OPEN ACCESS
Jurnal Ilmiah Ilmu Terapan Universitas Jambi
Vol. 9 No. 1. March 2025, pp. 144-160 DOI. 10.22437/jiituj.v9i1.37967
Research Article

ENHANCING LEARNING EFFECTIVENESS THROUGH ADAPTIVE LEARNING PLATFORMS AND EMERGING COMPUTER TECHNOLOGIES IN EDUCATION

Rapiia Isaeva[1,*], Nazgul Karasartova[2], Kalyibubu Dznunusnalieva[3], Kabira Mirzoeva[4], Mykola Mokliuk[5]

[1] Department of Physics and Natural Science Teaching Technology, Jusup Balasagyn Kyrgyz National University, Bishkek, Kyrgyz Republic
[2] Department of Physics and Technology of Its Education, Kyrgyz State University named after Ishenaly Arabaev, Bishkek, Kyrgyz Republic
[3] Institute of Additional Professional Education, Kyrgyz State University named after Ishenaly Arabaev, Bishkek, Kyrgyz Republic
[4] Department of Computer Science, Azerbaijan State Pedagogical University, Baku, Azerbaijan
[5] Department of Physics and Methods of Teaching of Physics, Astronomy, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Vinnytsia, Ukraine
Corresponding author email: isaevarapiya@gmail.com

Article Info
Received: Oct 24, 2024
Revised: Dec 17, 2024
Accepted: Feb 10, 2025
OnlineVersion: Feb 16, 2025

Abstract
The integration of adaptive learning platforms and emerging computer technologies has transformed education by personalizing learning experiences and increasing accessibility. However, challenges such as uneven access, inadequate teacher training, and technical limitations hinder their full potential. This study examines the impact of major educational platforms (Coursera, Khan Academy, edX) and adaptive technologies on the learning process, aiming to assess their effectiveness in diverse educational contexts. A mixed-methods approach was employed, combining qualitative content analysis of educational platforms such as Coursera, Khan Academy, and edX with quantitative assessment of their features, engagement levels, and effectiveness. The study analyzed data from educational institutions in Kyrgyzstan, Ukraine, and Azerbaijan, focusing on the role of analytics, interactive elements, and gamification in enhancing learning outcomes. Findings indicate that adaptive platforms enhance accessibility and flexibility in learning while offering real-time analytics for personalized feedback. Virtual labs, such as those utilizing the Quanser QNET DC Motor Control Board, demonstrated the feasibility of remote practical training. However, successful implementation depends on comprehensive planning, infrastructure readiness, and continuous professional development for educators. The study contributes to understanding the role of adaptive learning in addressing educational disparities. It highlights the necessity of institutional support and teacher training for the effective use of these technologies. Novel insights include the potential of integrating AI-driven analytics to optimize personalized learning experiences. Future research should explore long-term impacts on student engagement and academic performance, particularly in under-resourced educational settings.

Keywords: Educational Resources, Gamification, Interactive Elements, Learning Materials, Online Platforms

INTRODUCTION

Computer technologies play a pivotal role in transforming the educational process today. Online platforms such as Coursera, Khan Academy, and edX provide students with access to learning materials at their convenience and in flexible formats. However, the integration of these technologies into educational programs faces numerous challenges. Kukul (2023) highlights the importance of teacher training for the effective utilization of digital technologies, emphasizing that training programs must focus on both technical skills and the enhancement of pedagogical approaches. The study demonstrates that proper teacher preparation fosters a greater willingness to adopt technologies and facilitates their successful implementation.

The urgency of addressing these challenges is underscored by the rapid expansion of educational technology alongside persistent inequities in access and implementation. The COVID-19 pandemic brought this issue to the forefront, as over 1.6 billion students worldwide were affected by school closures in 2020, highlighting the critical need for robust and equitable online learning systems (UNESCO, 2021). In addition to teacher preparation, adapting educational technologies to the individual needs of students remains a crucial aspect. Underscore the significance of adaptive systems powered by artificial intelligence and machine learning in enhancing the learning process (Kaur et al., 2023; Essenzi, 2024; H & Saitakham, 2024; Yusipa, 2024). Their comprehensive review reveals that such systems support personalized learning by offering tailored recommendations based on student data analysis. This approach effectively addresses knowledge gaps and boosts student motivation. However, the authors also highlight the need for strategies to tackle issues related to unequal access to digital technologies.

The main problem is the uneven access to computer technology, insufficient teacher training and lack of adaptive techniques, which limits the effectiveness of their introduction into educational programmes. Voropayeva et al. (2022) studied the European experience of introducing innovative educational technologies in the training of managerial specialists. The results showed that the use of modern technologies significantly improves the quality of training, increases the competitiveness of graduates and educational institutions. The results of the study by Kovalchuk and Sheludko (2019) showed that digital technologies help modernize professional education by improving teachers' training and their ability to use modern educational tools. Gaps that require further investigation include training teachers to use innovative technologies and developing professional development programmes.

The problem identified in the study area is that current methods of introducing computer technology into educational programmes often do not take into account the diversity of educational contexts and the individual needs of students. Turaeva (2021) studied the improvement of the effectiveness of the educational process using computer technologies. Her study showed that such technologies improve learning outcomes and student engagement. Qureshi et al. (2021) concluded in their study that digital technologies can indeed enhance learning by improving access to educational resources and promoting individualized approach. The evaluation and monitoring of the actual results and benefits of the implementation of technology in the educational process requires further additional research.

Another of the current problems in this area is the insufficient integration of computer technology into educational processes. Sharlovych et al. (2023) found that digital technologies can significantly improve the learning process in higher education, but this requires the right implementation and support strategies, as well as overcoming the challenges of adapting and integrating technologies into educational programmes. Debeer et al. (2021) demonstrated that adaptive digital technologies based on educational game data can enhance learning by improving personalization of the learning experience and student engagement. The development of effective strategies for integrating computer technology into educational programmes and methods for assessing its long-term impact on learning and outcomes requires further study.

Another issue that requires further research is the development of methods for the effective use of digital technologies in different educational contexts. Haleem et al. (2022) found that successful implementation of technology requires careful planning and support, as well as training of teachers and students to use these tools effectively. A study by Lacka et al. (2021) found that digital technologies, including virtual learning environments and social media, can enhance student performance by providing access to interactive resources and supporting collaboration. The ethical and technical aspects of using computer technology in education, including issues of privacy and data security, require further consideration.

Despite numerous studies emphasizing the potential of computer technologies to transform education, significant gaps remain. Specifically, research on the adaptation of these technologies to diverse educational contexts and the long-term impacts on learning outcomes is limited. Furthermore, there is insufficient focus on developing comprehensive strategies to overcome barriers such as unequal access, lack of teacher training, and the need for adaptive learning tools. This study aims to bridge these gaps by examining the effectiveness of various platforms and strategies for integrating these technologies into educational programmes.

The aim of the work was to investigate the impact of online platforms and modern technologies on the learning process and to study the actual methods of their implementation in educational programmes. Within the framework of this goal, the following tasks were set: 1. Analysing the impact of platforms such as Coursera, Khan Academy and edX on access to educational resources and increased learning flexibility; 2. Exploring the use of adaptive platforms and analytical tools to personalize learning and track student progress; 3. Evaluating the role of interactive elements such as virtual labs and animations in increasing engagement and understanding of the learning material.

RESEARCH METHOD

The study employed a mixed-methods approach to examine the integration and impact of computer technologies in education. This entailed a combination of qualitative analyses of online platforms with quantitative assessments of their features and outcomes. The data collection process commenced with an exhaustive examination of prominent educational platforms, including Coursera, Khan Academy, edX, and MIT OpenCourseWare (OCW). The platforms were selected based on their usage statistics and recognition within the global discourse on education. Information was gathered from a variety of sources, including official platform websites, documentation, and analytics reports, as well as secondary sources such as educational technology reviews and user feedback. The data set comprised a range of platform characteristics, including the founding date, number of users, target audience, and course offerings. It also included details about the analytical tools employed to track student progress. The efficacy of these tools in monitoring test scores, assignment completion, discussion participation, and time spent studying materials was evaluated. The methods used by the platforms to provide feedback to students and instructors were also examined in order to evaluate their impact on learning outcomes.

