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Model Real-Time Viewer Monitoring Based on SDLC for Student Learning Outcomes

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Abstract: In modern educational environments, particularly within computer laboratory settings in higher education institutions, the lack of effective real-time supervision and streamlined assessment processes presents a persistent challenge. Most current systems still rely on manual monitoring and evaluation, which are not only inefficient and time-intensive but also vulnerable to academic dishonesty, such as copy-paste behaviour during lab work. This study identifies and addresses this critical gap by proposing the development and implementation of an integrated real-time monitoring and assessment system tailored for use in academic computer labs. The proposed solution is a desktop-based application that incorporates four key features: Real-Time Viewer (RTV) for live monitoring of student activities, Block Inappropriate Websites (BIW) to restrict access to non-educational or harmful content, Manage Computer Time (MCT) to regulate system usage duration, and Form Learning Assessment (FLA) for digitalized and efficient performance evaluation. The development process followed the System Development Life Cycle (SDLC) framework, ensuring a structured approach across analysis, design, implementation, testing, and maintenance stages. Empirical testing involved a series of functional test cases simulating real-use conditions. All seven critical scenarios—such as input validation, session management, access control, and data deletion—were executed and passed successfully, indicating

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the system's robustness and usability. In a pilot study conducted at Pekanbaru College of Technology, the application was tested among 30 students across multiple laboratory sessions. The results demonstrated a notable improvement in student engagement and learning performance. Quantitatively, students achieved learning assessment scores ranging from 84 to 96, with a calculated mean of 89.6 and a standard deviation of 4.1. These outcomes suggest that the introduction of automated, real-time monitoring significantly enhances not only instructional supervision but also the accuracy and fairness of learning assessments. This research contributes to the field by bridging the gap between digital classroom management and performance assessment in a higher education context. It introduces an innovative and practical approach for educators to maintain instructional quality while managing multiple learners in digital settings. Moreover, the findings provide empirical evidence supporting the integration of real-time supervision tools into educational systems to foster accountability, deter academic misconduct, and support data-driven instructional improvements.

Index Terms: Computer Surveillance, Real-Time Viewer (RTV), Block Inappropriate Websites (BIW), Form Learning Assessment

1. Introduction

Technology and Information in the era of the industrial revolution 4.0 is developing very rapidly and has an impact on education [1]. For this reason, students are educated to be able to face the challenges ahead to adapt to the rapid changes of the times [2]. Information and Communication Technology (ICT) has an impact on learning opportunities and can increase student motivation [3]. ICT allows teachers and students to tailor learning and dosage to individual needs [4]. According to [5] Technology-based learning environments can support changing learning outcomes. This is an opportunity for universities to utilize technology as a means of learning [6].

The use of digital technology in learning activities reflects cognitive processes and is causally related to student learning outcomes [7]. Opportunities from technological advances in dosing and learning provide digital competency knowledge and skills [8]. In education, technology adoption is an important component that determines teachers' desire to use digital devices in the teaching process [9]. So, in higher education digital technology is designed to drive strategic needs, professional development, and technological capabilities [10]. Students can develop critical thinking through the use of digital technology which increases their learning flexibility [11].

In today's era of globalization, many tasks require speed, precision, and ease. This has led to an increase in the use of technology and information, especially the use of computers and the Internet [12]. Almost every school need computer and the Internet to support student learning [13]. Computer labs are learning resources that can be used in the learning process. However, lecturers do not supervise the use of computers actively and thoroughly when students do practicum in the computer lab. In addition, the practicum results of each student are checked one by one during the assessment process. This process is less effective and takes a lot of time. In addition, if this process continues, students will become more inclined to copy-paste practicum projects because they feel they are not being supervised in real time by their teachers.

