Borneo Journal Of Medical Laboratory Technology
BJMLT
http://journal.umpalangkaraya.ac.id/index.php/bjmlt

# Improvement Of Quality and Quantity Of Technology-Based Learning in Pharmacy and Medical Laboratory Technology

## *Peningkatan Kualitas dan Kuantitas Pembelajaran Berbasis Teknologi pada Program Farmasi dan Teknologi Laboratorium Medis*

**Nurul Chusna** [1]
**Susi Novaryatiin** [1]
**Dwi Purbayanti** [2]
**Evi Mulyani** [1]
**Rinny Ardina** [2]
**Windya Nazmatur Rahmah** [2]
**Mohammad Rizki Fadhil Pratama** [1*]

[1] Department of Pharmacy, Universitas Muhammadiyah Palangkaraya, Palangka Raya, Indonesia

[2] Department of Medical Laboratory Technology, Universitas Muhammadiyah Palangkaraya, Palangka Raya, Indonesia

*email: mohammadrizkifadhilpratama@umpr.ac.id

***Keywords***:
*Medical Laboratory Technology, Pharmacy, Technology-based Learning*

***Abstract***

*The enhancement of technology-based learning in the fields of pharmacy and medical laboratory technology is imperative to keep pace with advancements in healthcare and educational methodologies. This study investigates the strategies and impacts of integrating cutting-edge technologies into the curricula of these disciplines. Key areas of focus include the implementation of virtual simulations, online learning platforms, and interactive multimedia resources. The research highlights how these technologies improve the quality of education by providing students with realistic, hands-on experiences that enhance their practical skills and theoretical knowledge. Additionally, the study explores the scalability and accessibility of technology-based learning, which contributes to increased student engagement and enrollment. By leveraging data analytics and feedback mechanisms, educators can tailor learning experiences to meet individual student needs, thereby improving learning outcomes. The findings suggest that the thoughtful integration of technology not only enriches the educational experience but also prepares students more effectively for the evolving demands of the healthcare industry. This research underscores the necessity of continuous investment in educational technologies to sustain the quality and quantity of learning in pharmacy and medical laboratory technology programs.*

## INTRODUCTION

The rapid advancement of technology has revolutionized education across various fields, including pharmacy and medical laboratory technology (MLT). Traditional teaching methods are increasingly being complemented or replaced by technology-based learning, also known as e-learning or digital learning. This shift involves the use of online platforms, virtual simulations, and multimedia resources to deliver content and facilitate learning. These tools provide students with flexible, accessible, and interactive educational experiences that are not confined by geographical or temporal limitations. By integrating technology into the curriculum, educational institutions aim to produce graduates who are well-equipped with the skills and knowledge required in the modern healthcare environment (Bahroun *et al*., 2023).

Technology-based learning offers numerous benefits that enhance educational outcomes in pharmacy and MLT. One of the most significant advantages is the ability to simulate real-life scenarios through virtual simulations and augmented reality. These technologies provide students with hands-on practice in a controlled, risk-free environment, allowing them to develop and refine their practical skills (Coyne *et al*., 2019). Additionally, online platforms and digital resources offer personalized learning experiences, enabling students to learn at their own pace and according to their individual needs. This personalized approach not

only improves understanding and retention of complex concepts but also increases student engagement and motivation. Furthermore, technology facilitates continuous assessment and feedback, helping educators identify areas where students need additional support and allowing for timely interventions (Das *et al.,* 2023). Despite the numerous benefits, the integration of technology-based learning in pharmacy and MLT education also presents several challenges. One of the primary obstacles is the digital divide, where unequal access to technology and the internet can hinder the learning experience for some students (Lorenzoni *et al*., 2019). Additionally, the effectiveness of e-learning heavily relies on the quality of the digital content and the educators' proficiency in using these technologies. There is also the challenge of maintaining the balance between virtual and hands-on practical experiences, which are crucial in medical education. Looking ahead, future directions for technology-based learning include the development of more sophisticated and immersive technologies, such as virtual and augmented reality, to further enhance the learning experience (Lewis *et al*., 2024). Continuous professional development for educators and investment in infrastructure are essential to overcome these challenges and fully realize the potential of technology-based learning in pharmacy and MLT education (McConnell *et al.,* 2010). Furthermore, this review article discusses the current landscape of technology-based learning, benefits of technology-based learning, challenges in implementing technology-based learning, and future directions and innovations related to technology-based learning in pharmacy and MLT.

