Integrating Biotechnology Virtual Labs into Online Education Platforms: Balancing Information Security and Enhanced Learning Experiences

Zhenzhen Wu [1*] iD

[1*] Ph.D Candidate, Department of Fine Arts, International College, Krirk University, Bangkok, Thailand. E-mail: wuzhen1982@outlook.com

Abstract

Information and Communication Technology (ICT)-enabled virtual labs to offer an online educational experience utilizing computer-based teaching resources (scenes, simulations, and remote-trigger activities) to enhance the active studying experience. This article discusses a project established to improve university and college instruction, which is evolving into a sophisticated training setting for addressing the geographical, social, and financial obstacles in the interdisciplinary domain of science learning, particularly in India. A pedagogical assessment was conducted through seminars and online comments to examine the function of biotechnology simulations in the contemporary school system, involving various student and instructor groups from many Indian institutions. This chapter discusses the utilization of biotechnology virtual laboratories in biotechnology to enhance teaching and learning processes through user involvement and how these technologies successfully mitigate the challenges of laboratory schooling, particularly in remote regions. The findings from user feedback evaluation indicate that online laboratories are advisable to incorporate into blended classes in giant classrooms to improve self-sufficient instruction and enhance virtual laboratory education in isolated and financially disadvantaged institutions.

Keywords:

Corresponding Author: Zhenzhen Wu, E-mail: wuzhen1982@outlook.com

Introduction

Biotechnology training has emerged as an expanding discipline, resulting in advancements across several domains, including genetics, recombinant DNA methods, developing novel drugs and vaccines, the food and agricultural sectors, and further diagnostic research (Liu et al., 2023). Laboratory trips are essential in biology education, facilitating applying theoretical understanding in practice (Röllke et al., 2021). To address the challenges in contemporary education, online laboratories are emerging as a possible technology that supports educational institutions by offering a creative educational setting for users.

In schooling, computer-aided technology provides distinct benefits for creating unique biology lessons and fostering extremely collaborative student-teacher relationships (Tormey, 2021). The online education system has significantly expanded as a supplementary resource in the contemporary educational landscape. Historically, traditional education involved professors delivering lectures based on a centralized syllabus; pupils relied on textbooks for information, and assessments were accomplished through examinations. Virtual lab approaches facilitate constructivist and imaginative instruction, motivating the student community (Serdar et al., 2021).

In recent years, computers have garnered significant attention as educational instruments in biology. The iLabs system offers online access to remotely triggered testing facilities, enabling users worldwide to engage in hands-on practical sessions (Manyilizu, 2023). The transition from school board sketching to computer-based visuals has significantly impacted users' learning and memorization abilities through drawing abilities.

Under the guidance of the new round of national curriculum reform, online learning has become a meaningful way to cultivate diversified and comprehensive talents that meet the needs of today's society (Ferri et al., 2020). Online learning can better stimulate students' autonomy and develop their higher-order abilities (Müller & Mildenberger, 2021). The size of the digital education market is shown in Fig. 1 and Table 1, and the size of users is shown in Table 2.
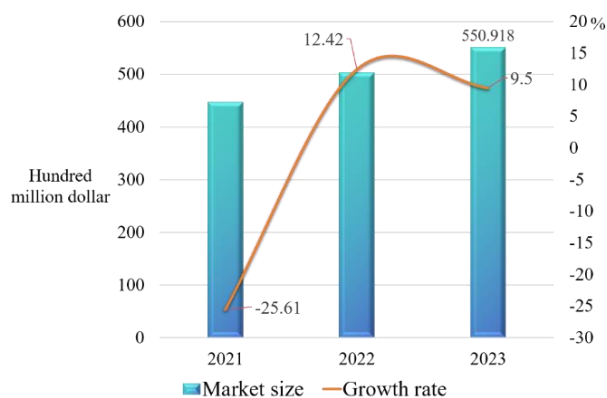

Figure 1. Digital education market size from 2021 to 2023.

The report shows that the digital education market size of 178.68 billion yuan in the first half of 2023 and the market size of 396.4 billion yuan in 2023, a year-on-year growth of 9.5%; it can be learned that the size of education in 2023 is constantly growing.

Table 1. Digital education market size

	2021	**2022**	**2023**
Market size (hundred million dollar)	447.517	503.109	550.918
Growth rate	-25.61%	12.42%	9.5%

Table 1 shows that the market size (growth rate) is $322 billion (-25.61%) and $362 billion (12.42%) in 2021 and 2022, respectively, which shows that the size of the digital market is expanding.