This study proposes a comprehensive digital classroom management system that not only allows lecturers to monitor student activities in real time but also incorporates direct assessment tools into the supervision interface. This dual-functionality system is novel in its integration and addresses a significant gap in current laboratory management technologies, which typically treat monitoring and assessment as separate processes. The Block Inappropriate Websites (BIW) feature is a feature that prohibits access to dangerous and inappropriate websites such as pornography, adult content, and criminal-related sites and blocks inappropriate websites. This system also has time management to manage surfing time accessing the internet [14]. The Manage Computer Time (MCT) feature is a feature to set time quotas and schedules for access to computers, individual applications, games, websites, and others. Meanwhile, to help the process of assessing learning outcomes/practicum, it is equipped with a Form Learning Assessment (FLA) feature, which is a feature that allows lecturers to input scores on applications based on monitoring carried out using the Real Time Viewer (RTV) feature. Learning assessment is an important aspect in the world of education because it is the key to success for teachers in bringing students to succeed in learning [15]. Previous research has focused on isolated aspects of digital classroom management, such as URL blocking, screen monitoring, or individual learning assessment systems. However, none has proposed or evaluated a system that integrates all these functionalities within a single, desktop-based application tailored to higher education lab environments. This study addresses this gap by designing and testing a multi-functional system that allows real-time supervision and simultaneous formative assessment, enhancing both student performance tracking and pedagogical efficiency.

1.1 Real-Time

According to the Oxford Computer Dictionary, real-time refers to any system where the output time is significant, meaning the delay between input and output must be minimal within the allowed time constraints [16]. Cooling, as cited in Rahmah, defines a real-time system as one that must generate the correct response within a specified time limit. If a

computer's response time exceeds this limitation, its performance may degrade or malfunction. A key characteristic of real-time systems is their connection to the environment through multiple interfacing devices, enabling the reception and transmission of various signals [17].

The problem faced is how to develop a system for monitoring hardware and system services that are in the computer system. Windows Management Instrumentation (WMI) is an infrastructure for data management and operations on Windows-based operating systems [18]. You can write WMI scripts or applications to automate administrative tasks on remote computers. WMI implements the functionality described in WMI classes called WMI Provider and WMI Class, as shown in Fig. 1.

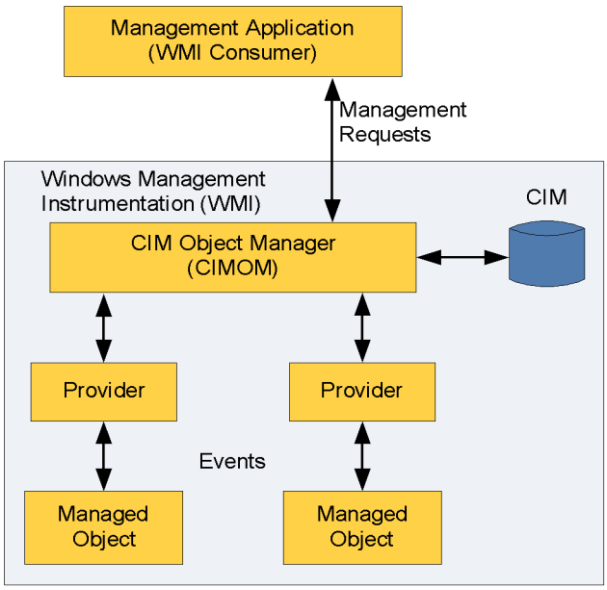


Fig. 1. WMI structure

1. WMI Consumer

   WMI Consumer is an application or script that interacts with WMI infrastructure.

2. CIM Object Manager

   Components in the WMI infrastructure that handle interactions between applications and providers.

3. Provider

Provider is a class of WMI to define interfaces for support retrieval, modification, deletion, data enumeration, and query processing (example: Win32 Provider).

4. Managed Object

Is a hardware or software system component represented as an object of the WMI class (example: Win32_OperatingSystem)

1.2 Form Learning Assessment (FLA)

Supervision has a very important role in maintaining the performance of an organization. In a general sense, supervision is a process of activities carried out by leaders in the organization to ensure that every activity carried out runs by plans, policies, and provisions that have been previously determined.

Supervision can be described with various views, such as inspection, assessment, and corrective actions for work results to be by the plan. With good supervision, leaders can ensure that every activity in the organization runs effectively and efficiently so that the organization can achieve its goals better. Therefore, supervision is one of the important factors in achieving the success of an organization.

Thus, assessment is not only aimed at scoring and ranking but also an effort to provide feedback to both students and educators to make improvements to teaching and learning as soon as possible to achieve common goals. In other words, assessment has always been an integral and integral part of learning and a crucial part of helping students and educators in teaching and learning.