## CURRENT LANDSCAPE OF TECHNOLOGY-BASED LEARNING

The current landscape of technology-based learning is marked by rapid innovation and widespread adoption across various educational fields, including pharmacy and MLT. With advancements in digital infrastructure, educational institutions are increasingly integrating virtual simulations, online platforms, and interactive multimedia into their curricula (Stoumpos *et al*., 2023). These tools provide students with immersive, hands-on experiences that closely mimic real-world scenarios, enhancing their practical skills and theoretical understanding. Virtual simulations, for instance, allow students to practice complex procedures in a risk-free environment, fostering proficiency and confidence before encountering actual clinical situations. Online platforms facilitate access to a vast array of resources, including video lectures, e-books, and collaborative tools, enabling flexible and personalized learning experiences (Coyne *et al*., 2021).

Moreover, the proliferation of mobile technology and high-speed internet has made education more accessible than ever before. Students from diverse geographical locations can now partake in high-quality learning experiences without the constraints of physical classrooms. This democratization of education is particularly significant in pharmacy and MLT, where continuous learning and up-to-date knowledge are critical (Bansal *et al*., 2024). Data analytics and machine learning algorithms further enhance technology-based learning by providing insights into student performance and learning patterns, allowing educators to tailor content and interventions to individual needs. Overall, the current landscape of technology-based learning is characterized by its dynamic, inclusive, and student-centric approach, paving the way for more effective and engaging educational experiences (Sharif & Atif, 2024). Technology-based learning in pharmacy and MLT includes various tools and methods such as:

***Online Courses and MOOCs***: Massive Open Online Courses (MOOCs) have revolutionized access to high-quality education in the fields of pharmacy and MLT. By offering courses from renowned institutions worldwide, MOOCs democratize learning, making advanced education accessible to a global audience. These online platforms provide a diverse range of

courses that cover fundamental concepts as well as specialized topics, allowing students to tailor their learning experiences to their career goals and interests. MOOCs facilitate self-paced learning, enabling students to manage their studies alongside professional and personal commitments. Furthermore, the interactive elements of these courses, such as discussion forums, peer assessments, and live sessions with instructors, foster a collaborative learning environment that enhances understanding and retention of complex material (Bettiol *et al*., 2022).

In addition to improving access to education, MOOCs in pharmacy and MLT contribute significantly to the professional development of practitioners in these fields. The continuous evolution of healthcare necessitates that professionals stay updated with the latest advancements and best practices. MOOCs offer an efficient and flexible way to achieve this, often providing certification that can bolster one's credentials and career prospects (Longhini *et al*., 2021). By utilizing multimedia resources, virtual laboratories, and real-world case studies, MOOCs simulate practical experiences that are crucial for mastering clinical and laboratory skills. This approach not only bridges the gap between theoretical knowledge and practical application but also prepares students and professionals to meet the rigorous demands of modern healthcare environments. Thus, MOOCs play a pivotal role in enhancing both the quality and quantity of education in pharmacy and MLT, ultimately leading to better healthcare outcomes (Sapriati *et al*., 2023).

***Virtual Simulations***: Virtual simulations have emerged as a transformative tool in pharmacy and MLT education, offering students the opportunity to gain practical experience in a controlled, risk-free environment. These virtual labs and simulations replicate real-world scenarios and procedures, allowing students to practice complex tasks such as compounding medications, conducting diagnostic tests, and interpreting lab results without the risk of causing harm or wasting resources (Potkonjak *et al*., 2016). The immersive nature of virtual simulations enables learners to repeat procedures multiple times, fostering a deeper understanding and mastery of skills that are critical in their professional fields. Furthermore, these simulations can be tailored to present a wide range of case studies and variable conditions, enhancing the students' ability to think critically and adapt to different clinical situations (Ke & Xu, 2020).