Table 2. The scale of digital education users and its growth rate from 2021 to 2023

	2021	**2022**	**2023**
Number of users (hundred million)	2.98	3.14	3.44
Growth rate	12.87%	5.36%	9.55%

As can be seen in Table 2, in terms of digital education user size, there will be 344 million digital education users in 2023, a year-on-year growth of 9.55%. The market size (growth rate) in 2021 and 2022 are 298 million people (-12.87%) and 314 million people (5.36%), respectively, which can be seen as the user scale is still growing.

A digital education analyst at Nethersole E-Commerce Research Centre pointed out that in a narrow sense, digital education generally refers to online education, a teaching method based on network-based learning behaviors that transfer knowledge content to the Internet to achieve online educational activities (Chakraborty et al., 2021). The teaching stage can be divided into preschool education, K12 education, higher education, vocational education, and so on. Digital education, in a broad sense, includes knowledge payment, online reading, innovative education, educational hardware, etc. Table 3 shows the classification of China's digital education industry in 2023 (first half).

Table 3. Classification of China's Digital Education Industry in the First Half of 2023

China's digital education industry	Vocational education	Shangde Institution, 51CTO College, Gaodun Online School, Zhengbao Accounting Online School, Zhonggong Online School, Global Online School, Xing Shuai Education, Chalk Education, and Hi Learning
	Early education category	Little Companion Dragon, Uncle Kai Telling Stories, Quibbling, Ivy Dad
	Higher education	Wisdom Tree, Wisdom Course Education, 3 Classes
	Language category	Xiaozhan Education, New Oriental Online, Akaso, Fanbei, Fluent Speaking, Aileqi, Poppy English, Dingdong Classroom, Kaochong, Whale Foreign Teacher Peiyou, Meilian English, Jiuqu English, Grape Smart Learning
	Education service providers	Xuebao Online, Longzhimen Education, Yunduo Education, Baijiayun, Bianan Education, Huayu Education, Precision Learning, Tuocuyun,

		Xiaoyang Education, Xueleyun, Yidianyidi, Yunxuetang, Youbijie
	Steam Education	Programming Cat, Spark Thinking, Code King, Art Treasure, Magic Code Planet, Watermelon Maker, Busy Planet, Dolphin Thinking, River Elephant, Walnut Programming, Pea Thinking, and Code Programming
	K12 class	Homework Help, Monkey Tutoring, Avatar Question, Three Good Websites, Xueersi Online School, Leader 1-on-1, Homework Box, Onion Teaching, Homework Together, Rubik's Cube, Love for Learning
	Comprehensive category	Tencent Classroom, Taobao Education, Gaotu, Litchi Micro Course, Hujiang Online School, Youdao

Related Work

Concepts of Online Education Platforms

An online education platform constitutes the digital network of an educational system. The core objective is to address national collaboration on resources, eliminate barriers, establish innovative communication methods, create a new academic and learning system, and develop a novel tool platform (Servaes, 2022). Virtual education systems utilize all available resources for instructional activities to enhance efficiency as a necessity (Stoyanov et al., 2022). The heart of distance learning study lies in using modern networks to transform communication between instructors and pupils, improving students' information acquisition and skill development efficiency. Table 4 describes the general concepts of online education platforms.

Table 4. General concepts of online education platforms

Concept	Describe
Online education platform	**Internet based:** online education platform transmits education content through the Internet, and students can access learning resources through the network at anytime and anywhere. The Internet: online education platform transmits education content through the Internet, and students can access learning resources through the network at anytime and anywhere.
	Multimedia teaching: Utilizing multimedia technology, including video, audio, images, etc., to provide a more vivid and intuitive teaching experience. Multimedia teaching
	Interactivity: Provide online discussions, Q&A, real-time chat and other interactive methods to promote communication and cooperation between The Joint Committee has been working on a number of issues related to the implementation of the programme, including the following
	Flexibility: Students can choose courses they are interested in based on their own schedule and learning speed, achieving a more flexible learning plan.
	Personalised learning: Employing technology tools to deliver customized learning trajectories and resources tailored to pupil behaviors, proficiency levels, and preferences.
	Evaluation and feedback: Provide online quizzes, exams, and real-time learning feedback to help students understand their learning situation and progress.

Concepts of Information Security

Information security protects information system data to ensure its confidentiality, integrity, and availability (Da Veiga et al., 2020). This concept includes a set of protective measures against potential threats, attacks, and risks, as well as ensuring the legitimacy, credibility, and sustainability of data. Table 5 provides an overview of the overall concept of information security.