2. Methods

System Development Life Cycle (SDLC) method. SDLC refers to the models and processes used to develop software systems and outlines the process, i.e., developers accept the move from problem to solution. System development and/or software engineering can mean putting together a completely new system or software or software that more often than not improves on the previous one. Stages used in research Fig. 2.

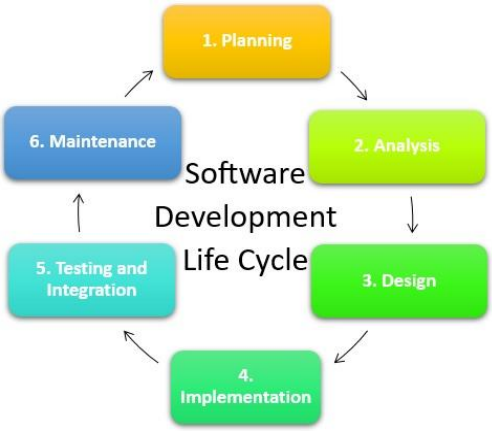


Fig. 2. SDLC Stages

1. Planning and Data Collection Phase

This stage is the planning and data collection needed in research. Data collection is carried out to obtain the information needed to achieve research objectives. Data collection is carried out by direct observation (observation), interviews, and documentation of library studies by studying books in libraries, journals, or even the internet that have something to do with the problems in this study.

2. Data Analysis Phase

From the results of planning and data collection, then conduct an analysis, namely analysis of system or application specifications, analysis of user specifications to analysis of operating devices that will be used to build the system.

3. System Design Stage

In designing or designing the system, the author uses model design in the form of Unified Modeling Language (UML) and design in the form of output design, input design, and database design.

4. System Creation and Implementation Stage

The system implementation stage is the stage where the model/design that has been designed is then built into a system by the research objectives.

5. System Testing Phase

Testing is done by black-box testing, which is a test that focuses on software functionality requirements. This test allows the system analyst to test the functionality of the system based on the input conditions worked on by the system.

6. System Maintenance and Development Phase

This stage is carried out to improve and keep the system running as it should.

7. Features of the App

Desktop-based computer surveillance applications such as personal computers, laptops, and notebooks are connected to the same network (Local Area Network).

The Real-Time Viewer (RTV) feature is a feature that works by monitoring every activity on the computer in real time. Form Learning Assessment (FLA) is a feature that allows lecturers to input grades on applications based on monitoring carried out using the Real Time Viewer (RTV) feature previously described. To facilitate the assessment, students are required to fill in the Student Identification Number when using the computer.

The Block Inappropriate Websites (BIW) feature is a feature that prohibits access to dangerous and inappropriate websites such as pornography, adult content, and criminal-related sites. The Manage Computer Time (MCT) feature is a feature to set time quotas and schedules for access to computers, individual applications, games, websites, and others.

The monitoring application was developed as a desktop-based system using the Microsoft .NET Framework, with the C# programming language selected due to its robust support for Windows-based development and seamless integration with Windows Management Instrumentation (WMI). This integration was critical for enabling real-time access to system-level data and control of user terminals, which is essential for implementing features such as the Real-Time Viewer (RTV), Block Inappropriate Websites (BIW), and Manage Computer Time (MCT). The software development was conducted using Microsoft Visual Studio, which served as the integrated development environment (IDE) and provided advanced capabilities for interface design (through Windows Forms), debugging, dependency management, and interaction with Windows Services.

From a systems architecture perspective, the application adopts a client-server model operating within a Local Area Network (LAN). This architecture allows multiple student workstations (clients) to be monitored and managed centrally by a lecturer terminal (server), enabling synchronous data exchange and supervision. Real-time communication between the server and client systems was achieved using socket programming, which facilitated instantaneous control signals such as computer shutdown commands or dynamic URL filtering enforcement.

The backend of the system utilizes Microsoft SQL Server for data persistence, ensuring secure and structured storage of essential information such as user login credentials, session logs, student identification numbers, assessment records, and activity history. The database design supports both transactional integrity and scalability, which is essential for institutional deployment. On the front-end, the application's interface was implemented using Windows Forms technology, allowing for an intuitive and user-friendly design that supports the full range of system functionalities.

Overall, the combination of WMI-based system access, socket-based network communication, and SQL-driven data storage enables the application to operate effectively in a real-time educational environment. This implementation not only ensures functional reliability and performance efficiency but also supports modular expansion for future features, such as cloud integration, learning analytics, or cross-platform deployment using .NET Core or MAUI (Multi-platform App UI).