The integration of virtual simulations into the curriculum also addresses several logistical and financial challenges associated with traditional hands-on training. Physical labs often require significant investment in equipment, materials, and maintenance, while also being limited by space and time constraints. Virtual labs, on the other hand, offer a scalable and cost-effective solution, enabling institutions to accommodate larger cohorts of students without compromising on the quality of education. Additionally, the use of data analytics within these platforms provides educators with valuable insights into student performance, allowing for personalized feedback and targeted interventions to address learning gaps. As technology continues to advance, the fidelity and interactivity of virtual simulations are expected to improve, further bridging the gap between theoretical knowledge and practical application in pharmacy and MLT education (Asare *et al*., 2023).

***E-Textbooks and Online Resources***: The advent of e-textbooks and online resources has revolutionized the landscape of education in pharmacy and MLT. Digital textbooks offer a dynamic alternative to traditional print materials, providing students with interactive content, multimedia enhancements, and the ability to quickly search for specific information. These features enhance the learning experience by making complex concepts more accessible and engaging. Additionally, digital textbooks are continually updated, ensuring that

students have access to the latest advancements and research findings in their fields. This real-time updating capability is crucial in disciplines like pharmacy and MLT, where staying current with new drugs, technologies, and methodologies can significantly impact patient care and safety (Rockinson- Szapkiw *et al*., 2013).

Online resources, including journals and specialized databases, further complement e-textbooks by offering a vast repository of peer-reviewed articles, case studies, and clinical trial results. These resources enable students and professionals to delve deeper into specific areas of interest, supporting a more comprehensive understanding of their subjects. The accessibility of these online materials means that students can conduct research, complete assignments, and stay informed about emerging trends from anywhere with an internet connection (Masic & Milinovic, 2012). Moreover, the integration of online resources into the curriculum fosters a culture of continuous learning and professional development, as learners become adept at navigating and utilizing these tools throughout their careers. Ultimately, the incorporation of e-textbooks and online resources in pharmacy and MLT education enhances both the quality and quantity of information available to students, preparing them for the dynamic and ever-evolving nature of the healthcare industry (Desmukh & Paliwal, 2024).

***Learning Management Systems (LMS)***: Learning Management Systems (LMS) such as Blackboard, Moodle, and Canvas play a pivotal role in enhancing the educational landscape of pharmacy and MLT programs. These platforms serve as comprehensive hubs for managing course content, tracking student progress, and facilitating seamless communication between students and educators. In pharmacy and MLT education, LMS platforms streamline the distribution of lecture materials, assignments, and resources, ensuring that students have consistent access to essential information. They also support the integration of interactive elements like quizzes, simulations, and virtual labs, which are crucial for developing the practical skills required in these fields (Kasabova *et al*., 2023).

Furthermore, LMS platforms enable educators to monitor student performance through advanced analytics, allowing for timely interventions and personalized feedback. This data-driven approach helps identify areas where students may struggle, enabling targeted support to improve learning outcomes. Communication tools within LMS, such as discussion forums, messaging systems, and video conferencing, foster a collaborative learning environment. These features are particularly beneficial for pharmacy and MLT students, who often need to engage in complex, interdisciplinary discussions and teamwork (Hernández-de-Menéndez *et al*., 2022).

By leveraging the capabilities of LMS platforms, educators can create more dynamic and flexible learning experiences. The adaptability of these systems allows for the incorporation of up-to-date information and real-time updates, keeping course content relevant and aligned with the latest industry standards. Overall, the integration of LMS in pharmacy and MLT education not only enhances the quality of learning but also ensures that students are well-prepared to meet the evolving challenges of the healthcare sector (Plch, 2020).

***Mobile Learning***: The landscape of healthcare education is undergoing a significant transformation with the rise of mobile learning. This innovative approach leverages the ubiquitous presence of smartphones and tablets to deliver educational content and facilitate knowledge acquisition anytime, anywhere (Alam & Mohanty, 2023). In the fields of pharmacy and MLT, mobile learning presents a wealth of opportunities. For pharmacy students and professionals, mobile apps can provide on-demand access to drug compendia, medication interaction

checkers, and clinical practice guidelines. Similarly, MLT students can utilize mobile learning platforms to access virtual lab simulations, practice interpreting diagnostic tests, and stay updated on evolving laboratory procedures. This portability and flexibility empower both pharmacy and MLT learners to become self-directed, lifelong learners, ultimately leading to improved patient care and a more knowledgeable healthcare workforce (Kho *et al*., 2022). However, challenges such as ensuring app quality, optimizing screen size for complex information, and addressing potential privacy concerns need to be addressed to fully harness the potential of mobile learning in these vital fields.