The analysis employed a combination of qualitative and quantitative methods, allowing for a comprehensive examination of the subject matter. A thematic content analysis was conducted to evaluate the efficacy of multimedia materials, including videos and animations, in facilitating comprehension and engagement with abstract concepts. The analysis was conducted in accordance with established educational technology frameworks, thereby ensuring a systematic assessment of the resources in question against a range of pedagogical objectives, including the enhancement of comprehension and the accommodation of diverse learning styles. The quantitative analysis employed descriptive statistics to evaluate adaptive learning platforms, focusing on key metrics such as course completion rates and user engagement. Furthermore, the study examined the deployment of adaptive learning platforms that employ machine learning and artificial intelligence algorithms to analyse student data and construct personalised learning pathways. The evaluation of these platforms was conducted in order to ascertain their capacity to adapt the pace and content of learning in accordance with the specific requirements of individual students, to provide real-time feedback, and to recommend areas for improvement.

The research further examined the utilisation of computer modelling and simulations in the field of education, with a particular emphasis on their deployment and efficacy in facilitating the integration of theoretical knowledge with practical skills. The Quanser QNET DC Motor Control Board was subjected to analysis in order to ascertain its suitability for integration into remote laboratories and its

capacity to facilitate hands-on learning in a virtual environment. The implementation of these technologies presents a number of challenges, including the necessity to consider software and hardware requirements, as well as the level of institutional readiness. These issues were explored through case studies of educational institutions in Kyrgyzstan, Ukraine, and Azerbaijan. The study addressed ethical considerations at all stages, with exclusively publicly available data being used and compliance with the data usage policies of the reviewed platforms ensured. No personally identifiable information was collected or analysed. The study was based on established research methodologies for the evaluation of educational technology, including frameworks for systematic review and adaptive learning strategies. The tools and metrics employed for the assessment of the platforms were adapted from the established guidelines in the field, thus ensuring the replicability and scholarly rigour of the findings.

RESULTS AND DISCUSSION

Increased access to learning materials and resources through online platforms is fundamentally changing the educational landscape, providing students with unique opportunities to learn at a convenient time and in a convenient format. These platforms play a key role in education by offering access to a wide range of learning materials that include text-based resources, video lectures, interactive assignments and practical exercises. Platforms such as Coursera, Khan Academy and edX regularly update their resources to keep students up-to-date with the latest developments and trends in various fields of study. Coursera stands out by providing courses from leading universities and organizations around the world. The platform includes both free and paid courses, as well as special programmes and certificates. This gives students the opportunity to gain qualifications and develop skills that are in demand in the labour market (Esen et al., 2022; Anggraeni, Rassy, & Sereesuchat, 2023; Romadhonsyah, 2024; Sriyono, 2024). Coursera works in partnership with universities and corporate partners to offer courses on the most relevant and in-demand topics, from technology and business to humanities and social studies. Coursera has more than 100 million registered users as of 2024. The platform offers more than 5,000 courses, certificate programmes and specializations and has a completion rate of around 40% (referring to the percentage of enrolled students who complete their courses). Student feedback is generally positive, especially for courses in programming and business.

Khan Academy is known for its emphasis on providing free learning materials in a wide range of subjects. The platform covers all levels of education, from primary school to college, offering resources in subjects such as maths, science, history, and art (Helida, Ching, & Oyewo, 2023; Maymunah, Ramorola, & Shobowale, 2023; Tang et al., 2023). Interactive assignments and self-testing tests help students consolidate knowledge and track their progress. Khan Academy also provides special features for teachers and parents to support and track student progress. Khan Academy serves more than 100 million students and teachers worldwide. The platform provides access to thousands of lessons and interactive assignments and while completion rates vary, students cite the accessibility of materials and interactive approach as strengths of the platform. Khan Academy is also praised for being free and affordable. edX presents courses from prestigious universities and organizations such as Harvard, MIT and other leading educational institutions. The platform offers both free courses and paid programmes with certificate and diploma options. edX focuses on providing high-quality education that meets international standards (Rai, 2019; Hardyanti, Lateef, & Abbas, 2023; Huda, Girei, & Keizi, 2023). Courses cover a wide range of topics including technology, engineering, business, law, and medicine, allowing students to deepen their knowledge in various fields and prepare for professional challenges. edX has over 40 million users. The platform offers more than 3,000 courses and programmes from universities and organizations, and the completion rate is around 30% (indicating the proportion of enrolled students who complete the courses). Students are positive about the high quality of the materials and the possibility of obtaining certificates from prestigious universities. The ability to study anytime and from anywhere gives students the freedom to tailor the learning experience to their individual needs and schedule. This flexibility allows students to learn at their own pace, fostering a deeper understanding of the material and improved learning outcomes. The variety of learning material formats helps cater for different learning styles and preferences, providing a more personalized approach to education.

Figure 1 presents a comparative analysis of key statistics for major educational platforms, highlighting the number of registered users and course completion rates for Coursera, Khan Academy, and edX.

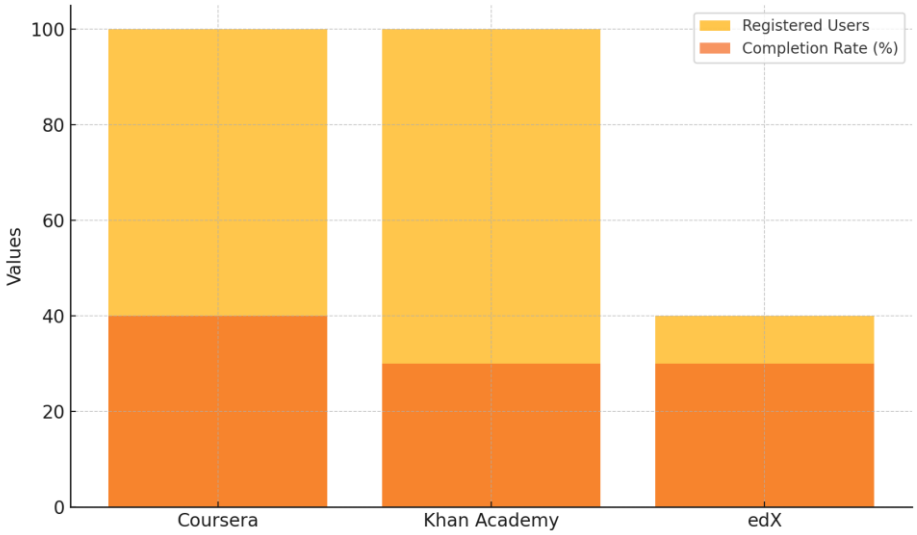

Figure 1. Comparison of educational Platforms

Source: compiled by the authors based on Esen et al. (2022), Tang et al. (2023) and Rai (2019).

The Figure 1 demonstrates the significant outreach of Coursera and Khan Academy, each serving approximately 100 million registered users, compared to edX's 40 million users. Despite their extensive reach, the completion rates remain modest, with Coursera achieving the highest at 40%. These data emphasize the ongoing challenge of student retention and course completion across all platforms.

Another significant development is the ability to access educational resources from anywhere in the world, which is a significant advantage for global education. Online platforms and digital resources offer students from remote or underserved regions a unique opportunity to receive education without leaving their region. This dramatically changes the landscape by allowing educational content to be available where traditional educational institutions may not be available or may be limited. Previously, students from remote or developing regions faced great difficulty in getting a quality education. The limited number of institutions, lack of qualified teachers and lack of educational resources were often major barriers. Today, however, they can register on international platforms such as edX and OCW, which offer courses and programmes from the world's leading universities and organizations. OCW is another important resource that offers free access to MIT educational materials. The platform includes lectures, textbooks, labs, and exams in a multitude of disciplines (Christiansen & McNally, 2022; Fakhroni & Puotier, 2023; Fitriah, Akorede, & Agyei, 2023). Students and self-study professionals can use these resources for in-depth study of topics of interest to them and to develop professional skills, greatly enhancing their career opportunities. OCW provides access to educational materials from one of the world's leading universities, MIT. As of 2024, the platform has more than 50 million unique users worldwide. OCW offers more than 2,500 courses, including lectures, textbooks, labs, and exams. Accurate course completion data is difficult to track as the platform is geared towards self-education, but users are free to study the materials at their own pace. User feedback emphasizes the high level of quality of educational materials and the value of accessing MIT content at no financial cost.

