

Makerspaces in School Libraries - Transforming Learning Ecosystems for 21st Century Education: A review

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Abstract

Makerspaces in school libraries have become transformative settings that enhance creativity, collaboration, critical thinking, and problem-solving skills in learners. Based on constructivist and constructionist theories, these spaces transition libraries from passive information stores to active learning environments. This review synthesizes existing research on the conceptual basis, implementation, educational effects, challenges, and future prospects of makerspaces, highlighting their role in supporting STEM/STEAM education, digital literacy, inquiry-based learning, and inclusive pedagogy. Global evidence, including guidelines from the American Association of School Librarians and the International Federation of Library Associations and Institutions, underscores the essential role of school librarians as facilitators and leaders in innovation. While studies indicate improved student engagement, self-directed learning, and collaborative knowledge construction, obstacles like funding shortages, training deficiencies, and sustainability challenges, particularly in developing areas, persist. The review concludes that makerspaces signify a paradigm shift in school librarianship, promoting 21st-century competencies and equitable access to creative technologies. To optimize their educational benefits, strategic planning, policy alignment, and librarian development are crucial.

Keywords: *Makerspaces, School Libraries, STEAM Education, Constructivism, Information Literacy, Digital Creativity, Inquiry-Based Learning*

1. Introduction

School libraries are changing dramatically from being typical book-centred places to being vibrant learning hubs. The incorporation of makerspaces is among the most significant advancements in this change. Makerspaces are cooperative spaces furnished with equipment and technology that allow students to create, test, construct, and invent.

The maker movement has gained a lot of traction in educational settings thanks to its effect on DIY culture and experiential learning. Makerspaces in school libraries encourage collaborative learning and connect academic subjects with practical inquiry. Makerspaces are becoming more and more recognized as crucial elements of contemporary school libraries as educational systems throughout the world place an emphasis

on creativity and innovation (Loertscher, Preddy, & Derry, 2013).

This study reviews academic research on makerspaces in school libraries, looking at their theoretical underpinnings, instructional advantages, implementation techniques, difficulties, and potential future developments.

1.2 Methodology

This study adopts a qualitative systematic review approach to analyse existing literature on makerspaces in school libraries. Relevant scholarly articles, conference proceedings, policy documents, and institutional reports were collected from databases such as Google Scholar, Scopus, and library science repositories.

The selection criteria included:

- (i) publications focusing on school library makerspaces,
- (ii) studies discussing educational impact, implementation strategies, or theoretical frameworks, and
- (iii) works published primarily between 2010 and 2025, with emphasis on recent developments.

A thematic analysis method was employed to categorize the literature into key domains, including theoretical foundations, educational impact, implementation models, challenges, and future directions. This approach ensures a comprehensive and structured synthesis of the evolving makerspace discourse.

2. Makerspace – a brief background

The development of web-based products, the rise of STEAM culture, and the ease of access to fabrication tools all contribute to the trend of both digital and physical manufacturing. This trend was dubbed "Maker Movement" by Make Magazine's founder, Dale Dougherty. In 2005,

Make Magazine published "Maker Movement," which was the first step toward Maker Space (American Library Association, 2013). The US Libraries began offering makerspace programs in their libraries that same year as a way to engage in making activities. The makerspace was initially provided by the Fayetteville Free Library, a public library.

According to Lay (2014), "the idea of 'maker culture' is that learning is best achieved through doing." It is the idea that people should make things with their hands or with technology in a different way. In reality, the maker culture is founded on skill-based and practical learning.

3. Theoretical Foundations

Constructivism (Piaget, 1970) and constructionism (Papert, 1980) are the main foundations of makerspace pedagogy. Constructionism expands on constructivism's theory that students actively create knowledge via experience by focusing on learning through the creation of physical things.

By offering areas where students may work on practical, inquiry-driven projects, makerspaces operationalize these notions. Maker-centred learning promotes collaborative problem-solving, iterative design thinking, and deep involvement (Sheridan et al., 2014).

According to Chakraborty and Chakraborty (2021), a makerspace is a designated area within a library for gathering, creating, and learning using various tools to develop new concepts or inventions. Their earlier work primarily conceptualizes makerspaces as evolving knowledge environments. In contrast, Chakraborty and Chakraborty (2026) extend this perspective by examining the documentation, metadata, and archival challenges associated with Indigenous makerspace knowledge systems.

Together, these studies demonstrate both the foundational and emerging dimensions of makerspace research.

The makerspace is a “metaphor for a unique learning environment that encourages tinkering, play, and open ended exploration for all the users of the library,” according to Laura Flemings (2014) (<https://worlds-of-learning.com>).

Furthermore, makerspaces support the idea of participatory culture (Jenkins, 2009), in which students move from being passive information consumers to active knowledge producers.

