016; Paul et al., 2025; Sharma & Shrivastava, 2024).

Modern tools of Virtual Reality and Augmented Reality are also becoming part of the makerspaces as reported by (Childrey, 2025; Michalak & Rysavy, 2019; Tomko et al., 2017; Wang et al., 2016). Other specialized equipment such as soldering machines and irons, Raspberry PI, Makey Makey Kits, Printed Circuit Board, Arduino Inventor Kit, Google Glass, Robotics, Computer Assisted Design (CAD) and Microcontrollers (Cao et al., 2020; Colegrove, 2017; Johnson, 2023; Osawaru et al., 2020; Wang et al., 2016).

The selection of tools and equipment in the makerspaces depends upon the nature of the higher education institution, budget availability for the makerspace, mission and vision of the makerspace. As in STEM subjects require highly specialized equipment whereas some other institutions with social sciences and humanities focus may start with basic technologies in the makerspaces to begin the culture of making, creativity and idea generation to enhance student learning.

Makerspaces enhancing Students Learning

The results of the systematic literature review suggested that makerspaces play a very important role in enhancing and supporting student learning in different ways such as constructivist and experiential learning, collaborative and peer learning, learning by doing or making, Project/Problem Based Learning (PBL), self-directed and social learning, informal and formal learning, active learning, stimulated active learning, hands-on learning and multi-sensory learning.

Learning by doing or making

Makerspaces enhancing students by encouraging learning by doing or making (Andrews, 2017; Cao et al., 2020; Curry, 2017; Paul et al., 2024). This informal way of learning helps students remember the knowledge gained from the experience. Many studies has used the term hands-on learning as being practiced in the makerspaces (Childrey, 2025; Johnson, 2023; Sharma & Shrivastava, 2024; Wong & Partridge, 2016).

Constructivist and experiential learning

Results of the study showed that majority of the studies reported experiential learning as the heart of the makerspaces learning outcomes (Andrews et al., 2021; Cao et al., 2020; Childrey, 2025; Johnson, 2023; Lv, 2016; Michalak & Rysavy, 2019; Sharma & Shrivastava, 2024). According to Curry, (2017) makerspace offers a cross-disciplinary experiential learning setting that promotes invention and creativity, facilitating the development of self-efficacy through self-directed learning opportunities within a productive and mutually supportive community. Paul (2024) argued that makerspaces integrate experiential learning, constructivism and conversation theory, he further connected experiential learning to Kolb's Experiential Learning Cycle and Dewey's Experiential Learning Theory. He further stated that experiential learning is using and producing something tangible and then reflecting on the creation as a learning process.

Self-Directed, Collaborative and Social Learning

According to Lee (2017) makerspaces support collaborative and peer learning through access to such spaces where students can collaboratively work and brainstorm ideas in groups and at the same time encouraging interaction across disciplines. Colegrove (2016) asserts that the technology in makerspace catalyzes not only self-directed but also social and collaborative learning through increased interaction. According to Johnson (2023) these collaborative makerspaces provide learning opportunities and equip students with soft and practical skills needed for the present economy which is innovation driven. Okpala (2016) described makerspaces as collaborative learning environment where people gather, collaborate, share materials and learn new skills. Overall, makerspaces promote the use of self-directed, collaborative and social learning approach in the makerspaces (Bell et al., 2023; Radniecki et al., 2016; Wang et al., 2016; Wong & Partridge, 2016).

Project/Problem Based Learning (PBL)

Project/problem Based Approach is considered very useful in educational institutions as a mode of learning and teaching. This approach is widely adopted in schools. According to Saorín et al. (2017) methodologies centered on teamwork and Project/problem-Based Learning (PBL) such as activities conducted in makerspace contexts, facilitate the investigation of numerous and varied solutions to a singular problem enabling divergent thinking. Bell et al., (2023) also identifies makerspaces as places for problem-based learning environment centered around creative thinking and finding solutions of the problems. Colegrove (2016) supported problem-based learning and constructivist approaches for meeting the needs of the modern era. Project/problem Based Learning (PBL) approach as being regularly used in the makerspaces as reported by (Nagle, 2020). Wong and Partridge (2016) mentioned that problem-based learning is an excellent technique in order to build and reinforce the knowledge of students.

Makerspaces enhancing Students Creativity and Innovation

The results of the study showed that makerspaces help enhance creative thinking, creativity, innovation and entrepreneurship.