It is also relevant to look at successful examples of introducing interactive platforms into teaching programmes in countries such as Kyrgyzstan, Ukraine, and Azerbaijan. Jusup Balasagyn Kyrgyz National University and Kyrgyz State University named after Ishenaly Arabaev are actively using Coursera, and Moodle platforms in training future physics teachers and for the professional development of teachers and students. For example, universities in Kyrgyzstan have started to use online courses for the professional development of teachers and the training of students. This is confirmed by various educational and news resources, which note that the Coursera platform has become an essential tool for educational institutions in the country. In this direction, a vivid example is the experience of Jusup Balasagyn Kyrgyz National University and Kyrgyz State University named after Ishenaly Arabaev, where they actively use the Coursera platform, Moodle for the professional development of teachers (Wardani, Fantaye & Ade, 2023; Isaeva et al., 2024). At the Faculty of Physics and Technology of the Kyrgyz State University named after Ishenaly Arabaev in the direction 550200 Physics and Mathematics Education, students are familiarized with new innovative technologies and Internet resources through the following disciplines: "Information and Communication Technologies in

Education", "Innovative Processes in Education" (at master's level) (Karasartova & Nogaev, 2020). For example, the Institute of Additional Professional Education (Teacher Development) of Kyrgyz State University named after Ishenaly Arabaev widely uses the following resources for digital teaching of geography at school: Mozaik, Miro Interactive Whiteboard, Obs Projec, Sanva, Kahoot, and Learnis (Junushalieva, 2023).

Taras Shevchenko National University of Kyiv is introducing interactive platforms such as edX and Coursera into the curriculum. This is also supported by reports of Ukrainian universities collaborating with international educational platforms to improve the quality of education and provide students with access to international educational resources. Baku State University utilizes resources such as Khan Academy to support the educational process. Platforms such as Khan Academy are often used by universities in Azerbaijan for additional learning and self-testing, as evidenced by various educational initiatives in the country. These examples show how online platforms help universities in different countries to improve the quality of education by providing access to international educational resources and supporting a flexible approach to learning. The increased accessibility to educational materials is also an important aspect. The ability to use smartphones, tablets, and other mobile devices for learning allows students to interact with learning content anytime and anywhere. This greatly increases the flexibility of the educational process, allowing students to integrate learning into their daily lives. For example, a student working full-time can use travelling or waiting time to learn new topics and complete assignments. This accessibility is especially helpful for students who cannot regularly attend traditional educational institutions due to limited resources or other obstacles. Online education makes the learning process more inclusive and democratic, reducing barriers to accessing quality learning and allowing students around the world to develop their skills and knowledge on a level playing field.

Personalizing learning is an essential step in improving the educational process, and the introduction of adaptive learning platforms is a key component of this strategy. Adaptive learning platforms are specifically designed to adapt to the knowledge level and individual needs of students, providing a more personalized approach to learning. Such platforms use advanced algorithms and technologies such as machine learning and artificial intelligence to analyse student data. Based on the information gathered about previous successes, preferences and current knowledge, the platform can tailor learning content and assignments to match the individual student's level of expertise. This avoids situations where students are faced with overly complex or, on the contrary, too simple materials, which can have a negative impact on motivation and learning outcomes. Adaptive platforms can offer different levels of difficulty of tasks and exercises, provide additional explanations and resources in areas where the student is struggling, and offer accelerated or slowed courses depending on the pace of learning (Srinivasa et al., 2022; Sukamdi, Lepik, & Denkovski, 2023; Arianti et al., 2024; Yanuar & Festiyed, 2024). For example, if a student demonstrates a high level of understanding of a particular topic, the platform can accelerate to more difficult topics. If learning is difficult, the system can suggest additional resources or repetition of topics to reinforce knowledge. In addition, adaptive platforms can include features to monitor student progress in real-time, providing instructors and students with detailed reports on achievements and problem areas. These reports can be used to adjust the curriculum and personalized recommendations, making the educational process more focused and effective.

Using analytics to provide personalized recommendations and progress tracking is a key element of the modern approach to personalizing learning. Analytics tools and technologies play an important role in creating more customized and effective learning processes. Analytics enables the collection and analysis of data about student behaviour, performance, and interaction with learning content. This data can include information on which topics are causing the most difficulty, which assignments are being completed faster, and which ones require extra time and effort. Analytical tools can be used to track how often a student asks for help, how well they do on tests and assignments, and identify their strengths and weaknesses (Triscova, Sudaryono, & Ekawarna, 2023; Ihnatenko et al., 2024). Based on the analysis of this data, the platform can provide individual recommendations for each student. For example, if the system notices that a student is struggling in a particular area, it can suggest additional resources such as supplementary materials, practice assignments, or video lessons specifically designed to improve understanding of that topic. Additional courses or specialized modules may also be offered to help reinforce knowledge in problem areas. In addition, analytics allows teachers and educational institutions to track student progress in real time. This makes it possible to identify problems in a timely manner and take action to correct them. For example, educators can receive reports

on which students are falling behind in certain subjects and offer them additional counselling or assistance. These reports can also be used to adjust curriculum and teaching methods to better meet student needs. Analytics tools can also include features to monitor long-term trends and student success. They allow educational institutions to evaluate the effectiveness of different teaching methods, analyse how changes in the curriculum affect student performance, and make informed decisions to improve the educational process (Diachuk, 2024). Thus, the use of analytics to provide individualized guidance and progress tracking significantly improves the educational process, making it more personalized and tailored to the needs of each student. This helps to increase learning motivation, improve learning outcomes, and create a more effective educational experience.

The integration of interactive and gamified elements into the educational process significantly increases student motivation and engagement (Chans & Castro, 2021; Agni, Febriawan, & Zainal, 2024; Baah, Konovalov, & Tenzin, 2024). These elements provide new ways to interact with the learning material, making the learning process more exciting and engaging. Interactive elements include various forms of activity that allow students to directly participate in the learning process. These can include interactive assignments, virtual labs, simulations, and educational games. For example, interactive assignments allow students to put their knowledge into practice by solving problems that require active participation and critical thinking. Virtual labs and simulations allow students to conduct experiments and explore concepts in a safe and controlled environment, which enhances comprehension and recall. Gamification, in turn, involves the use of game elements and mechanisms in an educational context. This can include points, levels, badges, leaderboards, and other game-like aspects that encourage students to actively participate and strive for achievement. For example, a points and badge system for completing tasks and achieving certain goals creates an element of competition and reward that can greatly increase student interest and motivation. Leaderboards that display students' successes in comparison to their peers can also stimulate the desire to improve their performance and participate more actively in the learning process.

Interactive and gamified elements help to create a more dynamic and interesting learning environment. They make learning less monotonous and more adaptable to different styles and preferences of students. These elements allow students to receive immediate feedback, which helps them quickly correct mistakes and improve their skills. In addition, such elements can help develop important skills such as teamwork, strategic thinking, and problem-solving. Interactive assignments and gamified activities often require collaboration and coordination, which helps students develop communication and teamwork skills. The use of multimedia materials, such as videos and animations, is an effective way to improve understanding of complex concepts and enrich the educational process (Anggraeni et al., 2019). These materials allow information to be visualized and demonstrated, which makes complex topics much easier to grasp and promotes deeper learning. Video, as a multimedia tool, provides an opportunity to present information in a dynamic and visualized format. Through video lessons and lectures, teachers can explain complex topics, use real-life examples and demonstrate practical applications of theoretical knowledge. Video can also include interviews with experts, historical records, documentaries and other resources that make learning more diverse and interactive. This helps students not only to see how theory is applied in practice, but also to better understand the context and relevance of the material being learnt.