Table 5. General concepts of information security

Concept	Describe
Information security	**Confidentiality:** Protect information from unauthorised access and ensure that only authorized personnel can access sensitive information.
	Integrity: Protect information from malicious tampering, ensuring that data is not accidentally or maliciously modified during transmission, storage, and processing. Integrity.
	Confidentiality: Protect information from unauthorised access and ensure that only authorized personnel can access sensitive information.
	Availability: Ensure that information is available when needed to prevent service unavailability due to attacks, malfunctions, or other issues.
	Non repudiation: Ensure that the communicating party cannot deny that a certain behaviour has been initiated, through techniques such as digital signatures. Signatures.
	Identity verification: Ensure the identity of users or systems to prevent unauthorised access.
	Authorization: Ensure that users or systems can only access their authorized resources to reduce potential misuse risks.
	Auditability: The ability to track and record system and user activities for security audits and investigations.
	Risk management: By analysing, evaluating, and addressing potential threats, corresponding risk management measures are taken to minimize the threats to information systems. Risk management: By analyzing, evaluating, and addressing potential threats, corresponding risk management measures are taken to minimize the
	Flexibility: Information security strategies and measures should be adaptable to respond to constantly evolving threats and attack tactics.
	Comprehensive: Information security is a comprehensive issue that requires comprehensive consideration of multiple aspects such as technology, personnel, processes, and policies. Comprehensive: Information security is a comprehensive issue that requires comprehensive consideration of multiple aspects such as technology, personnel, processes, and policies.

In summary, the achievement of information security requires the combined application of a range of technical, managerial, and educational measures to protect the information resources of organizations, individuals, and society (Hina & Dominic, 2020). It is an area of continuous evolution, with information security expanding and updating as technologies evolve and threats change.

Methodology

Information Security for Children's Education Platform Strategy

This paper takes the construction and operation of the public training service platform as an example. It discusses the security protection strategy of the online training service platform from the aspects of Deployment of security equipment, system construction and operation, improvement of the management system, and enhancement of the security awareness of the participating subjects.

- *Deployment of Improved Security Protection Hardware and Software Facilities*

According to the requirements of the information system level protection standard, the campus network is divided into distinct areas according to the different degrees of importance and business processing. Other security strategies and deployments are adopted, such as firewalls, filter gateways, intrusion prevention, vulnerability scanning, management systems, backup machines, and other security equipment, based on the "before, during, and after" integrated whole life cycle defense scheme. It deploys firewalls, filter gateways, intrusion prevention, vulnerability scanning and management systems, backup machines, and other security devices (Arogundade, 2023). Configure the security management platform to carry out unified management of security equipment and software, enabling managers to carry out unified management and centralized auditing of security equipment and various resources and technically guaranteeing the effectiveness of implementing different security measures. Fig. 2 shows the Deployment of the security lifecycle defense diagram.
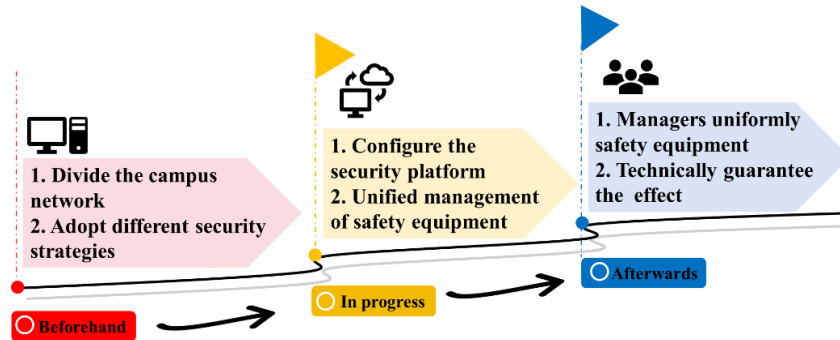

Figure 2. Deploy a security lifecycle defense diagram.

Firstly, users' regular operation is ensured through identity authentication technology during the system's daily operation. The system establishes user databases for teaching staff and off-campus study users. It carries out centralized, hierarchical management of user rights and access modes to simplify system processes and improve management efficiency. Secondly, next-generation firewall technology is used for network access control, and the security of the external server of the university is protected through the setting of DMZs; WEB firewall is deployed to prevent webpage tampering and protect the content of the website pages, preventing unauthorized personnel from tampering with the content at will, and enhancing the security of the website (Wu et al., 2021). Thirdly, intrusion detection technology, combined with the detection engine

formed by protocol anomaly detection, state detection, and correlation analysis, intercepts various types of malicious attack traffic in the data traffic in real time and defends the attack outside the unit network.

- ***Regulating the Construction and Management of Online Education Platforms***

Information security is the first element in developing an online training system, and information security must be integrated into the development and construction of the system. At the beginning of the system's development, technical experts and user departments were invited to conduct a comprehensive demonstration to meet information security needs from multiple perspectives, such as software architecture, implementation details, and system security guarantee technology. In the software construction stage, the study determines the software progress plan, software development technology, function realization, software security protection measures, and other elements and promptly deals with the software development problems. It improves them, improves the quality of the software development, guarantees the smooth progress of the software development and installation plan, and reduces the security problems that exist in the process of the platform system construction (Mishra & Otaiwi, 2020).