3. Result and Discussion

3.1 Use Case Diagram

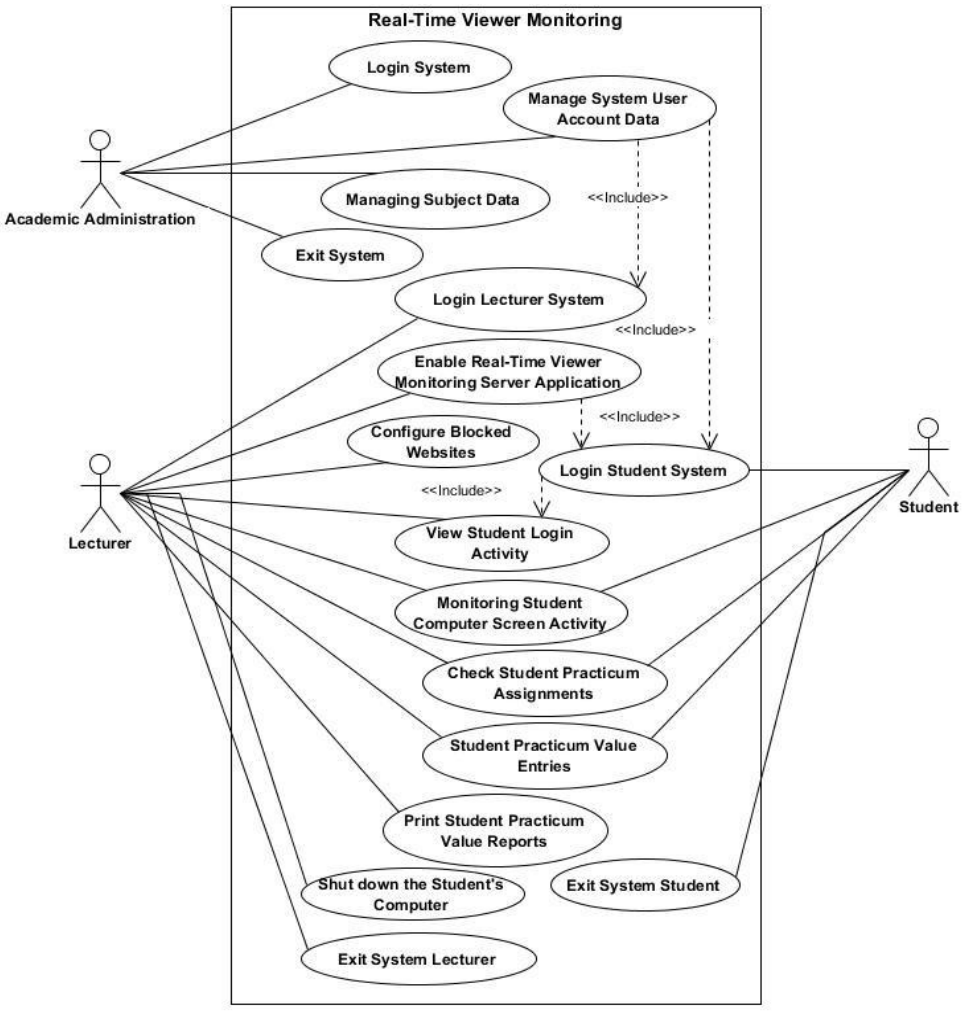


Fig. 3. Use case Diagram Application Monitoring System

Fig. 3. is a use case diagram of the monitoring system. Use cases are diagrams that illustrate the interaction relationships between systems and actors. The monitoring system has 3 actors, namely lecturers, students and Baak. Lecturers have a role as the main user of the application that can see computer status, manage site blocks, manage application limits, conduct monitoring, and conduct assessments. Meanwhile, students only log in and do practicum in the laboratory. While Baak is in charge of managing.

The specific roles and interactions of each actor within the system lecturers, students, and administrative staff (Baak) are outlined in detail in Table 1, which provides a structured breakdown of each use case associated with the system's functionality. Lecturers serve as the primary users, with access to comprehensive controls including monitoring student activity, managing access restrictions to websites and applications, inputting student performance evaluations, and viewing assessment results. Students, on the other hand, engage with the system by logging in, performing practicum tasks, and adhering to the rules set by the monitoring system. Meanwhile, Baak is responsible for system-level administration, ensuring user data accuracy, access control, and overall maintenance of lab operations. This table captures the full interaction flow and functional permissions for each actor, illustrating how the system supports instructional goals while maintaining structured operational boundaries between users.