Animations, in turn, are a powerful tool for visualizing abstract or complex concepts. They allow complex ideas to be broken down into simpler and more understandable elements, demonstrating processes and phenomena that are difficult to describe in words. For example, animations can illustrate chemical reactions, physical phenomena, or mathematical models, making them more easily understood. Interactive animations allow students to interact with the material, change parameters and observe the results, which contributes to better understanding and consolidation of knowledge. Multimedia materials also help to cater for the different learning styles of students. Some students absorb information better visually, through images and videos, while others prefer text-based materials. Incorporating multimedia into the classroom helps to meet these different needs and make learning more effective (Horbatiuk et al., 2021). Multimedia resources can significantly increase student engagement. Visually appealing and interactive elements make the learning process more interesting and stimulating. This helps to keep students' attention and increases their motivation to learn. The use of multimedia also promotes better memorization of information. Research shows that visual and audiovisual elements can improve memory and speed up the learning process. Students can return to

videos and animations for repetition and in-depth study of topics, making the learning process more flexible and tailored to their needs.

Computer modelling and simulations play a key role in education, providing students with unique opportunities to apply theoretical knowledge in practice and analyse complex systems and processes. These tools allow the creation and study of models of various phenomena such as physical processes, chemical reactions and economic systems. Computer simulation gives students the opportunity to reproduce and analyse real-world phenomena in a virtual environment. This involves creating virtual models that can represent physical systems such as the movement of objects under different forces, chemical reactions between substances, or biological processes such as cell growth and the interaction of organisms. Such models allow the visualization and study of processes that may be hard to access or difficult to observe in real life. Interactive modelling platforms provide students with the opportunity to actively interact with models by changing parameters and observing how these changes affect the results. This interaction helps students gain a deeper understanding of theoretical concepts and principles, as well as develop their analytical and critical thinking skills. Virtual models allow experimentation with different scenarios and conditions, which enhances learning and practical skills. The use of computer modelling, and simulations also provides a safe and controlled environment for experimentation (Vlachopoulos & Makri, 2017). Students can conduct research and testing without risking health hazards or destroying equipment, making learning more accessible and less costly. Such opportunities allow for the study of complex and potentially hazardous processes, as well as repeated experiments to reinforce knowledge.

The creation of virtual labs is a significant step forward in the development of educational technology, allowing students to conduct experiments and research without the need for physical equipment. Virtual labs provide access to a variety of tools and experiments in a digital format, making learning more accessible and secure. For example, the Quanser QNET DC Motor Control Board – Quanser QNET DC Motor Control Board was chosen to implement a remote lab in the areas of automated electric drive, mechatronics, and electrical home appliances. This board is an excellent example of equipment that can be integrated into a remote laboratory for practical experiments and research (Anishchenko et al., 2015). The Quanser QNET DC Motor Control Board remote lab design incorporates interaction between real equipment and remote access, allowing students to conduct experiments and analyse results in real-time from different locations. This approach greatly enhances opportunities for self-study and professional development, making the educational process more flexible and accessible. Virtual laboratories using such boards provide students with the opportunity to study the mechanisms of controlling electric drives and mechatronic systems in greater depth, which promotes the development of practical skills and critical thinking. The structure diagram of the remote lab is as follows (Figure 2).

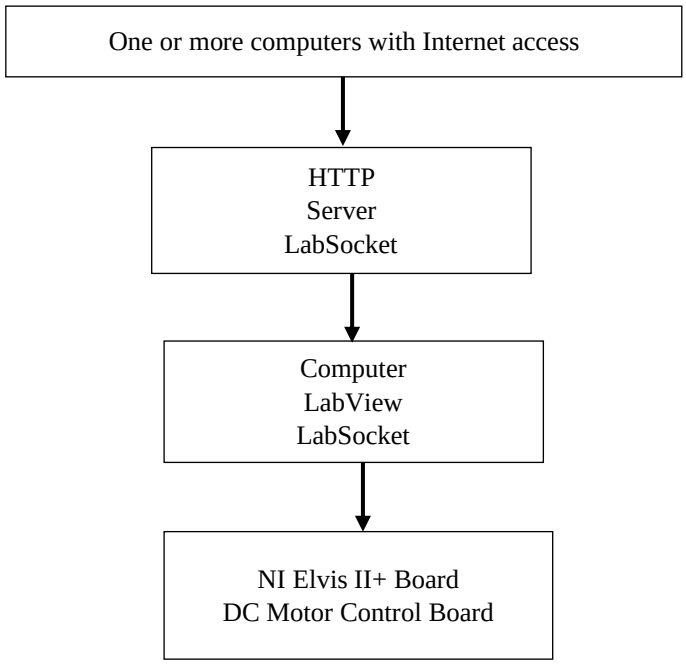

Figure 2. Structure diagram of the remote laboratory

Source: compiled by the authors based on Chans and Castro (2021).

The development and integration of educational platforms play a key role in today's educational environment, providing access to learning at different levels and facilitating the effective implementation of new technologies in the learning process. The successful implementation of distance learning platforms, such as Massive Open Online Courses (MOOCs) and Learning Management Systems (LMSs), has significantly expanded educational opportunities, making it accessible to a wide audience, regardless of geographical location and social status. MOOCs such as Coursera, Udacity and edX provide access to courses from leading universities and educational institutions around the world. These platforms offer a wide range of courses, from basic to advanced levels, covering a variety of disciplines from humanities to technology and science. Students can take courses at a time that is convenient for them, which is especially critical for those who combine their studies with work or other commitments. LMSs such as Moodle, Blackboard and Canvas have also become indispensable tools in educational institutions, allowing them to manage learning processes, track student progress and provide access to learning materials (Voudoukis & Pagiatakis, 2022). The most important features and differences between MOOCs and LMSs are summarized in Table 1.

Table 1. Comparative characteristics of MOOCs and LMSs

Characterization	Coursera (MOOC)	edX (MOOC)	Moodle (LMS)	Canvas (MLS)
Type of platform	MOOC	MOOC	LMS	LMS
Target audience	Students, professionals, organizations	Students, professionals, academic institutions	Educational institutions, organizations	Educational institutions, organizations
Courses and programmes	Courses, specializations, certificates, diplomas	Courses, certificates, micro-masters, diplomas	Courses, modules, training programmes	Courses, modules, training programmes
Access to courses	Open access, there are paid and free courses	Open access, there are paid and free courses	Depends on the institution's settings	Depends on the institution's settings
Level of learning	From beginner to advanced	From beginner to advanced	Depends on the curriculum	Depends on the curriculum
Interactive elements	Video lectures, tests, forums, projects	Video lectures, tests, forums, labs	Forums, tests, assignments, interactive modules	Forums, tests, assignments, interactive modules
Certification	Paid certificates and diplomas	Paid certificates and diplomas	Certificates and assessments issued by the educational institution	Certificates and assessments issued by the educational institution
Support for mobile devices	Mobile app and web version	Mobile app and web version	Mobile app and web version	Mobile app and web version
Integration with other services	Integration with LinkedIn, Google, MS Teams	Integration with LinkedIn, Google, MS Teams	Integration with Google, MS Teams, Zoom	Integration with Google, MS Teams, Zoom
Cost of use	Courses: from free to paid programmes	Courses: from free to paid programmes	Free use (with the possibility of paid add-ons)	Paid subscription for educational institutions

This comparison table helps to understand what features different platforms offer and how they can be used for educational purposes. For example, for organizations looking to provide students with access to massive courses, MOOC platforms such as Coursera or edX may be preferable. Whereas, for internal learning management and student interaction at the institution level, LMS platforms such as

Moodle or Canvas may be better suited. Integrating new technologies into existing educational systems requires a carefully considered approach to minimize technical disruptions and ensure that platforms run smoothly (Shkoukani, 2019). Implementing new technologies can face a variety of challenges, including software incompatibility, problems with customization and data integration, and the need to train staff and students on new tools. However, with proper planning and support, these challenges can be overcome, allowing educational institutions to reap the full benefits of modern technology. Minimizing technical glitches in the integration of new educational platforms is a critical aspect that requires coordination between different departments, including IT, teachers, and administration. It is important to take into account the specifics of existing infrastructure and user needs to ensure a smooth transition to new systems. This may include testing, phased implementation, and providing support throughout the integration process.