In the process of using the online training service platform system, the staff should regularly maintain it to ensure the regular operation of the system and make the functions and effects of the online training service platform meet the development needs of the information security environment. Platform system maintenance staff need to regularly test the performance of the software, pay attention to the system log report, grasp the use of the software, deal with system abnormalities, and record them in a book promptly. Regularly ask the information center to conduct the evaluation. Relevant responsible departments of the College should perform regular inspections of the system's operation and propose corrective actions based on the inspections.

Optimization Strategies for Enhancing the Learning Experience on Children's Education Platforms

Personalized learning enhances the learning experience, and it is a research field of intelligent learning whose goal is to provide practical learning resources to specific learners on the learning platform to enhance learning motivation and learning effect. After analysis, there are three main recommendation methods in the Related Courses section: 1) recommending current popular courses for users; 2) recommending related courses of other users that are similar to them; and 3) recommending related courses that are similar to the course being studied.

- ***Learning Compacts Signed, and Individual Learning Plans Fulfilled***

A precise study plan can guide learners' learning and improve learners' metacognition. An ideal study plan can help learners clarify their learning goals, arrange their time wisely, improve their motivation and learning efficiency, and enable them to transform their motivation into practical actions. The Platform allows students to customize personalized learning plans, which consist of long-term goals and short-term plans, which the Platform then cuts into daily tasks based on algorithmic technology. As the learning contract can effectively promote student learning, after cutting the tasks, they need to be confirmed by the learners to reach the contract.

After the learner enters the software, the plan customization page will appear. The online education platform needs to provide options to help the learner customize the long-term plan and then provide options to help the learner customize the short-term plan after the customization. The online education platform system needs to divide the tasks according to a specific algorithm between the learner's long-term and short-term plans. Then, after the division is done, the learner confirms the functions if the learner is not satisfied with the tasks. If the learner is unhappy with the task, they can re-customize the plan or modify it according to the customized task page provided by the online education platform. If the learner is satisfied with the task, they will sign a commitment letter to complete the customization of their plan. The process of customizing the personalized learning plan is shown in Fig. 3.
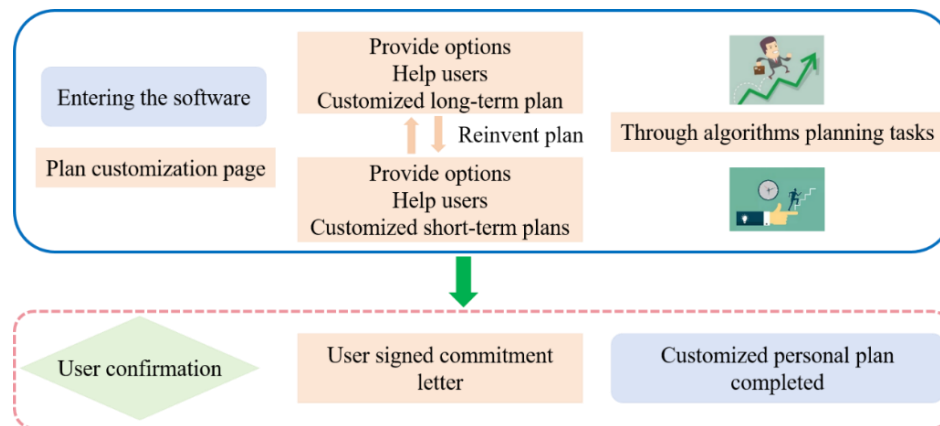

Figure 3. Process diagram for customizing personalized learning plans

- ***Improve Personalized Recommendations and Actively Implement Burden Reduction and Efficiency Enhancement***