## BENEFITS OF TECHNOLOGY-BASED LEARNING

The traditional classroom setting in Pharmacy and MLT education is undergoing a significant transformation due to the integration of technology. This shift offers a multitude of benefits for both students and educators. Technology-based learning platforms can enhance the educational experience by providing interactive simulations, 3D visualizations of complex biological processes, and access to vast online databases of medical information. This fosters a deeper understanding of scientific concepts and allows students to practice procedures in a safe, virtual environment (Alhur *et al*., 2023). Furthermore, technology streamlines information delivery, enabling educators to personalize learning through adaptive learning tools and readily update curriculum content to reflect the latest advancements in these rapidly evolving fields. As a result, the integration of technology empowers students to become more engaged, self-directed learners while preparing them for the technologically advanced healthcare landscape they will encounter in their professional careers (Contrino *et al*., 2024).

***Accessibility and Flexibility***: Students can access learning materials anytime and anywhere, accommodating different learning paces and schedules. Interactive Learning: Technology enhances engagement through interactive modules, quizzes, and multimedia content, making learning more effective and enjoyable.

***Personalized Learning***: Adaptive learning technologies tailor educational experiences to individual student needs, improving comprehension and retention.

***Practical Skills Development***: Virtual simulations and augmented reality (AR) provide hands-on experience, essential for fields like pharmacy and MLT.

***Collaborative Learning***: Online forums, social media, and collaborative tools foster communication and teamwork among students and educators globally.

## CHALLENGES IN IMPLEMENTING TECHNOLOGY-BASED LEARNING

Despite the undeniable advantages technology offers in education, its implementation in pharmacy and MLT programs faces distinct challenges. While technology can enhance learning by providing interactive simulations, gamified experiences, and readily-available resources, ensuring its effectiveness requires careful consideration. The specific needs of these fields, where practical skills and a deep understanding of complex scientific concepts are paramount, necessitate a thoughtful integration of technology that complements, rather than replaces, traditional hands-on training and expert faculty guidance (Babatunde *et al*., 2023). This highlights the potential of technology-based learning while acknowledging the challenges specific to pharmacy and MLT education:

***Technical Issues***: Dependence on technology can lead to problems such as software glitches, connectivity issues, and hardware failures.

***Digital Divide***: Not all students have equal access to technology and the internet, leading to disparities in learning opportunities.

***Quality Control***: Ensuring the quality and accuracy of online content can be difficult, requiring rigorous standards and regular updates.

***Instructor Training***: Educators need training and support to effectively use technology in their teaching practices.

***Student Engagement***: Keeping students motivated and engaged in a virtual environment can be challenging, especially for practical and laboratory-based subjects.

## FUTURE DIRECTIONS AND INNOVATIONS

The future of technology-based learning in pharmacy and MLT is brimming with promise. Several emerging trends and innovations hold the potential to revolutionize how these vital healthcare professionals acquire and retain knowledge. We can expect to see a rise in immersive learning experiences like virtual reality simulations that mimic real-world scenarios (Coyne *et al*., 2019). Additionally, advancements in artificial intelligence (AI) could personalize learning pathways, tailoring content and delivery methods to individual student needs. Furthermore, the expanding realm of big data offers exciting possibilities for creating adaptive learning platforms that continuously assess student progress and adjust the learning journey accordingly (Gligorea *et al*., 2023). By embracing these advancements and fostering a culture of continuous learning, the future of pharmacy and MLT education looks set to be more engaging, effective, and accessible than ever before:

***Artificial Intelligence (AI) and Machine Learning***: AI can provide personalized learning experiences, predictive analytics for student performance, and automated grading systems.

***Virtual and Augmented Reality (VR/AR)***: VR and AR technologies can create immersive learning environments, simulating real-world scenarios for practical training.

***Blockchain Technology***: Blockchain can enhance the security and verifiability of academic credentials and certifications.