The development of interactive learning materials is becoming a major part of modern learning, providing deeper student engagement and improving their understanding of the material. Interactive materials include various elements such as animations, simulations, interactive tasks and games that help students actively interact with the learning content. These materials can be used to explain complex concepts, create visual representations of data, and provide hands-on experience in a virtual environment. Interactive learning materials promote active learning by allowing students to put knowledge into practice and receive immediate feedback. This creates a more engaging and motivating learning experience because students can see a direct link between their actions and results. For example, simulations and virtual labs allow students to conduct experiments and observe results without risking real-world resources. Gamification, which incorporates gamification elements into educational content, also helps keep students interested and makes learning more engaging. This approach helps students to think more deeply and remember learning material, as interactive elements help to create a more vivid and memorable experience.

Adapting traditional textbooks and courses to electronic formats simplifies access to educational materials, allowing students to learn anytime and anywhere through a variety of devices. E-textbooks often include hyperlinks, search functions, multimedia elements and interactive assignments, enhancing interaction and making content more relevant and accessible (Vivek & Bhattacharjee, 2021). They also allow for easy updating of materials and include features to monitor and analyse student progress, which helps teachers track student performance and engagement. However, the introduction of technology into the educational process can be accompanied by negative aspects. Technical issues such as instability and glitches can disrupt the learning process and require additional technical support. Digital inequality can limit access to resources for students with inadequate equipment or internet connections (Simonson et al., 2019). Motivation and engagement issues can arise from a lack of face-to-face interaction, which reduces learning engagement. Data security also becomes an important issue as educational platforms may be exposed to threats of information leakage. Finally, uneven content quality and lack of timely support can hamper learning.

Effective methods for assessing the impact of technology on the learning process include surveying students, analysing feedback and monitoring their interaction with educational platforms. Collecting and analysing data on learning outcomes helps to identify trends, adapt curricula and improve educational processes, making programmes more flexible and relevant to students' needs. Regular analyses of results help identify student needs, adapt course content and improve the overall learning experience The findings of this study confirm that digital educational technologies significantly enhance access to educational resources and improve the learning process by providing students with flexibility and personalized learning paths. The integration of adaptive platforms such as Coursera, Khan Academy, and edX has led to higher student engagement and improved retention rates.

These findings indicate that the successful implementation of these technologies is contingent upon the availability of resources and the development of bespoke strategies that accommodate the diverse educational contexts in which they are deployed. These results align with the findings of Kukul (2023), who emphasized that the successful adoption of digital technologies depends on structured teacher training and institutional support. For instance, training programs tailored to the operational and pedagogical aspects of adaptive tools have been shown to foster more effective integration. The experiences of the Kyrgyz National University and the Kyrgyz State University underscore the transformative potential of targeted professional development initiatives. By incorporating platforms such as Coursera and Moodle into teacher training programs, these institutions have improved both teaching quality and student outcomes. Similarly, the Taras Shevchenko National University of Kyiv

and Baku State University provide compelling examples of institutional support in action. These universities not only integrate platforms like edX and Khan Academy into their curricula but also use them as resources to refine teaching methodologies. However, this study extends previous work by highlighting the critical role of institutional frameworks in ensuring sustainability and scalability of these technologies across diverse educational settings.

Notwithstanding these developments, there is a continued requirement for longitudinal studies to assess the long-term impact of these technologies on learning outcomes and student engagement across diverse geographical regions and educational systems. In order to facilitate the integration of technology in education, it is essential that educational institutions develop certification programmes that are tailored to specific platforms, establish partnerships with technology providers for the sharing of resources, and create feedback systems that allow teachers to report challenges and receive solutions in a timely manner (Khmelnytska, 2019). These measures guarantee that teacher training and institutional support mechanisms function in unison to facilitate the effective adoption of educational technologies, thereby enhancing the learning experience.

This is especially relevant for regions with limited educational resources, where access to quality learning has previously been difficult. These platforms provide the opportunity to gain knowledge and develop professional skills without leaving one's own region, thus democratizing education and reducing barriers to learning. An essential aspect of the development of these platforms is the personalization of learning. The use of adaptive learning platforms and analytical tools allows for a more personalized educational experience. These technologies analyse student data and offer personalized recommendations, adjusting learning materials based on students' backgrounds and needs. This approach helps avoid situations where students are faced with material that is too difficult or, conversely, too easy for them. As a result, personalization of learning helps to increase students' motivation and improve their learning outcomes. Similar conclusions were reached by Fabus et al. (2023) who studied MOOC platforms and their impact on modern distance learning. In their work, they noted the significant increase in access to educational materials and the importance of these platforms for regions with limited educational resources. Sancenon et al. (2022) also confirmed the effectiveness of these approaches in their paper on a new web-based personalized learning system which, in his opinion, improves student learning outcomes by adapting learning materials to their individual needs. However, unlike these studies, the present research underscores the importance of continuous feedback mechanisms for educators to ensure optimal platform utilization.

The incorporation of adaptive learning platforms and emerging technologies into the educational sector has been shown to have a significant impact on enhancing student engagement, personalisation and accessibility. The findings of this study corroborate those of prior research, which has emphasised the transformative potential of these technologies. However, several critical gaps remain unaddressed. For example, while El-Sabagh (2021) demonstrated the role of adaptive e-learning environments in fostering student engagement, further investigation is required to ascertain the broader implications for diverse educational settings. Similarly, Kaur et al. (2023) emphasised the efficacy of adaptive systems in language learning but also highlighted challenges related to scalability and institutional readiness, which are consistent with the barriers identified in this study.

The advent of emerging technologies, including artificial intelligence (AI) and immersive tools, has ushered in novel approaches to engagement in STEM education, as reviewed by Chng et al. (2023). However, these developments must be considered alongside more established methods to create a comprehensive educational environment. For instance, the use of adaptive platforms analysed in this study can be seen to complement, rather than replace, established pedagogical practices. Hafezi et al. (2024) emphasise the importance of rigorous evaluations of technological adoption in higher education, advocating for strategies that integrate these tools seamlessly into existing curricula while addressing regional and infrastructural disparities.

Interactive assignments, virtual labs and gamification significantly increase student engagement in the learning process. These elements make learning more interesting and dynamic, allowing students to actively participate in the process and receive instant feedback. This not only helps in better learning but also develops important skills such as teamwork, strategic thinking and problem-solving. Incorporating multimedia such as videos and animations also plays a key role in enhancing the educational process. Multimedia resources promote a better understanding of complex concepts and enrich the learning experience by allowing information to be visualized and demonstrated. This makes complex topics much easier to grasp and promotes deeper learning. The combination of interactive

elements and multimedia materials creates a more engaging and effective learning environment, which enhances student motivation and success. Sanzana et al. (2023) also highlight in their study of gaming virtual labs look at the transition from traditional physical environments to interactive learning. Their work points out that virtual labs allow students to conduct experiments and explore concepts in a safe and controlled environment, which also supports your idea of the need to create a more dynamic and safe educational experience. Septiani et al. (2020) emphasized how multimedia resources can strengthen students' character and improve their performance. Their work confirms that the use of videos, animations, and other multimedia elements in the learning process enhances understanding of complex concepts and makes learning richer and more diverse. Multimedia helps to visualize and demonstrate information, which makes complex topics easier to grasp and promotes deeper learning.

The study revealed that computer modelling and simulations play an important role in the educational process, providing students with unique opportunities to apply theoretical knowledge in practice. These tools allow students to interact with virtual models of complex systems and processes, which facilitates deeper understanding and analysis of materials. Virtual labs and interactive models allow students to conduct experiments, explore different scenarios, and observe the consequences of their actions in a safe and controlled environment. This approach fosters critical thinking, analytical skills and practical skills, which are essential to prepare students for real-world professional challenges. Virtual labs can also provide access to equipment and technology that may not be available in traditional educational institutions, expanding research and learning opportunities. In addition, regular monitoring and analysis of student achievement data play a key role in improving the quality of educational programmes. The use of analytical tools allows data on student progress to be collected and analysed, identifying trends and issues that may require correction. These tools help to identify strengths and weaknesses in the educational process, allowing for timely changes in teaching approaches. For example, data on which topics cause the most difficulty for students can be used to adapt learning materials and teaching methods. Analytics can also track the effectiveness of new technologies, such as computer simulations and virtual labs, and adjust their use to achieve the best results. As a result, regular data analysis and monitoring helps to create a more adaptive and effective educational space where learning technologies work to improve the educational process and outcomes.