The digital portrait of the learner is an essential source of data in personalized recommendations. A learner's digital portrait is the sum of labels given to the learner by a computer based on a large amount of data generated by the learner during the learning process. After machine learning, various labels are given to the learner. The digital portrait enables the Platform to provide personalized learning services to learners more accurately. The Platform can start to improve the user portrait when a new user registers, first initialize the user's data portrait through the user's registration information and the data provided by the user, such as points of interest, and then cluster the courses based on the user's data in advance. When the user enters the course platform, using a priori data and selecting representatives from the classifications in the prior clustering, recommending popular courses and courses related to the user's points of interest to the user, and then gradually optimizing the user's digital portrait according to the user's feedback. The personalized recommendation process is shown in Fig. 4.
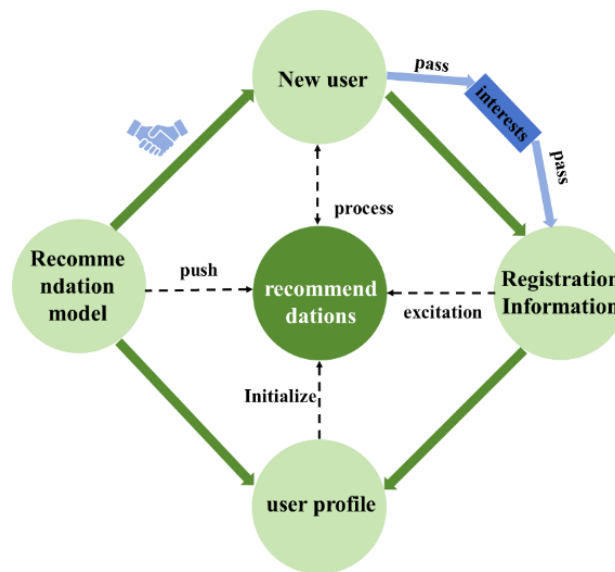
Figure 4. Personalised recommendation flowchart

The user's behavioral information, social network data, data on courses taken, etc., can be used to make recommendation algorithms. In the author's opinion, a personalized recommendation can make horizontal and vertical recommendations. In addition to recommending courses and materials related to the current learner's situation, it is necessary to consider that the learner's interests will change with the learning process, and the personalized recommendation should align with the learner's development and change with the development of people. To address the above issues, this paper proposes the integration of reinforcement learning with recommender systems, which can allow online education platforms to recommend dynamically in the dynamic changes of learners. Reinforcement learning focuses on machine learning by computers in changing factors. The essence is to adjust its action strategy through the constant interaction between the intelligent body and the environment. After observing the results of its behavior, it gets the corresponding rewards according to the changes in the environment.

- *Generate Personalized Question Bank Error Attribution, Timely Feedback on the Right Medicine*

A personalized question bank needs to satisfy the three features of error attribution, accurate recommendation, and citation. The usability of a personalized question bank depends on the underlying knowledge-tracking model. Knowledge tracking is a supervised sequential learning task that evaluates students' mastery of knowledge points based on their learning history and predicts their future performance to provide better diagnosis of personalized question banks, more accurate recommendation of questions for learners, and, by way of example, the ability to analyze the cause of errors when they are found.

The personalized question bank first needs to provide the learner with regular questions. After the learner completes the questions, the learner's wrong questions are presented using knowledge tracking to attribute the wrong questions to the learner. At the same time, the data related to the learner's questions are generated. The sequence data of historical questions are analyzed to derive the learner's current learning

mastery status and the information of the questions, which are classified separately. The algorithms predict the learner's performance in the questions, and the personalized question bank is derived from the prediction. The personalized question bank is then optimized using other data generated by the learner during the learning process and the learner data profile. Finally, the customized question bank is generated.

Feedback can improve learners' self-efficacy to some extent. However, in online learning, with the increase in the number of courses, teachers need a lot of time and energy to develop personalized feedback for each student; in the online education platform, a teacher needs multiple students, but the time and energy of the teacher are limited, and it is challenging to implement manual personalized feedback. Therefore, the computer can automatically generate customized feedback for a certain period to meet the timed input and the proper remedy. Personalized feedback must be tailored to the learner's past, present, and future aspects. The learner data in personalized feedback needs to be extracted from a database, and the learner database design is shown in Fig. 5.
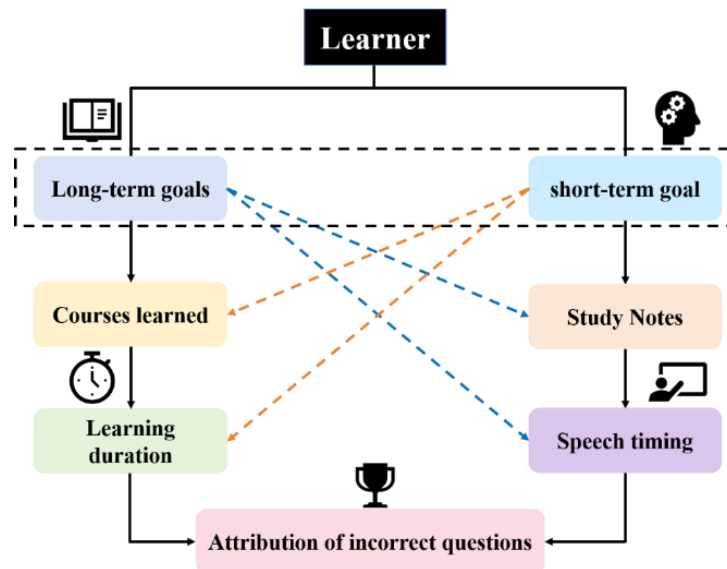