Table 1. Use Case Description

No	Use case	Description
1.	Login	All actors can log in, and by logging in, users will be given access to various features or functions available on the system or device.
2.	View Computer Status	All actors can check the status or condition of hardware and software on a computer. This can include information about the specifications of the application that has been built.
3.	Doing Practicum in the Laboratory	Performed by student actors. Use equipment and instruments available in the laboratory to carry out learning activities.
4.	Manage Site Blocks	Lecturers can use this feature by involving setting access to certain websites. Blocking websites can be done for a variety of reasons, such as to avoid access to inappropriate content or to improve network security.
5.	Manage App Restrictions	Lecturers can manage application restrictions involving setting access to specific applications on a device or system. This can be done to control the use of unwanted applications or to improve the efficiency of the learning process.
6.	Monitoring	Lecturers carry out monitoring that can monitor certain activities or events on the device. This can include monitoring network traffic, as well as the use of computer activity.
7.	Conducting Assessments	Lecturers assess the performance or results of students. Assessments can be done for a variety of purposes, such as to evaluate progress.
8.	View a list of student grades	Lecturers can view and check student grade records.

3.2 Activity Diagram

Fig. 4 illustrates the detailed Activity Diagram representing the workflow of the monitoring process carried out by lecturers during laboratory sessions. This diagram outlines each sequential step taken by the lecturer, starting from system login and authentication, proceeding to the selection of target student devices, and continuing with real-time supervision via the Real-Time Viewer (RTV) feature. It also includes interactions such as initiating the blocking of inappropriate websites through the BIW module, managing application access, setting computer usage limits via the MCT feature, and conducting formative assessments using the FLA interface. This activity diagram is crucial as it visually demonstrates the dynamic interactions between the lecturer and system components, ensuring an efficient and responsive monitoring process that supports both classroom management and real-time performance evaluation. By representing these actions in a structured process flow, the diagram enhances understanding of the system’s operational logic and supports validation of its usability and pedagogical effectiveness.

Fig. 5 presents the Activity Diagram illustrating the sequence of actions performed by students when utilizing the system in a laboratory environment. The process begins with students logging into the monitoring application using their unique credentials, typically including their student identification number (NIM). Upon successful authentication, students proceed to engage in practical lab activities by operating assigned computers connected to the Local Area Network (LAN). During this session, all student activities are continuously monitored in real time by the lecturer via the Real-Time Viewer (RTV).

If students attempt to access inappropriate websites or unauthorized applications, the system, through the BIW (Block Inappropriate Websites) and MCT (Manage Computer Time) modules, automatically restricts access and may display warning messages. The diagram also captures user interactions such as receiving system notifications, adhering to session time limits, and responding to assessments initiated by the lecturer via the Form Learning Assessment (FLA) feature. This activity flow emphasizes the system’s role in fostering student accountability, reducing off-task behavior, and supporting structured, technology-enhanced learning practices in the lab setting.