***Gamification***: Incorporating game elements into learning can increase engagement and motivation, making education more enjoyable.

***Telemedicine and Remote Labs***: Advances in telemedicine and remote laboratory technology allow students to participate in practical training and internships virtually.

## CONCLUSION

Technology-based learning has significantly transformed education in pharmacy and MLT, offering numerous benefits such as enhanced accessibility, personalized learning, and improved practical skills development. However, challenges such as technical issues, the digital divide, and ensuring quality control must be addressed to fully realize its potential. With ongoing innovations and a focus on overcoming these challenges, technology-based learning is poised to play an increasingly vital role in the education of future healthcare professionals.

## REFERENCES

Alam, A. & Mohanty, A. (2023). Educational technology: Exploring the convergence of technology and pedagogy through mobility, interactivity, AI, and learning tools. *Cogent Engineering*, **10**(2), 2283282. https://doi.org/10.1080/23311916.2023.2283282

Alhur, A., Hedesh, R., Alshehri, M., Al Qasim, S., Alkhaldi, R., Bazuhair, W., Shamlan, W.B., Alshahrani, S., Alshahrani, S., Alasiri, A., Alshalwi, R., Alnefaie, S., Alotaibi, R., Aljehani, R.K. & Alzahrani, L. (2023). Incorporating Technology in Pharmacy Education: Students' Preferences and Learning Outcomes. *Cureus*, **15**(12), e50158. http://dx.doi.org/10.7759/cureus.50158

Asare, S., Amoako, S.K., Biilah, D.K., & Apraku, T.B. (2023). The Use of Virtual Labs in Science Education: A Comparative Study of Traditional Labs and Virtual Environments. *International Journal of Science Academic Research*, **4**(11), 6563-6569.

Babatunde, Y., Adegbite, M.A., Oladipo, H.J., Omojuyigbe, J.O., Sampson-Oladipupo, E., Ibrahim, A.A., Oziama, B., Adedeji, O., & Ibrahim, A.D. (2023). Augmented reality and gamification in pharmacy education: A call for implementation in African countries and other low resource settings. *Pharmacy Education*, **23**(1), 7-17. https://doi.org/10.46542/pe.2023.231.717

Bahroum, Z., Anane, C., Ahmed, V., & Zacca, A. (2023). Transforming Education: A Comprehensive Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis. *Sustainability*, **15**(17), 12983. https://doi.org/10.3390/su151712983

Bansal, S.K., Sharma, R.K., Jain, R.K., Chaturvedi, V., & Sharma, A. (2024). Significance and Advancement of the Educational Technology: Holistic Development of Learners in the Digital Age. *Educational Administration: Theory and Practice*, **30**(5), 6088-6095.

Bettiol, S., Psereckis, R., & MacIntyre, K. (2022). A perspective of massive open online courses (MOOCs) and public health. *Frontiers in Public Health*, **10**, 1058383. https://doi.org/10.3389/fpubh.2022.1058383

Contrino, M.F., Reyes-Millán, M., Vázquez-Villegas, P., & Membrillo-Hernández, J. (2024). Using an adaptive learning tool to improve student performance and satisfaction in online and face-to-face education for a more personalized approach. *Smart Learning Environments*, **11**, 6. https://doi.org/10.1186/s40561-024-00292-y

Coyne, L., Merritt, T.A., Parmentier, B.L., Sharpton, R.A., & Takemoto, J.K. (2019). The Past, Present, and Future of Virtual Reality in Pharmacy Education. *American Journal of Pharmaceutical Education*, **83**(3), 7456. https://doi.org/10.5688/ajpe7456

Coyne, E., Calleja, P., Forster, E., & Lin, F. (2021). A review of virtual-simulation for assessing healthcare students' clinical competency. *Nurse Education Today*, **96**(5), 104623. https://doi.org/10.1016/j.nedt.2020.104623

Das, A., Malaviya, S., & Singh, M. (2023). The Impact of AI-Driven Personalization on Learners' Performance. *International Journal of Computer Sciences and Engineering*, **11**(8), 15-22. http://dx.doi.org/10.26438/ijcse/v11i8.1522