Creativity through creative problem solving, design-thinking, experimentation and tinkering

Makerspaces help in promoting and enabling creativity through design-thinking, creative problem solving, experiential learning and innovation by providing access to creative and innovative environments equipped with technology as hubs of innovation (Childrey, 2025). Johnson (2023) termed makerspaces as a source for opening opportunities to students for prototyping specially in STEM subjects and individual students can use these spaces as "creative outlet" a place to play around with novel ideas and sharing those ideas.

Curry (2017) stated that makerspaces foster creativity and enable students' self-efficacy in creativity and transforming ideas into reality as these spaces facilitate self-directed and also collaborative learning environment. Andrews (2017) mentioned uTEC model (using, tinkering, experimenting and creating) for makerspaces to help enhance students self-direct and social learning, creativity and innovation. Andrews et al. (2021) stated the useability of makerspaces as a space for transforming ideas to creativity through the means of informal learning from peers and supervisors encouraging collaborative work.

Lam et al. (2021) mentioned the creativity framework by Sanders consisting of four key elements (doing-adapting-making-creating) as a means of helping people appreciate creativity occurring in places like makerspaces. The authors further argued that makerspaces assist in fostering creativity to a great extent. Saorin (2017) makerspaces flourish students' ability of divergent thinking (generating multiple solutions to a problem) as opposed to convergent thinking (focusing only on one solution) also identified makerspaces as places of creation with digitally controlled machines.

Tomko et al. (2017) highlighted the value of makerspaces by identifying the interplay between expertise, learning and creativity and how it is strengthened by continuous interaction with peers and how it facilitates exploring creative avenues for students. Radniecki et al. (2016) argues that the technologies in the makerspaces are catalyst for previously unseen innovation and creativity and also serve as a source of inspiration and innovation.

Many other studies have mentioned makerspaces fostering creativity through design-thinking, critical thinking and problem solving, innovation by providing a structured yet open and inclusive environment strengthening idea generation, creativity and innovation (Cao et al., 2020; Lv, 2016; Paul et al., 2024; Wang et al., 2016; Zhan et al., 2021). Overall, the results showed that makerspaces help in enhancing students' creativity and innovation.

Discussion

The data extracted for the study indicated that makerspaces significantly help in increasing students' learning creativity and innovation through informal, self-directed and social learning based on problem solving and constructivism and its tech-driven environment aligning with 21st century requirements. Makerspaces are a relatively new phenomenon that has emerged in the last couple of decades and has taken libraries of all kinds, especially academic and public libraries by storm. Makerspaces emerged from the "Maker Movement" which was a global cultural trend that emphasized focus on do-it-yourself (DIY), craftsmanship, hands-on learning and innovation with the use of technology.

Since its evolution, libraries have adopted the concept of makerspace at a rapid pace especially in developed countries. The purpose of such spaces is to provide collaborative learning space for community and students to foster their learning, critical thinking, making and creativity. Makerspaces are separately managed places in institutions of higher education in some cases as well as it is also managed and run by the library whether it is public or academic library.

Technological equipment varies according to the size, type and budget of the library, from low-tech equipment to high-tech equipment and from higher education institutions to schools. Academic libraries from relatively small educational institutions maintain low-tech equipment including sewing machines, power and hand-tools essential for woodworking and general making, embroidery machines, button and jewelry making equipment, measuring and marking tools, cutting and shaping tools, electrical and soldering tools, printing and papercraft along with one or two high-end technological equipment such as 3D printers and Scanners. Libraries with more budgets and from bigger institutions can afford to have high-tech equipment specially for meeting the needs of students of STEM subjects. High-tech equipment includes 3D printers, 3D scanners, CNC machines, vinyl cutters, Molding machines, computer and robotic tools such as Arduino & Raspberry PI, Microcontrollers, PCB milling machines and Artificial Intelligence tools such as Augmented and Virtual Reality tools. Advanced manufacturing tools such as Waterjet cutters, Plasma cutters, Injection molding machines, high-tech textile and coding and AI development tools are also part of some makerspaces.

However, it was identified that 3D printers, laser cutters and 3D scanners are amongst the most found technological equipment in the makerspaces along with low-tech equipment based on its ease of maintenance and sustainability. Makerspaces started with basic equipment to develop a culture of learning and creativity and then based on the usage and availability and then develop from that with having some of the high-tech equipment. High-tech equipment is found mostly in the specialized makerspaces meeting the needs of STEM students with the purpose of enhancing their learning, creativity, innovation and entrepreneurship.