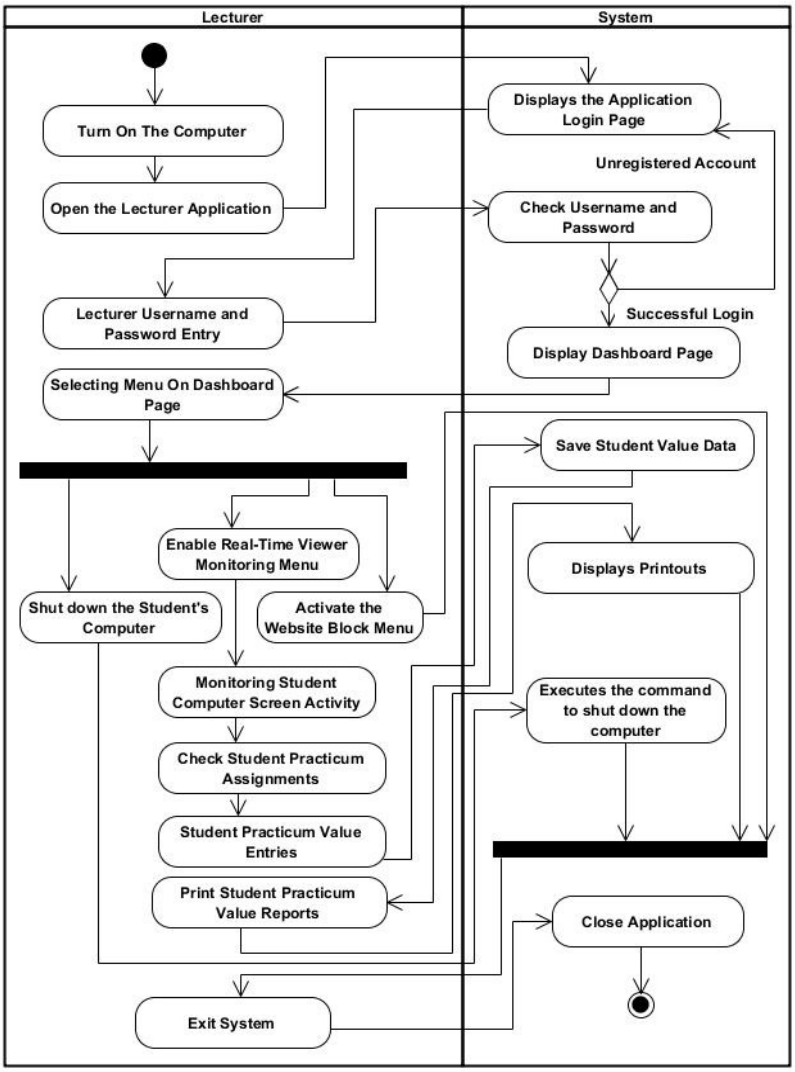


Fig. 4. Activity Diagram of the running Monitoring process

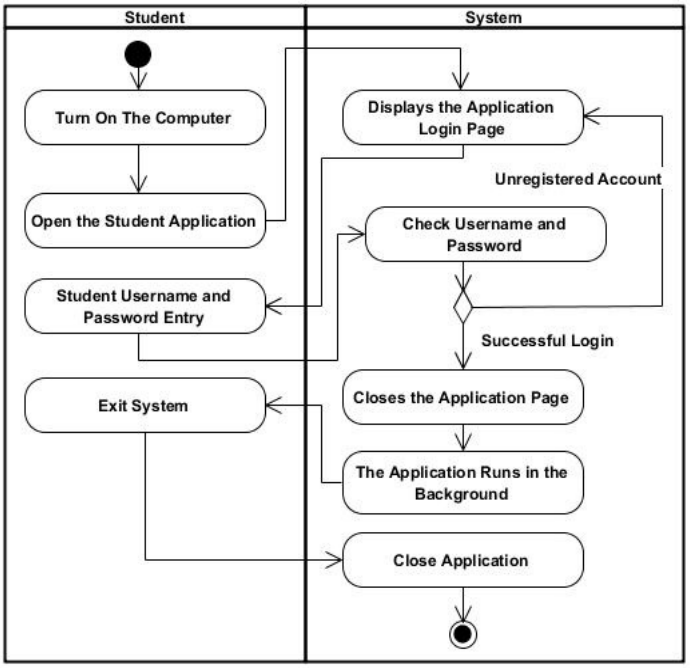


Fig. 5. Activity Diagram of Laboratory Use by Students through the system

Fig. 6 shows the Activity Diagram detailing the actions performed by Baak (administrative staff) in managing and supporting the operation of the monitoring system. The Baak role is crucial in ensuring the readiness and stability of the system before and during laboratory sessions. The diagram begins with the Baak logging into the system, followed by verification of administrative privileges.

Once authenticated, Baak is responsible for performing key preparatory tasks, such as updating user account data (students and lecturers), registering and validating student identification numbers (NIM), and verifying network connectivity to ensure all laboratory computers are properly linked within the Local Area Network (LAN). Additionally, Baak may assist in scheduling lab sessions, ensuring system time synchronization, and providing technical support to resolve issues related to user access or computer readiness.