4. Purpose and Benefits of Makerspace in Libraries

According to Janet Balas (2012), "libraries are evolving from places that house materials to places where users can work....Libraries are not just places for the quiet study of scholarly

materials, but they can also be places where the creation of audio or video presentations can take place." Certain incredibly creative libraries can also serve as locations for creating tangible products.

The main purpose of the makerspace in Libraries are to:

- Promote community engagement
- Encourage literacy and education
- Foster active learning and a culture of making
- Provide easy access to creative tools
- Respond to community needs and requests
- Offer experiential education
- Make co-working facilities available
- Achieve user-specific objectives, including:

- Creative abilities
- Problem-solving and critical thinking
- Hands-on learning
- Peer-to-peer cooperation
- Youth empowerment

4.1 Technologies, Tools and Activities in Institutional Library Makerspace

Table 1 Tools and Technologies for various institutional makerspaces

School Library Makerspace	College/ University Library Makerspace	General
• Craft supplies • Cardboard • Plastic materials • Paper • Styrofoam • Paint • Collage materials • Rainbow Loom • Knitting and crochet supplies • Plastimake etc.	• 3D printers • Robotics materials – WeDo/Lego • Motors • LED lights • Snap Circuits • Dash and Dot Robots • Cubelet Robots • Arduino / Raspberry Pi • Tinkering • Animation • Game creation • Website creation • Digital music recording etc.	• Sewing machines • Electric keyboard • Tinkering tools • Video production materials – green screen and lighting

5. Role of School Libraries in the Maker Movement

Because school libraries play a crucial role in schools and are multidisciplinary, they are in a unique position to host makerspaces. According to the American Association of School Librarians (2018), school libraries should promote inquiry, teamwork, and exploration—all of which are fundamental components of maker education. Likewise, libraries are promoted as innovation centres that promote lifelong learning by the International Federation of Library Associations and Institutions (2015).

The relationship between a makerspace and a library is reflected in the makerspace's features. The role of libraries is constantly evolving as a result of the digital revolution. "Makerspaces are shifting educational and public organizations from being places where things are made or information is found to places where knowledge and ideas are developed and imagination and creativity are fostered," according to Tashjian (2014). The library is undergoing adjustments because it is an educational institution. A library is a crucial component that promotes and makes it easier for individuals to meet and exchange ideas, information, etc. Because of this, libraries have the potential to become hubs for makers.

As facilitators, librarians assist students with research, design, and reflection. By combining research and creativity, makerspaces enhance information literacy education rather than take the place of conventional services (Koh & Abbas, 2015).

3D printers, robotics kits, coding platforms, craft supplies, electronics, and multimedia creation tools are examples of typical makerspace equipment. But according to research, low-tech creation techniques like paper engineering and

storytelling can have just as much of an impact as high-tech ones (Moorefield-Lang, 2015).

6. Educational Impact of Makerspaces

6.1 Enhancing STEAM Learning

Makerspaces encourage multidisciplinary problem-solving, which is a powerful way to boost STEM and STEAM education. According to Blikstein (2013), students can successfully prototype scientific and engineering concepts with the use of digital fabrication technologies.

6.2 Developing 21st Century Skills

Critical thinking, creativity, communication, and teamwork are all fostered in makerspaces. Bowler (2014) discovered that through iterative learning processes, kids participating in maker activities exhibit greater levels of resilience and self-efficacy.

6.3 Promoting Digital and Information Literacy

Makerspaces expand on conventional information literacy frameworks by combining research, design, and production. According to Koh and Abbas (2015), students gain the ability to assess information sources, use knowledge creatively, and record their learning experiences.

6.4 Inclusion and Equity

Makerspaces can help close the digital divide by providing equitable access to emerging technologies and learning opportunities. They support diverse learning styles and foster inclusive participation across socio-economic and cultural backgrounds (Sheridan et al., 2014).

Importantly, makerspaces also offer significant potential for engaging Indigenous communities and preserving local knowledge systems. When thoughtfully implemented, Indigenous makerspaces can serve as platforms for cultural expression, intergenerational learning, and community-driven knowledge creation. However, libraries must ensure ethical considerations such as intellectual property rights, cultural sensitivity, and community governance while designing such spaces (Chakraborty & Chakraborty, 2026).

Thus, inclusive makerspaces extend beyond access to technology, encompassing cultural inclusivity, knowledge diversity, and participatory empowerment.

Recent studies (2020–2025) further reinforce the effectiveness of makerspaces in enhancing student engagement and interdisciplinary learning. Emerging research highlights the role of makerspaces in fostering computational thinking, design-based learning, and digital resilience in students. Additionally, post-pandemic studies emphasize the importance of hybrid and remote makerspace models in sustaining collaborative learning environments.