Makerspaces plays vital role in enhancing the learning and creativity of the students in different ways other than formal classroom learning. Learning is facilitated through, experiential and constructivist approach, self-directed, social and collaborative learning from peers, supervisors and instructors. It also facilitates learning to project/problem based learning improving students divergent thinking, critical thinking and problem solving skills. Makerspaces help students overcome their fear of learning and creating new things with little risk. The most identified approach was learning by doing or learning by making or hands-on learning. Makerspaces also facilitate improving students' creativity, innovation and entrepreneurship through design-thinking, divergent instead of convergent thinking, experimentation and tinkering, making and creative problem solving. These approaches have been mentioned by many studies as methods for enhancing creativity and innovation.

Besides the many benefits of the makerspaces, it presents significant challenges for the management and administration in terms of resource constraints, training requirements, assessment and learning outcomes, maintenance and sustainability issues which needs to be dealt with for provision of such spaces in academic libraries. The best approaches to develop and maintain makerspaces could be proper strategic planning with clear goals and objectives, developing collaborations and inclusive design involving students from diverse backgrounds.

This will ensure successful implementation of makerspaces in academic libraries in order to enhance and support learning and creativity.

Conclusion

Makerspaces at university libraries function as transformative educational settings that improve student learning, cultivate creativity, and equip individuals with vital skills for the future workforce. Despite existing obstacles, strategic planning and inclusive policies can optimize their effectiveness. Academic libraries are now adopting the idea of makerspace as a collaborative learning environment equipped with gadgets, and technology which can help improve students creative thinking and problem-solving skills by enhancing creativity and innovation. Makerspaces will be essential in the evolution of higher education by fostering new and immersive learning opportunities.

References

ACRL. (2024). *2024 Top trends in academic libraries*. College and Research Libraries News. Retrieved February 14, 2025, from https://crln.acrl.org/index.php/crlnews/rt/printerFriendly/26379/34322

Andrews, C. E. & Albert R. Mann. (2017). Learning and teaching in library makerspaces: A literature review on making literacies. *ISAM*. https://assets.pubpub.org/c5mw4mhd/21585583154859.pdf

Andrews, M. E., Borrego, M., & Boklage, A. (2021). Self-efficacy and belonging: the impact of a university makerspace. *International Journal of STEM Education*, *8*(1). https://doi.org/10.1186/s40594-021-00285-0

Bean, V., Farmer, N. M., & Kerr, B. A. (2015). An exploration of women's engagement in Makerspaces. *Gifted and Talented International*, *30*(1–2), 61–67. https://doi.org/10.1080/15332276.2015.1137456

Bell, E. C., Piper, S., & O'Sullivan, C. (2023). Users' experiences in a regional academic library makerspace. *Journal of the Australian Library and Information Association*, *72*(2), 135–149. https://doi.org/10.1080/24750158.2023.2202512

Cao, F., Wu, S., & Stvilia, B. (2020). Library makerspaces in China: A comparison of public, academic, and school libraries. *Journal of Librarianship and Information Science*, *52*(4), 1209–1223. https://doi.org/10.1177/0961000620908657

Chakraborty, S., & Chakraborty, S. B. (2021). Library Makerspace: A new dimension to the future library services. In *International Virtual Conference on Library and Information Services (IVCLIS 2021)*.

Childrey, C. (2025). Scaling Innovation: How academic library leaders Can develop and sustain next generation makerspaces for student success and community engagement. *Journal of Library Administration*, *65*(2), 235–243. https://doi.org/10.1080/01930826.2024.2437965

Colegrove, P. T. (2017). Makerspaces in Libraries: Technology as Catalyst for Better learning, Better teaching. *Ingenieria Solidaria*, *13*(21), 19–26. https://doi.org/10.16925/in.v13i21.1724

Curry, R. (2017). Makerspaces: a beneficial new service for academic libraries? *Library Review*, *66*(4/5), 201–212. https://doi.org/10.1108/lr-09-2016-0081

Fletcher, C. (2020). A case for scholarly making in the library: Makerspaces, innovation labs, and the evolution of scholarly communications. *College & Undergraduate Libraries*, *27*(2–4), 339–353. https://doi.org/10.1080/10691316.2021.1899881

