THE IMPACT OF THE LIBRARY ENVIRONMENT ON STEM EDUCATION: METHODOLOGICAL FOUNDATIONS FOR THE EFFECTIVE USE OF RESOURCES

Authors: [1]Polatuly S., [2]Yedilbayev Ye., [3]Kurbanbekov B., [4]Abdurashidov S.A.
Affiliation: [1]PhD., Khoja Akhmet Yassawi International Kazakh-Turkish University (Kazakhstan,Turkistan), [2] Lecturer., Khoja Akhmet Yassawi International Kazakh-Turkish University (Kazakhstan,Turkistan), [3]PhD., Khoja Akhmet Yassawi International Kazakh-Turkish University (Kazakhstan,Turkistan), [4]Physics Teacher at Sh. Niyazov General Secondary School (Kazakhstan,Turkistan)
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ABSTRACT

This article aims to explore the impact of the library environment on the quality of STEM (science, technology, engineering, mathematics) education and to propose methodological foundations for the effective use of resources. The study analyzes the transformation of the modern library's traditional role, emphasizing its potential not only as a repository of information resources but also as an interactive learning and research space. The relevance of the research lies in the need to fully utilize the potential of library resources to enhance STEM education. By applying literature review, analytical, and systematization methods, the authors suggest ways to effectively integrate the library environment into the educational process. The findings reveal that the effectiveness of an educational environment built on the basis of the Resource-Methodological System (RMS) depends on the harmonious interaction of its four main components: resources, research opportunities, methodological support, and socio-cultural environment. The article proposes methodological mechanisms for developing students' practical skills, research competence, and professional socialization through the use of library resources.

Keywords: STEM education, library environment, resource-methodological system, resource utilization, innovative methods, research competence.

INTRODUCTION

In the modern education system, the importance of science, technology, engineering, and mathematics (STEM) fields is steadily increasing. These disciplines play a decisive role in preparing future specialists, fostering innovative thinking, and ensuring sustainable economic development. However, the effective implementation of STEM education requires going beyond traditional teaching methods and utilizing modern resources and environments. In this regard, the role of the library environment has become more distinctive.

Today, the library is not only a center for the accumulation of information resources but also a space that promotes interactive learning, research, and creativity. In the context of STEM education, libraries provide resources such as digital collections, e-books, specialized software, 3D printers, robotics kits, and laboratory instruments, thereby enabling the practical application of theoretical knowledge. G.

Totikova and colleagues examined the psychological effectiveness of the STEAM approach through the use of 2D and 3D modeling. Their findings demonstrated that visual modeling enhances students' cognitive activity and creative thinking. Moreover, 3D modeling improves research skills and increases the efficiency of the learning process [1]. Similarly, Ä. Eskermesuly and colleagues investigated the use of 3D modeling and robotics in teaching. Their study revealed that these methods contribute to the development of students' research skills, critical thinking, and creativity. In addition, by strengthening interdisciplinary connections and increasing interest in project-based learning, this approach has proven its significance in the educational process [2]. Furthermore, in their study, Saltanova and colleagues considered the development and implementation of an automated information system for university libraries. The authors highlighted the advantages of the system in optimizing information resource management, facilitating access to data, and providing high-quality services to users. The system contributes to the digital transformation of libraries and supports learners' scientific and research potential [3].

The purpose of this study is to determine the impact of the library environment on the quality of STEM education and to propose methodological foundations for the effective use of resources. The research analyzes optimal approaches, opportunities, and challenges of integrating library resources into the educational process, while also providing recommendations for enhancing teaching and learning outcomes.

The relevance of the study arises from the fact that the potential of library resources in improving STEM education has not yet been fully explored. The theoretical significance lies in developing a methodology for effective resource utilization, whereas the practical value is reflected in designing recommendations that can directly support the educational process.

LITERATURE REVIEW

In modern education, the number of studies exploring the role of the library environment in STEM has significantly increased over the past five years. Shtivelband, Spahr, Jakubowski, LaConte, and Holland examined the concept of "STEM-readiness" in public libraries. The authors analyzed the potential of libraries in supporting STEM education, focusing on their resource base, staff preparedness, and community engagement. The findings highlighted that libraries are evolving beyond being mere sources of information to becoming important environments for implementing STEM initiatives [4].

Accordingly, the transformation of library services has also influenced their educational models. For instance, Lalwani and Allee described the adaptation of engineering libraries to the changing educational ecosystem. They examined issues of modernizing library services, introducing structural changes, developing human capacity, and managing resources more effectively. Through case studies, the research presented contemporary approaches to meeting the new informational needs of engineering students and faculty. The study emphasized the necessity for engineering libraries to integrate digital resources, data literacy skills, and interdisciplinary support in the future [5].

Similarly, the integration of information literacy has gained significant importance. Addressing this issue in greater depth, Serik, Nurgaliyeva, and Yerlanova explored methodological aspects of incorporating various robotics technologies into Kazakhstan's STEM education system. Using project-based learning approaches, the

authors focused on developing learners' research, technical, and creative skills. Their findings demonstrated that the effective use of robotic tools enhances students' scientific thinking, strengthens interdisciplinary understanding, and improves their ability to solve practical problems. Moreover, this approach contributes to developing the professional competence of future teachers and improving the overall quality of STEM education [6].

Furthermore, the methodology of using digital resources has also been the subject of research. Continuing in this direction, E. Rusydiyah, E. Purwati, and A. Prabowo analyzed the significance of digital literacy as a learning resource in the training of future teachers in Indonesia. Their study showed that mastering digital skills expands teachers' pedagogical competence and enhances their ability to effectively apply modern technologies. The authors emphasized that developing digital literacy increases students' capacity for self-directed learning and enables them to adopt innovative methods [7].