7. Implementation Models in School Libraries

Implementation strategies vary depending on institutional resources and goals. Common models include:

1. **Dedicated Makerspace Rooms** – Fully equipped innovation labs.
2. **Mobile Makerspaces** – Portable kits that rotate among classrooms.
3. **Integrated Learning Commons** – Flexible spaces combining print, digital, and maker resources.

Professional development for librarians, curricular alignment, and administrative assistance are necessary for successful implementation. According to Loertscher et al. (2013), community collaborations and strategic planning are crucial.

The conceptual framework of school library makerspaces (Figure 1) illustrates the relationship between inputs, processes, outputs, and long-term educational outcomes.

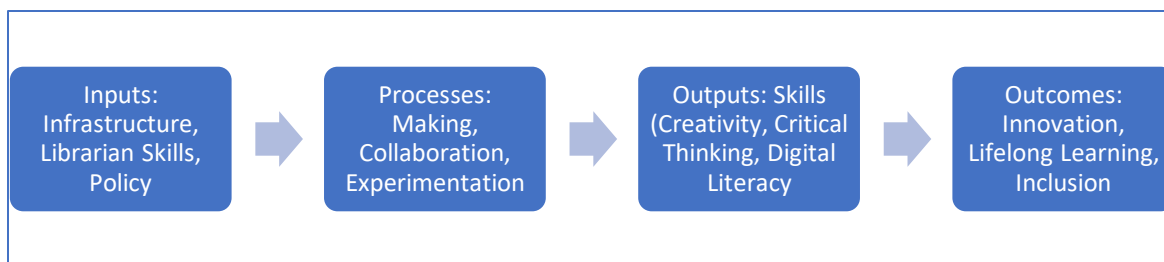


Figure 1 Conceptual Framework of School Library Makerspace Ecosystem

7.1 Indian Schools with Makerspace like facilities

Under the Atal Tinkering Labs, thousands of Indian schools have makerspace-style facilities that offer resources like robotics kits, sensors, and 3D printers to foster creativity. Atal Tinkering Labs (ATLs) are cutting-edge, school-based workspaces created by NITI Aayog's Atal Innovation Mission (AIM) to support students in Classes 6 through 12 in developing their STEM abilities, creativity, and entrepreneurial spirit. These labs, which are outfitted with DIY kits, robotics, 3D printers, and IoT, allow for practical learning and prototyping to address real-world issues (NITI Aayog Government of India, n.d.).

Examples include:

1. Kendriya Vidyalaya (many campuses)
2. Navodaya Vidyalaya (selected schools)
3. City Montessori School – Has makerspace and robotics labs to encourage innovation (Times of India, 2025; City Montessori School, 2026).
4. Maa Anandmayee Memorial School – ATL-based makerspace (*Atal Tinkering Lab - MAMS - Maa Anandmayee Memorial School*, 2023).
5. DAV Public School (several branches)
6. Amity International School (multiple campuses)

8. Challenges and Limitations

Despite their benefits, makerspaces face several challenges:

- **Funding Constraints:** High-tech equipment can be costly.

- **Professional Development Gaps:** Librarians may require technical and pedagogical training.
- **Curricular Integration Issues:** Aligning maker activities with standardized curricula can be complex.
- **Sustainability Concerns:** Long-term maintenance and evaluation frameworks are often lacking.

In developing contexts, these challenges are intensified by infrastructural limitations and policy gaps.

9. Future Directions: The Next Frontier of School Library Makerspaces

The future of school library makerspaces lies in the integration of emerging technologies such as Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), and Internet of Things (IoT). These technologies are poised to redefine makerspaces as intelligent, immersive, and adaptive learning environments.

AI-powered tools can support personalized learning pathways, automate design processes, and assist in creative problem-solving. Similarly, VR and AR technologies enable immersive experiential learning, allowing students to simulate real-world environments and complex scientific phenomena.

Hybrid makerspaces, combining physical and virtual platforms, are emerging as flexible and scalable models, especially relevant in post-pandemic educational ecosystems. These environments support remote collaboration, digital prototyping, and global knowledge exchange.

As the “next frontier,” school library standards must evolve to incorporate these technological advancements, ensuring that librarians are equipped with the competencies required to facilitate future-ready learning. Policy frameworks should prioritize innovation, sustainability, and digital inclusivity in makerspace development.

10. Conclusion

A paradigm change in school librarianship, makerspaces turn libraries into ecosystems for collaborative creation. They encourage experiential learning, creativity, and interdisciplinary involvement and are based on constructivist learning theories. Although there are still issues with financing, training, and sustainability, there are significant educational advantages.

Makerspaces can transform school libraries into inclusive, future-ready learning spaces that equip students for challenging global issues with careful planning and expert assistance.

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Declaration of Conflicting Interests

The author/s declare/s no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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