Figure 5. Design diagram of learner database

Virtual Lab Presentation

The creation of biotechnology virtual laboratories involved integrating innovative technical methods and the conception of biological processes to create a space for interaction and customer experiences. This was accomplished using graphical motions that provide a high-quality active self-learning environment for learners utilizing 2D Adobe Flash in a flexible, accessible manner. The laboratory apparatuses, including the Light Microscope, are accessible online to clients using intuitive graphical interfaces, facilitating investigations and equipment usage akin to those performed in conventional laboratory settings. Simulation-based studies enhance hands-on training for every test by supplementing actual laboratory procedures and abilities. In addition to animations and training, laboratories utilized remote-triggered or remotely controlled tests, emphasizing online architecture for distant control.
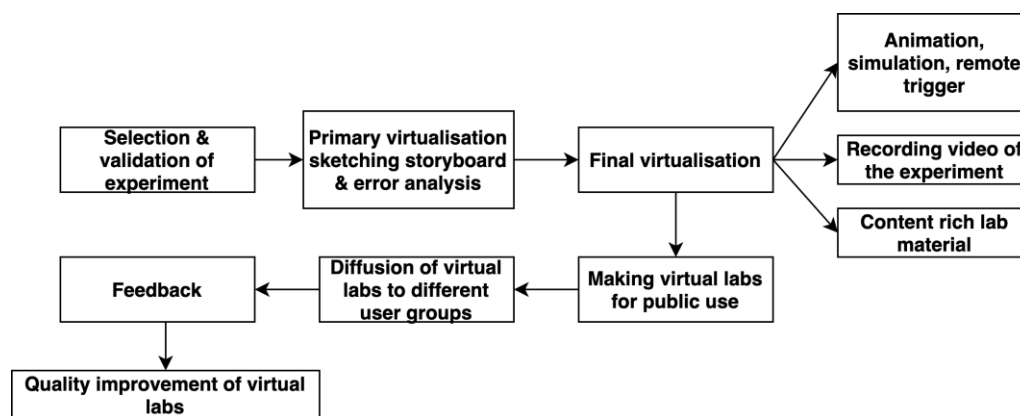
Figure 6. Design of virtual lab for biotechnology

The film documenting the experiments conducted in Indian laboratories is produced and supplied as extra content to enhance the users' active learning experience. Alongside these videos, our laboratories offer a comprehensive laboratory protocol that encompasses theoretical background, a meticulous step-by-step experimental procedure, tests, homework, and supplementary references (Fig. 6) to fulfill the essential objectives of our online laboratories in delivering high-quality instruction to geographically isolated regions as well as financially disadvantaged institutions.

The user must initially review the hypothesis tab, which elucidates the fundamental scientific principles underlying every test, followed by an examination of the method section that delineates the usual process for experimenting. The user is anticipated to engage in self-assessment quizzes to gauge their knowledge level and then watch animations that simulate wet laboratory procedures in an understandable format. Additional tabs comprise the remote panel (exclusively for remotely initiated trials), tasks, citations, and response tabs. User-reported online input served as the evaluative measure for the efficacy of the online laboratory studies. Feedback was documented online and tracked and evaluated. Comments were utilized to assess user participation in an online course study.

Results and Discussion

With the advent of the digital age, the popularity of children's education platforms has become an essential trend in education. By analyzing the above methods, balancing the relationship between information security and learning experience becomes a core issue that must be considered to build a successful educational platform. Through the above strategic approach, the research can find an effective way to balance maintaining information security in children's education platforms while enhancing the learning experience.

Guarantee of Information Security

Firstly, learning users should be subject to enhanced authentication, and advanced authentication technologies, such as two-factor authentication, should be used to ensure that only legitimate users can access the Platform and to reduce security risks. The Platform should use advanced data encryption technology to protect students'

and parents' personal information while following relevant privacy regulations. Establish a regular security audit mechanism to identify and fix potential security vulnerabilities promptly to ensure the long-term stability of the Platform. Secondly, a comprehensive risk assessment mechanism should be established to formulate a scientific and reasonable information security strategy through a comprehensive assessment of potential threats within and outside the organization, providing the basis for building an information security guarantee system. Strengthen technical security measures and adopt advanced technical means, including but not limited to encryption technology, intrusion detection systems, firewalls, etc., to improve the system's ability to resist attacks. Cultivate information security culture, establish the importance of information security among platform employees through training and publicity activities, form an information security culture with full participation, and reduce internal security loopholes. Finally, comply with relevant regulations and standards, ensure that the establishment of the information security assurance system is in line with relevant national and industry regulations and standards, and improve the organization's compliance at the legal level. Establish an internal compliance monitoring mechanism, set up a special compliance monitoring team, conduct regular internal compliance reviews, correct non-compliant behavior promptly, and prevent potential legal risks. The Platform can introduce artificial intelligence technology to use artificial intelligence technology to analyze large amounts of security data to improve the speed of identifying and responding to threats and promote the application of blockchain, which is used in the field of information security to improve the transparency and non-tampering of data and enhance the credibility of information.