This diagram also reflects how Baak supports data consistency by maintaining the integrity of backend databases, ensuring that all logged activities and assessments are recorded accurately. Their administrative interactions, while less frequent than those of lecturers or students, are vital for the system's smooth operation and data management. The inclusion of this actor in the system architecture illustrates the collaborative nature of digital learning infrastructure and emphasizes the importance of non-teaching staff in facilitating real-time, technology-assisted education.

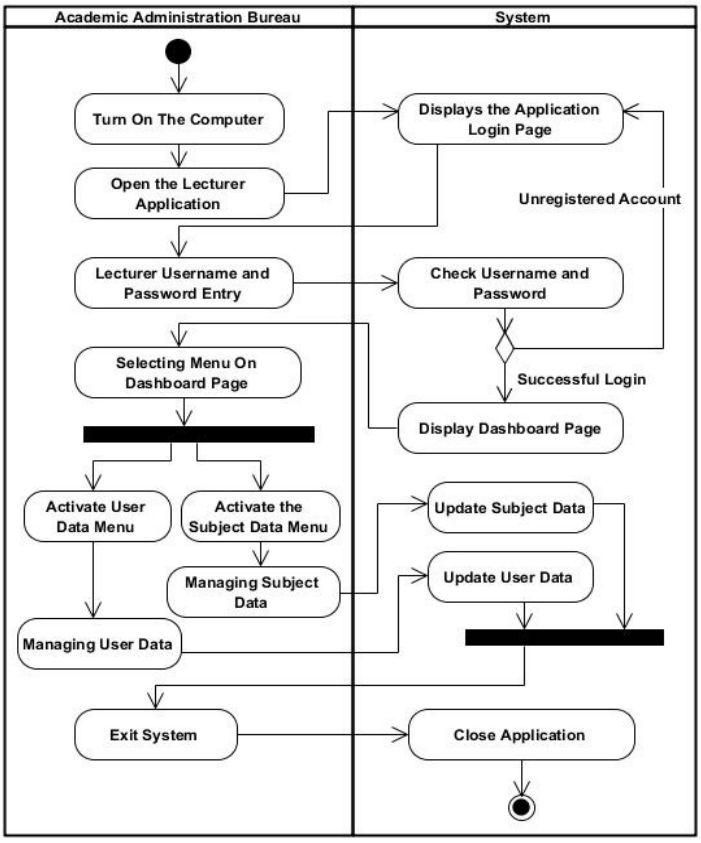


Fig. 6. Activity Diagram of Laboratory Use by Baak

3.3 Sequence Diagram

Sequence diagrams are essential tools in system design documentation, used to visually represent the chronological interaction between system components, users, and functional modules over time. They help developers, analysts, and stakeholders understand the flow of operations, communication logic, and dependencies between actors and system elements. In the context of this research, the sequence diagram in Fig. 7 specifically illustrates the interaction process initiated by the lecturer when using the monitoring application during a laboratory session.

The diagram outlines a step-by-step communication sequence starting from the lecturer logging into the system, followed by authentication and validation of credentials. After successful login, the lecturer initiates a monitoring session where requests are sent to retrieve the status of all connected student computers. The server responds with real-time activity data, which is then displayed via the Real-Time Viewer (RTV). The lecturer may then activate additional features such as blocking inappropriate websites (BIW), restricting access to certain applications (MCT), or directly inputting performance evaluations through the Form Learning Assessment (FLA) interface.

The diagram also includes message exchanges such as confirmation responses from the client devices, error handling messages (e.g., “PC offline”), and commands for locking, restarting, or logging activities. Each of these interactions is sequenced to reflect the temporal order of operations, reinforcing the system’s real-time responsiveness and the lecturer’s control over the lab environment. This structured visualization supports clearer system

implementation, reduces the risk of miscommunication during development, and facilitates future maintenance or feature integration.