Rakić et al. (2020) and Llerena et al. (2021) focused on the application of agent-based modelling and simulations in educational processes. Rakić et al. (2020) focused their work on the use of these technologies for learning, investigating their effectiveness and impact on the educational process. This study highlighted that such tools allow the simulation of complex systems and processes, creating dynamic and interacting models that students can explore and analyse. In turn, a study by Llerena et al. (2021) focused on the use of analytical tools to monitor student progress. This work compared different analytical platforms such as Analytics Graphs and Edwiser Reports to determine their effectiveness in tracking and improving academic performance. It highlighted that the use of such tools enables educational institutions to conduct detailed analysis of student performance, identify problems early and make necessary adjustments to educational programmes. The implementation of educational technologies such as LMS and MOOCs is a complex and multifaceted process that requires careful planning and comprehensive support at every stage of integration. One of the key aspects of this process is the need for a detailed analysis of the needs of the educational institution. It is necessary to identify the goals to be achieved with the new technologies and select the platform that best fits the specifics of the educational process. One of the main challenges is the integration of new systems into the existing infrastructure, which requires careful preparation and planning. Special attention should be paid to the training of teachers and technical staff. It is recommended to consider phased implementation of technologies, which will reduce risks and correct possible errors in the early stages. It is also important to provide support at all levels so that all users are prepared for the changes and can use the new systems effectively. Braun et al. (2021) came to the same conclusions, but emphasized the importance of such courses in preparing students for more complex materials and successful integration of new technologies into the learning process. Similarly, the work of Kovalenko (2023) demonstrates the successful application of distance technologies and points out the importance of their integration into traditional education. She highlighted the advantages of distance learning, such as increased access to educational resources and flexibility of learning, and emphasizes the need for careful planning and preparation when introducing new technologies.

The findings of this study demonstrate that adaptive learning technologies not only enhance accessibility but also create opportunities for more efficient and targeted learning experiences. A

significant contribution of this research is the demonstration that institutional preparedness and strategic partnerships with technology providers have a substantial impact on the successful implementation of digital education tools. A departure from the focus of previous studies on student-centred outcomes, this research underscores the pivotal interplay between policy frameworks, teacher preparedness, and technological infrastructure. Collectively, these elements determine the effectiveness of adaptive learning platforms.

The integration of computer technologies into educational programs, while promising, faces several significant challenges that must be addressed to fully realize their potential. One of the primary issues is the uneven access to these technologies, which can exacerbate existing educational inequalities. Students in underserved or remote regions may lack the necessary infrastructure, such as reliable internet access or adequate devices, to benefit from online platforms and digital resources. Additionally, there is a notable gap in teacher training, with many educators insufficiently prepared to effectively utilize these new tools. This lack of preparation can hinder the successful implementation of technology-enhanced learning strategies, leading to suboptimal educational outcomes. Furthermore, the adaptation of these technologies to diverse educational contexts remains a complex task, requiring tailored solutions that consider the unique needs and constraints of different learning environments.

Another critical limitation of the study is the lack of comprehensive, long-term data on the impact of these technologies on learning outcomes. Most research focuses on short-term effects, which may not capture the sustained benefits or potential drawbacks of technology integration. There is also a need for more nuanced analyses that consider the varied experiences of different student populations, including those with disabilities or from diverse cultural backgrounds. Additionally, the study does not fully address the ethical and technical challenges associated with the use of digital technologies, such as data privacy concerns and the potential for technical disruptions. These issues highlight the necessity for ongoing research and the development of robust frameworks to support the effective and equitable integration of computer technologies in education.

In order to address the gaps identified in this research, future studies should focus on several key areas. Firstly, there is a necessity for longitudinal studies to evaluate the sustained impact of digital education technologies on learning retention and professional development. Secondly, comparative research across different geographical regions would provide insights into how socio-economic and cultural factors influence the adoption and effectiveness of adaptive learning platforms. Furthermore, there is a need for further exploration of the ethical implications of AI-driven personalisation, with particular attention to issues of data privacy and inclusivity. Furthermore, future research should examine the long-term impact of interactive, gamified, and multimedia-based learning on student performance and career development. Further studies are also needed to assess the effectiveness of VR/AR technologies and adaptive systems in different disciplines, considering their practical applications and long-term outcomes. Finally, conducting cost-benefit analyses of large-scale technology integration in education would assist policymakers in formulating sustainable strategies for digital transformation in learning institutions.

CONCLUSION

The study found that the use of online platforms such as Coursera, Khan Academy and edX significantly increases access to educational materials. This allows students from different parts of the world to receive quality education that was previously unavailable to them. Distance courses and learning materials help to overcome geographical and social barriers, making education more inclusive and democratic. The ability to learn at a convenient time and in a convenient format facilitates the adaptation of the learning process to the individual needs of students. Personalized curricula and adaptive platforms using artificial intelligence technologies allow students to be offered content and assignments that are relevant to their level of expertise and learning style. This increases motivation and improves learning outcomes. The paper emphasizes that the integration of interactive and game elements into the learning process contributes to increasing students' interest in learning. Virtual labs, simulations and educational games create a dynamic and engaging environment that encourages students to actively participate in the learning process and develop critical thinking and practical skills. The use of videos, animations, and other multimedia resources enhances understanding of complex concepts and makes learning more enriching. The introduction of computer modelling and simulations into educational programmes provides students with unique opportunities to apply theoretical knowledge in practice. These studies have shown that the implementation of adaptive assessment and

feedback systems also significantly improves the educational process. Adaptive systems can instantly adjust the curriculum based on students' progress and needs, which makes learning more effective. Such systems can automatically identify weaknesses in students' knowledge and suggest additional resources and assignments to address them. In addition, the use of virtual and augmented reality technologies is becoming increasingly popular, giving students the opportunity to immerse themselves in complex and abstract concepts through interactive visualizations. These technologies open new horizons for learning, especially in areas where traditional teaching methods may be less effective. Regular collection and analysis of data on student learning outcomes allows timely identification of problems and improvement of the quality of educational programmes. The use of analytical tools for monitoring student progress and assessing the effectiveness of educational technologies helps educational institutions to adapt programmes to modern requirements and expectations of students.

For those engaged in teaching, the utilisation of these technologies facilitates the process of designing and delivering instruction that is tailored to the specific requirements of each individual learner. The utilisation of adaptive systems and analytics tools facilitates the provision of immediate feedback on student performance, thereby enabling educators to identify and address learning gaps in a more efficient manner. Educators may employ gamified elements, virtual laboratories, and simulations to construct engaging and dynamic learning environments that enhance student engagement and achievement. The utilisation of multimedia resources also facilitates the effective explanation of complex concepts by educators, thereby enhancing the accessibility and appeal of their lessons. Future research should examine the long-term impact of interactive, gamified, and multimedia-based learning on student performance and career development. Additionally, further studies are needed to assess the effectiveness of VR/AR technologies and adaptive systems in different disciplines, considering their practical applications and long-term outcomes.

ACKNOWLEDGMENTS

Not applicable.

AUTHOR CONTRIBUTIONS

R.I.: Conceptualization, Formal Analysis, Investigation, Writing – Original Draft Preparation; N.K.: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft Preparation; K.D.: Methodology, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; K.M: Conceptualization, Software, Investigation, Writing – Review & Editing; M.M.: Formal Analysis, Data Curation, Validation, Writing – Review & Editing.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

Agni, R., Febriawan, A., & Zainal, S. (2024). Uncovering the veil: Overcoming challenges in science teaching standards. *Integrated Science Education Journal*, *5*(3), 181-186. https://doi.org/10.37251/isej.v5i3.1272.