Optimization of the Learning Experience

The online learning experience must be continually optimized to improve student engagement and learning outcomes. First, innovative teaching design. Multimedia teaching content adopts innovative teaching design, incorporating interactive and engaging teaching content to stimulate students' interest in learning and enhance the learning experience. Adopt multimedia elements such as images, audio, video, etc., to enrich the teaching content, stimulate students' interest in learning, and improve the effect of information transfer.

Second, personalized learning experience. By analyzing students' learning behaviors and interests, customized learning paths are tailored for each student to improve the relevance and effectiveness of learning. They are establishing an intelligent learning system to provide each student with a customized learning path and advice by analyzing students' learning behavior and interests.

Third, enhancing interactivity. Real-time online discussion: Setting up online discussion forums encourages students to raise questions and share insights during the learning process and promotes interaction and communication among classmates. Incorporate group cooperation projects and design group cooperation projects to solve problems through collaboration, prompting students to learn teamwork and enhance interactivity.

The online learning experience can be significantly enhanced through the integration of innovation, personalization, and interactivity, and such optimization efforts will help to stimulate students' interest in learning, improve learning outcomes, and make online learning a more productive and satisfying form of education. Educational institutions and educators should.

Balancing Information Security and the Learning Experience

Children's education platforms must enhance information security and students' learning experience. This can be done through education platform design principles, which consider the needs of both information security and learning experience at the early stage of platform design to ensure that the concept of balance runs through the entire platform development process. User training and awareness-raising, providing information security training for users of the education platform, enhancing their awareness of information security, helping them to use the Platform better, and improving the learning experience. A timely feedback mechanism, establishing user feedback and complaint mechanism, promptly solving user problems in information security and learning experience, and maintaining the stability of the Platform and user satisfaction. By comprehensively considering information security and learning experience, a balanced children's education platform has become essential in the current education field. Only by ensuring information security and optimizing the learning experience can the long-term sustainable development of the Platform be genuinely achieved. Therefore, balance is the key to building a successful education platform, which requires the joint efforts of educational institutions, technical teams, and users to promote the healthy development of the Platform. Fig. 7 is a diagram of balancing information security and learning experience.
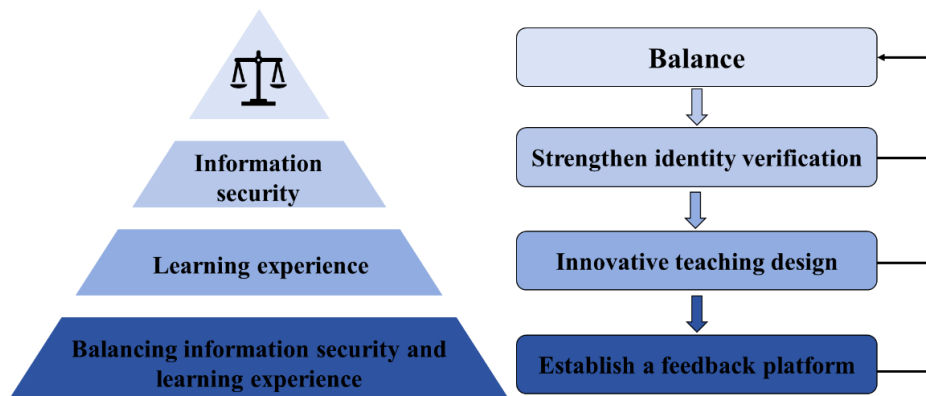

Figure 7. Balancing information security and learning experience diagram

Conclusion

This deployment-based research employed a trial-and-error approach to examine student-teacher interactions while utilizing content-rich biotechnology virtual laboratories to address the fundamental classroom requirements in a traditional learning environment. The study evaluated the general caliber of biotechnology

Virtual Labs using a questionnaire-based feedback mechanism. Several inquiries about virtualization were posed among the principal topics.

This study investigated the adaptation of ICT-enabled biotechnology virtual labs in schooling, the efficacy of biotechnology virtual laboratories as instructional tools, and the trends among educators in incorporating biotechnology virtual laboratories into their curricula. Participants in the workshops concurred on the prospective function of biotechnology virtual laboratories as adaptable learning environments for enhancing performance levels. Virtual laboratories might thus be regarded as a preliminary stage in improving user satisfaction.