Johnson, P. C. (2023). University Library Makerspaces: Connect, Create, Collaborate! In *2023 ASEE Annual Conference & Exposition*.
Lam, B., Choi, Y., Chen, X., Ni, M., & De Sousa, S. (2021). Fostering creativity through co-design and making: case studies of makerspaces in the UK. *J Of Design Research*, *19*(1/2/3), 133. https://doi.org/10.1504/jdr.2021.121056
Lee, R. J. (2017). Campus-Library Collaboration with Makerspaces. *Public & Access Services Quarterly*, *13*(2), 108–116. https://doi.org/10.1080/15228959.2017.1303421
Lv, J. (2016). Research and Practice on the Construction of Hackerspace in Libraries. In *2nd International Conference on Electronics, Network and Computer Engineering (ICENCE 2016)*. https://doi.org/10.2991/icence-16.2016.186
Melo, M., Hirsh, K., & March, L. (2023). Makerspaces in libraries at U.S. public colleges and Universities: A census. *Portal Libraries and the Academy*, *23*(1), 35–43. https://doi.org/10.1353/pla.2023.0007
Michalak, R., & Rysavy, M. D. T. (2019). Academic Libraries in 2018: A Comparison of Makerspaces within Academic Research Libraries. In *Advances in library administration and organization* (pp. 67–88). https://doi.org/10.1108/s0732-067120190000040008
Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1). https://doi.org/10.1186/2046-4053-4-1
Nagle, S. B. (2020). Maker Services in Academic Libraries: A review of case studies. *New Review of Academic Librarianship*, *27*(2), 184–200. https://doi.org/10.1080/13614533.2020.1749093
Okpala, H. N. (2016). Making a makerspace case for academic libraries in Nigeria. *New Library World*, *117*(9/10), 568–586. https://doi.org/10.1108/nlw-05-2016-0038
Osawaru, N. K. E., Dime, N. a. I., & Okonjo, N. E. H. (2020). The right Time for makerspaces in Nigerian Academic Libraries: Perceived Benefits and challenges. *International Journal on Integrated Education*, *3*(10), 103–115. https://doi.org/10.31149/ijie.v3i10.694
Paul, Y., Vecchione, A., & Colegrove, P. T. (2024). Makerspaces in libraries. In *Elsevier eBooks*. https://doi.org/10.1016/b978-0-323-95689-5.00186-3
Radniecki, T., Klenke, C., & Purpur, E. (2016). Makerspaces in academic libraries: Opportunities for teaching and learning. *ICERI Proceedings*. https://doi.org/10.21125/iceri.2016.1009
Saorín, J. L., Melian-Díaz, D., Bonnet, A., Carrera, C. C., Meier, C., & De La Torre-Cantero, J. (2017). Makerspace teaching-learning environment to enhance creative competence in engineering students. *Thinking Skills and Creativity*, *23*, 188–198. https://doi.org/10.1016/j.tsc.2017.01.004
Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*, *349*(jan02 1), g7647. https://doi.org/10.1136/bmj.g7647
Sharma, K. C., & Shrivastava, R. (2024). Implementation and impact of makerspaces in Indian academic libraries: a study of select three academic libraries of North India. *Library Hi Tech News*. https://doi.org/10.1108/lhtn-09-2024-0161

Sheridan, K., Halverson, E. R., Litts, B., Brahms, L., Jacobs-Priebe, L., & Owens, T. (2014). Learning in the Making: A comparative case study of three makerspaces. *Harvard Educational Review*, *84*(4), 505–531. https://doi.org/10.17763/haer.84.4.brr34733723j648u

Tomko, M., Nagel, R. L., Linsey, J., & Aleman, M. (2017). A qualitative approach to studying the interplay between expertise, creativity, and learning in university makerspaces. In *ASME 2017 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference*. https://doi.org/10.1115/detc2017-68256

Wang, F., Wang, W., Wilson, S., & Ahmed, N. (2016). The state of library makerspaces. *International Journal of Librarianship*, *1*(1), 2. https://doi.org/10.23974/ijol.2016.vol1.1.12

Wong, A., & Partridge, H. (2016). Making as Learning: Makerspaces in Universities. *Australian Academic & Research Libraries*, *47*(3), 143–159. https://doi.org/10.1080/00048623.2016.1228163

Zhan, Q., Chen, X., & Retnawati, E. (2021). Exploring a construct model for university makerspaces beyond curriculum. *Education and Information Technologies*, *27*(3), 3467–3493. https://doi.org/10.1007/s10639-021-10761-3