However, several challenges remain in integrating library resources. In this regard, Baryshev and colleagues examined the transformation of university libraries in the digital era. They described the shift from traditional services to electronic resources and remote access, while also noting the need for staff to adapt to new competencies. Nevertheless, financial and infrastructural constraints were found to hinder the effective implementation of these changes [8]. Similarly, Kato, Kisangiri, and Kaijage reviewed the development of university digital library resources. Their study revealed that the transition from traditional libraries to digital ecosystems improves accessibility and accelerates teaching and research processes. Yet, limitations in infrastructure, funding, and staff training remain the main barriers [9]. In addition, Aliyyah and colleagues analyzed the effectiveness of digital libraries for educators in the context of Industry 4.0. The findings showed that digital libraries are highly valued as tools for enriching learning content and fostering student autonomy. At the same time, the lack of technical support, insufficient digital literacy, and platform instability were identified as persistent challenges [10].

In conclusion, the literature review demonstrates that the library environment in STEM education is not merely a source of resources but also a significant factor in transforming the learning process. On this basis, it can be concluded that achieving effectiveness depends not on the resources themselves but on the methodological mechanisms of their utilization, staff preparedness, and alignment with educational programs.

RESEARCH METHODOLOGY

The methodological basis of the research is formed by the principles of a systems approach, which allows for the analysis of the library environment as a complex and integrated system within the STEM educational process. To solve the given problem and achieve the research objectives, the following set of methods was used:

Systematic literature review and analysis. This method was aimed at defining the evolution of the library environment in modern STEM education, its role and potential, as well as the theoretical foundations of the Resource-Methodological System (RMS) concept. The analysis of domestic and international literature (journals, monographs, conference proceedings) confirmed the relevance of the research subject and provided a theoretical basis for developing practical recommendations.

Comparative analysis method. This method was used to comparatively study the experience of integrating the library environment into STEM education in different socio-cultural contexts (e.g., Kazakhstan, Russia, USA, Indonesia). It helped identify the most effective approaches, trends, and common challenges in developing methodological recommendations.

Systematization method. Theoretical and practical data obtained during the research (types of library resources, methods of their use, mechanisms of pedagogical impact) were systematized. This served as the basis for presenting the impact of the library environment on the quality of STEM education holistically, within the framework of four main components (resources, research opportunities, methodological support, socio-cultural environment), and for constructing the RMS model.

Synthesis method. Based on the generalization and synthesis of results obtained from the methods mentioned above, the methodological foundations for effectively integrating the library environment into the educational process were proposed. The combined use of these methods ensured the theoretical depth and practical orientation of the research.

RESULTS

The results of the study revealed that the effectiveness of the modern educational environment, established based on the Educational-Methodical Complex (RMS), in comprehensively preparing future specialists is grounded in the harmonious interaction of the following four interrelated factors:

- *Acquisition of practical skills:* Innovative resources such as 3D printers, robotics kits, and VR headsets provide opportunities to reinforce theoretical knowledge through hands-on practice, making the learning process more sophisticated and engaging.
- *Development of research competencies:* The transformation of the library into a "laboratory-library" creates an ideal environment for project development and collaborative work. This is further supported by specially designed methodological materials (guidelines, instructional resources), which facilitate the systematic organization of students' independent research activities.

Facilitation of professional socialization: The socio-cultural component of the educational environment, implemented through dedicated events and open communication spaces, promotes the emergence of professional communities among future specialists, enhances their communication skills, and supports career development.

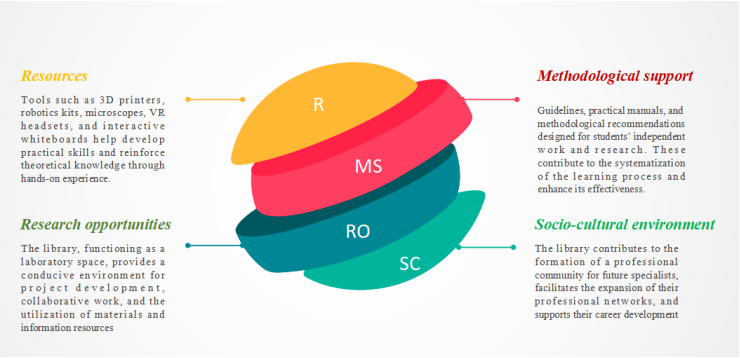

Figure 1. The Impact of the Library Environment on STEM Education

Thus, the study fully demonstrates that the integration of resources, research opportunities, methodological support, and the socio-cultural environment as a unified system elevates the learning process to a qualitatively new level. The proposed approach transforms the learner from a passive recipient of knowledge into an active architect of their own educational trajectory, ultimately preparing competent and well-rounded specialists capable of meeting the evolving demands of the labor market.

CONCLUSION

The results of the study indicate that the impact of the library environment on STEM education goes beyond its role as a mere information source, demonstrating its potential to become a central component of an innovative educational ecosystem. According to the methodology proposed by the educational-methodical complex (RMS), a modern library is envisioned as a comprehensive space that functions as a "laboratory-library," offering resources such as 3D printers, robotics kits, and VR technologies, while also providing methodological support and socio-cultural integration. Enhancing the quality of STEM education depends not only on the level of technological equipment but also on the methodological mechanisms for integrating these resources into the learning process, as well as on the preparedness of instructors and the professional networking of future specialists. Developing the library in this direction ensures a holistic learning process, transforming students from passive recipients of knowledge into active creators. As a result, it enables the training of well-rounded specialists who are flexible in responding to changing market demands, possess critical thinking skills, and are capable of generating creative solutions. Thus, the advancement of the library environment represents one of the most promising avenues for the further development of STEM education.

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