The comments indicated that teachers favored utilizing biotechnology virtual lab resources for class speeches, reducing time spent on topic preparation and enhancing classroom instruction. Educators endorsed that integrating virtual laboratories in the biotechnology program might improve the quality of teaching in institutions that need more laboratory facilities and proficient instructors. Someone who participated in the session highlighted our results with her remark: "Virtual laboratories are quite beneficial to pupils who want to gain knowledge and engage in logical thinking before entering the laboratory." It assists educators in enhancing their preparation for improved outcomes, delivering superior results to my school and our nation. The effective integration of virtual laboratories across all institutions would undoubtedly enhance the standard of those leaving annually.

The message of safety in an online educational platform for children's education should come from the student and go to the student. As a platform party, the most essential thing that should be regarded and cannot be ignored in the learner's learning is that the student is a developing person. Online learning should be horizontal and vertical, focusing on the breadth and depth of learning to provide learners with dynamic recommendations to better provide personalized services. In addition to this, it is necessary to concentrate on human-computer collaboration. The online education platform integrates technology and education. However, the learning process is pretty complex. The human teacher is essential, but the robot can do enough for human teachers to reduce repetitive, monotonous labor, to use the data to understand the learner, for the learner to carry out accurate recommendations, knowledge tracking, and so on. Of course, real learning is a complex, cumbersome process, affected by many factors. Still, personalized learning in online education platforms is slowly progressing, and real customized learning will be realized shortly.

Current research demonstrates a rising trend in the amount of biotechnology virtual lab participants. The study suggests that online laboratories can serve as an ancillary solution to the challenges encountered by various institutions and consumers in urban and rural regions of physically and financially disadvantaged countries while functioning as a successful promotion tool for education and self-directed learning processes. While the aspects require future enhancement, our virtualization strategy has effectively addressed several critical outcomes in developing virtual lab functionalities, including a teacher-independent and teacher-friendly method for e-learning.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

Reference

Arogundade, O. R. (2023). Network security concepts, dangers, and defense best practical. *Computer Engineering and Intelligent Systems*, 14(2).

Chakraborty, P., Mittal, P., Gupta, M. S., Yadav, S., & Arora, A. (2021). Opinion of students on online education during the COVID-19 pandemic. *Human Behavior and Emerging Technologies*, 3(3), 357-365.

Da Veiga, A., Astakhova, L. V., Botha, A., & Herselman, M. (2020). Defining organisational information security culture—Perspectives from academia and industry. *Computers & Security*, 92, 101713. https://doi.org/10.1016/j.cose.2020.101713

Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies*, 10(4), 86.

Hina, S., & Dominic, P. D. D. (2020). Information security policies' compliance: a perspective for higher education institutions. *Journal of Computer Information Systems*.

Liu, X. Y., Wang, X., Jia, S., Li, T., Zhang, Y., Lu, C., & Wang, Y. F. (2023). LEPPA: A teaching modality of biotechnology course for postgraduate students in biomedical majors. *Innovations in Education and Teaching International*, 60(2), 263-273.

Manyilizu, M. C. (2023). Effectiveness of virtual laboratory vs. paper-based experiences to the hands-on chemistry practical in Tanzanian secondary schools. *Education and Information Technologies*, 28(5), 4831-4848.

Mishra, A., & Otaiwi, Z. (2020). DevOps and software quality: A systematic mapping. *Computer Science Review*, 38, 100308. https://doi.org/10.1016/j.cosrev.2020.100308

Müller, C., & Mildenberger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. *Educational Research Review*, 34, 100394. https://doi.org/10.1016/j.edurev.2021.100394

Röllke, K., Sellmann-Risse, D., Wenzel, A., & Grotjohann, N. (2021). Impact of inquiry-based learning in a molecular biology class on the dimensions of students' situational interest. *International Journal of Science Education*, 43(17), 2843-2865.

Serdar, C. C., Cihan, M., Yücel, D., & Serdar, M. A. (2021). Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies. *Biochemia medica*, 31(1), 27-53.

Servaes, J. (2022). Communication for development and social change. In *The Routledge handbook of nonprofit communication*, 23-31, Routledge.

Stoyanov, S., Glushkova, T., Tabakova-Komsalova, V., Stoyanova-Doycheva, A., Ivanova, V., & Doukovska, L. (2022). Integration of STEM centers in a virtual education space. *Mathematics*, 10(5), 744.

Tormey, R. (2021). Rethinking student-teacher relationships in higher education: a multidimensional approach. *Higher Education*, 82(5), 993-1011.

Wu, Z., Shen, S., Zhou, H., Li, H., Lu, C., & Zou, D. (2021). An effective approach for the protection of user commodity viewing privacy in e-commerce website. *Knowledge-Based Systems*, *220*, 106952. https://doi.org/10.1016/j.knosys.2021.106952