Anggraeni, A.D., Pentury, H.J., & Tanamal, N.A. (2019). Blending humour and animation in English learning for students of English education programs in universities. *International Journal of Innovation, Creativity and Change*, *5*(6), 540-553. https://www.ijicc.net/images/vol5iss6/5650_Anggraeni_2019_E_R.pdf

Anggraeni, F. D. R., Rassy, R. P., & Sereesuchat, S. (2023). Development of a textured picture book equipped with crosswords as a media for learning biology sub-material epithelial tissue. *Journal of Educational Technology and Learning Creativity*, *1*(2), 68-77. https://doi.org/10.37251/jetlc.v1i2.793.

Anishchenko, N., Tymoshchenko, A., & Tkachenko, A. (2015). Creation of a remote laboratory at the Department of Automated Electromechanical Systems of NTU "KPI". *Bulletin of the National Technical University "Kharkiv Polytechnic Institute. Problems of Automated Electric Drive. Theory and Practice*, *12*(1121), 33-38. https://repository.kpi.kharkov.ua/handle/KhPI-Press/20059

Arianti, R., Fitriyah, I. J., Puji, A. D., & Firmansyah, M. R. (2024). Development of board game media "galaksi bimasakti project" to improve learning outcomes. *EduFisika: Jurnal Pendidikan Fisika*, *9*(1), 14-22. https://doi.org/10.59052/edufisika.v9i1.27879.

Baah, R., Konovalov, O., & Tenzin, S. (2024). Effectiveness of E-Assessment in science learning: Improving the quality and efficiency of assessment in the digital era. *Integrated Science Education Journal*, *5*(2), 74-81. https://doi.org/10.37251/isej.v5i2.960.

Braun, C., Ebner, M., Fickert, L.H., & Schön, S. (2021). The online course as initial stage of a course in higher education: implementation and evaluation of the pre-MOOC concept in a technical degree course. *International Journal of Emerging Technologies in Learning*, *16*(6), 245-258. https://doi.org/10.3991/ijet.v16i06.16617

Chans, G.M., & Castro, M.P. (2021). Gamification as a strategy to increase motivation and engagement in higher education chemistry students. *Computers*, *10*(10), 132. https://doi.org/10.3390/computers10100132

Chng, E., Tan, A.L. & Tan, S.C. (2023). Examining the use of emerging technologies in schools: a review of artificial intelligence and immersive technologies in STEM education. *Journal for STEM Education Research*, *6*(3), 385-407. https://doi.org/10.1007/s41979-023-00092-y

Christiansen, E., & McNally, M. (2022). Examining the technological and pedagogical elements of select open courseware. *First Monday*, *27*(10), 1-24. https://doi.org/10.5210/fm.v27i10.11639

Debeer, D., Vanbecelaere, S., Van Den Noortgate, W., Reynvoet, B., & Depaepe, F. (2021). The effect of adaptivity in digital learning technologies. Modelling learning efficiency using data from an educational game. *British Journal of Educational Technology*, *52*(5), 1881-1897. https://doi.org/10.1111/bjet.13103

Diachuk, O. (2024). Development of digital competence of teachers in vocational education institutions. *Scientia et Societus*, *3*(1), 77-91. https://doi.org/10.69587/ss/1.2024.77

El-Sabagh, H.A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, *18*(1), 53. https://doi.org/10.1186/s41239-021-00289-4

Esen, A., Kütük, Y., & Zor, Ü. (2022). Academic entrepreneurship: The case of Coursera. In M.A. Eklund, G. Wanzenried (Eds.), *Academic and Educational Entrepreneurship: Foundations in Theory and Lessons from Practice* (pp. 175-189). Cham: Springer. https://doi.org/10.1007/978-3-031-10952-2_14

Essenzi, D. S. (2024). Analysis of community health center performance on tuberculosis control programs. *Journal of Health Innovation and Environmental Education*, *1*(1), 1-6. https://doi.org/10.37251/jhiee.v1i1.1039.

Fabus, J., Garbarova, M., Kremenova, I., & Vartiak, L. (2023). MOOC platforms: Modern distance learning. In *EDULEARN23 Proceedings of the 15th International Conference on Education and New Learning Technologies* (pp. 3122-3130). Palma: International Academy of Technology, Education and Development. https://doi.org/10.21125/edulearn.2023.0868

Fakhroni, A. A., & Puotier, Z. (2023). Efforts to improve mathematics learning outcomes using napier bone teaching aids for elementary school students. *Interval: Indonesian Journal of Mathematical Education*, *1*(2), 36-46. https://doi.org/10.37251/ijome.v1i2.779.

Fitriah, F., Akorede, A., & Agyei, E. (2023). Improving mathematics learning outcomes through the consideration model for class vii students. *Interval: Indonesian Journal of Mathematical Education*, *1*(2), 47-55. https://doi.org/10.37251/ijome.v1i2.771.

H, A. N., & Saitakham, K. (2024). Analysis of syntactic errors in writing of third semester students of the department of english and literature. *Journal of Language, Literature, and Educational Research*, *1*(1), 1-6. https://doi.org/10.37251/jolle.v1i1.1000.

Hafezi, R., Ghaboulian Zare, S., Taghikhah, F.R., & Roshani, S. (2024). How universities study the future: A critical view. *Futures*, *163*, 103439. https://doi.org/10.1016/j.futures.2024.103439

Haleem, A., Javaid, M., Qadri, M.A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Hardyanti, V. S., Lateef, H., & Abbas, S. A. (2023). The influence of teacher teaching creativity on student learning outcomes in mathematics subjects. *Interval: Indonesian Journal of Mathematical Education*, *1*(2), 56-60. https://doi.org/10.37251/ijome.v1i2.778.

Helida, Y., Ching, C. P., & Oyewo, A. (2023). Development of a simple stirling engine demonstration tool on the subject of thermodynamics. *Journal of Educational Technology and Learning Creativity*, *1*(2), 59-67. https://doi.org/10.37251/jetlc.v1i2.790.

Horbatiuk, R., Sitkar, S., Taras, S., Konovalchuk, S., & Burega, N. (2021). The effectiveness of testing as a method of pedagogical control of future specialists with higher education. *Professional Education: Methodology, Theory and Technologies*, (13), 79-95. https://doi.org/10.31470/2415-3729-2021-13-79-95

Huda, I., Girei, M. M., & Keizi, F. (2023). Development of a practical tool for linear momentum collisions using a microcontroller. *Journal of Educational Technology and Learning Creativity*, *1*(2), 42-49. https://doi.org/10.37251/jetlc.v1i2.788.

Ihnatenko, O., Tolmachov, V., & Ryabko, A. (2024). Training of future primary school and computer science teachers in the structure of information systems. *Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"*, *10*(2), 98-109. https://doi.org/10.52534/msu-pp2.2024.98

Isaeva, R., Omaralieva, Z., Moldoiarova, Z., & Bekzhan kyzy, G. (2024). Didactic training of future physics teachers to apply innovative technologies in educational process in the Kyrgyz Republic. *Scientific Herald of Uzhhorod University. Series "Physics"*, *55*, 1569-1579. https://doi.org/10.54919/physics/55.2024.156ys9

Junushalieva, K. (2023). Geography in Russian language classes in secondary schools. https://kutbilim.kg/ru/methodical/inner/geografiya-v-klassah-s-russkim-yazykom-obucheniya-v-srednih-shkolah/

Karasartova, N.A., & Nogaev, M.A. (2020). Innovative approaches to the development of an educational module for integrating knowledge of physics and biology. *Topical Issues of Education and Science*, *1*(69), 24-26. https://www.elibrary.ru/item.asp?id=42560153

Kaur, P., Kumar, H., & Kaushal, S. (2023). Technology-assisted language learning adaptive systems: A comprehensive review. *International Journal of Cognitive Computing in Engineering*, *4*, 301-313. https://doi.org/10.1016/j.ijcce.2023.09.002

Khmelnytska, O. (2019). Professional training of a teacher to the practical realization of the idea of the new Ukrainian school. *Professional Education: Methodology, Theory and Technologies*, (9), 211-225. https://doi.org/10.31470/2415-3729-2019-9-211-225