Desmukh, P. & Paliwal, S. (2024). Pharmacy education 2.0 with special reference to digital India. *Multidisciplinary Business Review*, **7**(4), 2024065. https://doi.org/10.31893/multirev.2024065

Gligorea, I., Cioca, M., Oancea, R., Gorski, A.T., Gorski, H., & Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. *Education Sciences*, **13**(12), 1216. https://doi.org/10.3390/educsci13121216

Hernández-de-Menéndez, M., Morales-Menendez, R., Escobar, C.A., & Mendoza, R.A.R. (2022). Learning analytics: state of the art. *International Journal on Interactive Design and Manufacturing*, **16**(3), 1209-1230. https://doi.org/10.1007/s12008-022-00930-0

Kasabova, G., Parusheva, S., & Bankov, B. (2023). Learning Management Systems as a Tool for Learning in Higher Education. *Izvestia Journal of the Union of Scientists - Varna Economic Sciences Series*, **12**(2), 224-233. https://doi.org/10.56065/IJUSV-ESS/2023.12.2.224

Ke, F. & Xu, X. (2020). Virtual reality simulation-based learning of teaching with alternative perspectives taking. *British Journal of Educational Technology*, **51**(6), 2544-2557. https://doi.org/10.1111/bjet.12936

Kho, B.P., Wong, S.M.A., Chiu, J.W.T., & Liew, E. (2022). Preference and usage pattern of mobile medical apps for drug information purposes among hospital pharmacists in Sarawak, Malaysia. *BMC Medical Informatics and Decision Making*, **22**(1), 199. https://doi.org/10.1186/s12911-022-01949-9

Lewis, K.O., Popov, V., & Fatima, S.S. (2024). From static web to metaverse: reinventing medical education in the post-pandemic era. *Annals of Medicine*, **56**(1), 2305694. https://doi.org/10.1080/07853890.2024.2305694

Longhini, J., Rossettini, G., & Palese, A. (2021). Massive open online courses for nurses' and healthcare professionals' continuous education: a scoping review. *International Nursing Review*, **68**(1), 108-121. https://doi.org/10.1111/inr.12649

Lorenzoni, A.A., Manzini, F., Soares, L., & Leite, S. (2019). E-learning in Pharmacy Education: what do we know about it? *Brazilian Journal of Pharmaceutical Sciences*, **55**(66), e18100. http://dx.doi.org/10.1590/s2175-979020190000118100

Masic, I. & Milinovic, K. (2012). On-line biomedical databases-the best source for quick search of the scientific information in the biomedicine. *Acta Informatica Medica*, **20**(2), 72-84. https://doi.org/10.5455/aim.2012.20.72-84

McConnell, K.J., Newlon, C.L., & Delate, T. (2010). The impact of continuing professional development versus traditional continuing pharmacy education on pharmacy practice. *Annals of Pharmacotherapy*, **44**(10), 1585-1595. https://doi.org/10.1345/aph.1p161

Plch, L. (2020). Perception of Technology-Enhanced Learning by Medical Students: an Integrative Review. *Medical Science Educator*, **30**(4), 1707-1720. https://doi.org/10.1007/s40670-020-01040-w

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrovic, V.M., & Jovanovic, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers & Education*, **95**, 309-327. https://doi.org/10.1016/j.compedu.2016.02.002

Rockinson- Szapkiw, A.J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education*, **63**, 259-266. https://doi.org/10.1016/j.compedu.2012.11.022

Sapriati, A., Suhandoko, A.D.J., Yundayani, A., Karim, R.A., Kusmawan, U., Adnan, A.H.M., & Suhandoko, A.A. (2023). The Effect of Virtual Laboratories on Improving Students' SRL: An Umbrella Systematic Review. *Education Sciences*, **13**(3), 222. https://doi.org/10.3390/educsci13030222

Sharif, H. & Atif, A. (2024). The Evolving Classroom: How Learning Analytics Is Shaping the Future of Education and Feedback Mechanisms. **14**(2), 176. https://doi.org/10.3390/educsci14020176

Stoumpos, A.I., Kitsios, F., & Talias, M.A. (2023). Digital Transformation in Healthcare: Technology Acceptance and Its Applications. *International Journal of Environmental Research and Public Health*, **20**(4), 3407. https://doi.org/10.3390/ijerph20043407