Kovalchuk, V.I., & Sheludko, I.V. (2019). Implementation of digital technologies in training the vocational education pedagogues as a modern strategy for modernization of professional education. *Annales Universitatis Paedagogicae Cracoviensis*, *9*, 122-138. https://oldbioannales.uken.krakow.pl/wp-content/uploads/sites/52/2020/08/Strony-od-Folia-2961-14.pdf

Kovalenko, O. (2023). Distance learning technologies in a higher educational institution: Experience in using and implementing e-learning courses in the educational process. *ScienceRise: Pedagogical Education*, *1*(52), 23-29. https://doi.org/10.15587/2519-4984.2023.275501

Kukul, V. (2023). Modelling the spectrum of technology integration from teacher training to usage intention: Findings from a two-phase study. *Technology, Knowledge and Learning*, *28*(4), 1615-1633. https://doi.org/10.1007/s10758-023-09658-6

Lacka, E., Wong, T.C., & Haddoud, M.Y. (2021). Can digital technologies improve students' efficiency? Exploring the role of virtual learning environment and social media use in higher education. *Computers & Education*, *163*, 104099. https://doi.org/10.1016/j.compedu.2020.104099

Llerena, J., Alava-Moran, N., & Zamora-Galindo, J. (2021). Learning analytics for student academic tracking, a comparison between Analytics Graphs and Edwiser Reports. In *2021 Second International Conference on Information Systems and Software Technologies (ICI2ST)* (pp. 101-107). Quito: Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/ICI2ST51859.2021.00022

Maymunah, A., Ramorola, M., & Shobowale, I. O. (2023). Development of an inquiry-based science module on plant parts and their functions in elementary schools. *Journal of Educational Technology and Learning Creativity*, *1*(2), 50-58. https://doi.org/10.37251/jetlc.v1i2.789.

Qureshi, M.I., Khan, N., Raza, H., Imran, A., & Ismail, F. (2021). Digital technologies in Education 4.0. Does it enhance the effectiveness of learning? A systematic literature review. *International*

Journal of Interactive Mobile Technologies, *15*(04), 31-47. https://doi.org/10.3991/ijim.v15i04.20291

Rai, L. (2019). Successful learning through massive open online courses. *IEEE Potentials*, *38*(6), 19-24. https://doi.org/10.1109/MPOT.2018.2869076

Rakic, K., Rosic, M., & Boljat, I. (2020). A survey of agent-based modelling and simulation tools for educational purpose. *Technical Gazette*, *27*(3), 1014-1020. https://doi.org/10.17559/TV-20190517110455

Romadhonsyah, A. (2024). Contribution of arm muscle power and body flexibility regarding volleyball services for athletes. *Multidisciplinary Journal of Tourism, Hospitality, Sport and Physical Education*, *1*(1), 1-5. https://doi.org/10.37251/jthpe.v1i1.1032.

Sancenon, V., Wijaya, K., Wen, X.Y.S., Utama, D.A., Ashworth, M., Ng, K.H., Cheong, A., & Neo, Z. (2022). A new web-based personalized learning system improves student learning outcomes. *International Journal of Virtual and Personal Learning Environments*, *12*(1), 1-21. https://doi.org/10.4018/ijvple.295306

Sanzana, M.R., Abdulrazic, M.O.M., Wong, J.Y., Karunagharan, J.K., & Chia, J. (2023). Gamified virtual labs: Shifting from physical environments for low-risk interactive learning. *Journal of Applied Research in Higher Education*, *16*(1), 208-221. https://doi.org/10.1108/jarhe-09-2022-0281

Septiani, A.-N.N.S.I., Rejekiningsih, T., Triyanto, Rusnaini. (2020). Development of interactive multimedia learning courseware to strengthen students' character. *European Journal of Educational Research*, *9*(3), 1267-1279. https://doi.org/10.12973/eu-jer.9.3.1267

Sharlovych, Z., Vilchynska, L., Danylyuk, S., Huba, B., & Zadilska, H. (2023). Digital technologies as a means of improving the efficiency of higher education. *International Journal of Information and Education Technology*, *13*(8), 1214-1221. https://doi.org/10.18178/ijiet.2023.13.8.1923

Shkoukani, M. (2019). Explore the major characteristics of learning management systems and their impact on e-learning success. *International Journal of Advanced Computer Science and Applications*, *10*(1), 296-301. https://doi.org/10.14569/ijacsa.2019.0100139

Simonson, M., Zvacek, S., & Smaldino, S. (2019). *Teaching and learning at a distance: Foundations of distance education*. Charlotte: Information Age Publishing.

Srinivasa, K.G., Kurni, M., & Saritha, K. (2022). Adaptive teaching/learning. In *Learning, Teaching, and Assessment Methods for Contemporary Learners: Pedagogy for the Digital Generation* (pp. 201-240). Singapore: Springer. https://doi.org/10.1007/978-981-19-6734-4_9

Sriyono, S. (2024). Improving learning results in hydrocarbon chemistry with mind mapping and classical music accompaniment. *Journal of Chemical Learning Innovation*, *1*(1), 1-6. https://doi.org/10.37251/jocli.v1i1.1016.

Sukamdi, S., Lepik, A., & Denkovski, V. (2023). Tapping into creativity: Crafting engaging math lessons for middle schoolers with macromedia flash. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *13*(1), 10-20. https://doi.org/10.22437/teknopedagogi.v13i1.36396.

Tang, K.-S., So, H.-J., & Rappa, N. (2023). Examining the multimodal design of explainer videos: A multimodal content analysis of Khan Academy online resources. https://dx.doi.org/10.2139/ssrn.4561629

Triscova, V., Sudaryono, S., & Ekawarna, E. (2023). Growing with Language: Innovation in developing Indonesian language learning materials. *Tekno - Pedagogi : Jurnal Teknologi Pendidikan*, *13*(1), 1-9. https://doi.org/10.22437/teknopedagogi.v13i1.32512.

Turaeva, G.E. (2021). Improving the efficiency of the educational process using computer technology. *ACADEMICIA: An International Multidisciplinary Research Journal*, *11*(8), 407-410. http://dx.doi.org/10.5958/2249-7137.2021.01830.9

UNESCO. (2021). *Education: From disruption to recovery*. Retrieved from https://www.unesco.org/en/covid-19/education-response

Vivek, K., & Bhattacharjee, P. (2021). Use of information and communication technologies in education: Effectively integrating technology in under-resourced education systems. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/336441618203838356/use-of-information-and-communication-technologies-in-education-effectively-integrating-technology-in-under-resourced-education-systems

Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education*, *14*, 22. https://doi.org/10.1186/s41239-017-0062-1

Voropayeva, T., Järvis, M., Boiko, S., Tolchieva, H., & Statsenko, N. (2022). European experience in implementing innovative educational technologies in the training of management specialists: Current problems and prospects for improvement. *IJCSNS International Journal of Computer Science and Network Security*, *22*(7), 294-300. https://doi.org/10.22937/IJCSNS.2022.22.7.35

Voudoukis, N., & Pagiatakis, G. (2022). Massive Open Online Courses (MOOCs): Practices, trends, and challenges for the higher education. *European Journal of Education and Pedagogy*, *3*(3), 288-295. https://doi.org/10.24018/ejedu.2022.3.3.365.

Wardani, E. P., Fantaye, A. K., & Ade, J. A. (2023). Analysis of student's misconceptions in the subject material circle in view of learning readiness and student's think style. *Interval: Indonesian Journal of Mathematical Education*, *1*(1), 30-35. https://doi.org/10.37251/ijome.v1i1.612.

Yanuar, D., & Festiyed, F. (2024). The validity of authentic assessment instruments in the poe of dynamic fluid materials for high school. *EduFisika: Jurnal Pendidikan Fisika*, *9*(1), 01-13. https://doi.org/10.59052/edufisika.v9i1.31638.

Yusipa, Y. (2024). Comparative analysis of students' biology learning outcomes: memory and understanding aspects. *Journal of Academic Biology and Biology Education*, *1*(1), 1-9. https://doi.org/10.37251/jouabe.v1i1.1012.