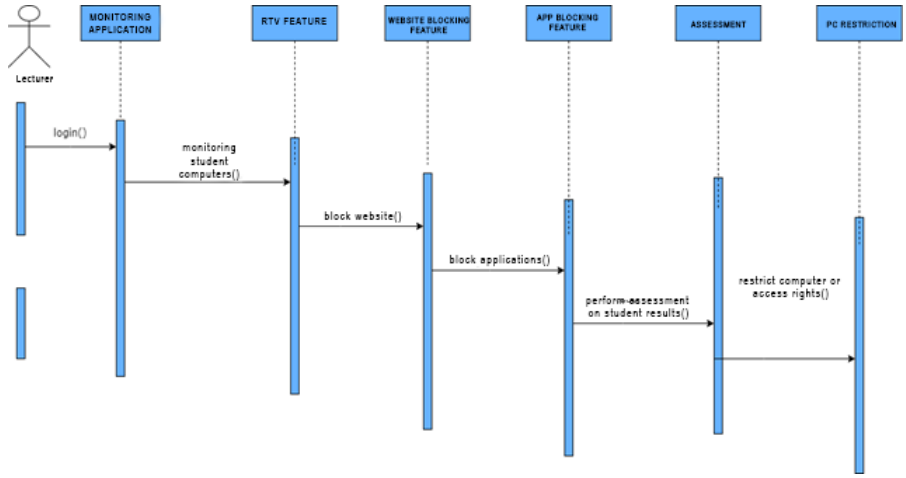


Fig. 7. Sequence Diagram of Monitoring Application

3.4 Application Interface Design

The login view, as shown in Fig. 8, represents the primary access interface through which all users—lecturers, students, and administrative staff (Baak)—authenticate themselves before entering the system. This interface serves as a security gateway that ensures only authorized individuals can interact with system features according to their designated roles.

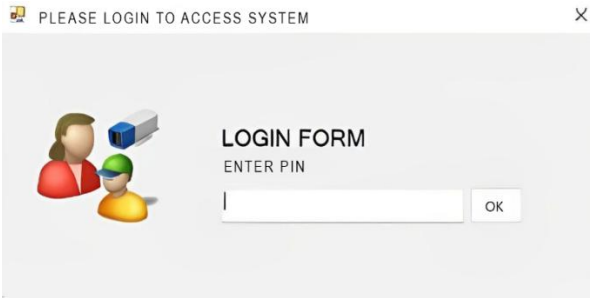


Fig. 8. Application access login view

The lecturer's main page, depicted in Fig. 9, is the core dashboard interface that becomes accessible immediately after a successful login by users assigned the lecturer role. This interface is specifically designed to centralize all monitoring and assessment functionalities needed for supervising student activity during lab sessions. It provides a user-friendly, task-oriented layout where lecturers can easily navigate between essential features such as Real-Time Viewer (RTV), Block Inappropriate Websites (BIW), Manage Computer Time (MCT), and Form Learning Assessment (FLA).

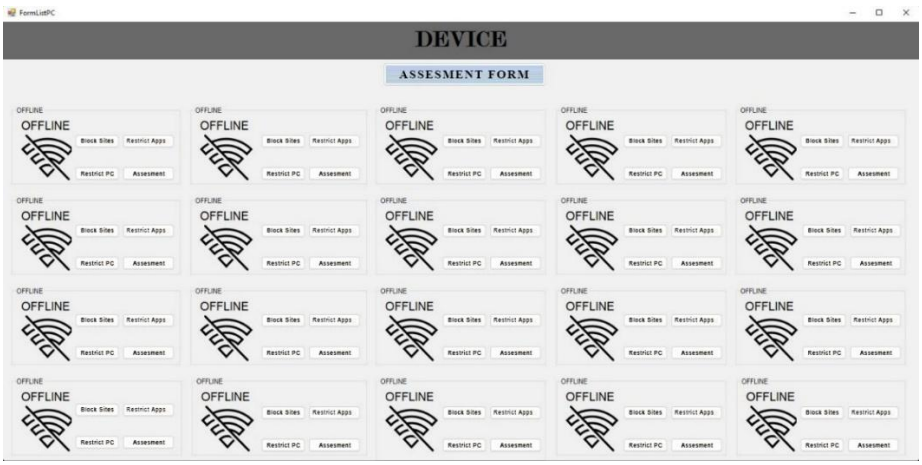


Fig. 9. Display of the Lecturer's Main Page

The Restrict Site View feature, as illustrated in Fig. 10, is a core component of the system's digital supervision tools designed to enhance student focus and reduce exposure to inappropriate or distracting online content during lab sessions. This feature enables lecturers to actively manage internet access by blocking access to predefined websites categorized as non-educational, such as social media, entertainment, gambling, or adult content. The site-blocking mechanism operates by implementing URL filtering rules at the client level, which are controlled and updated in real time through the lecturer's dashboard interface.

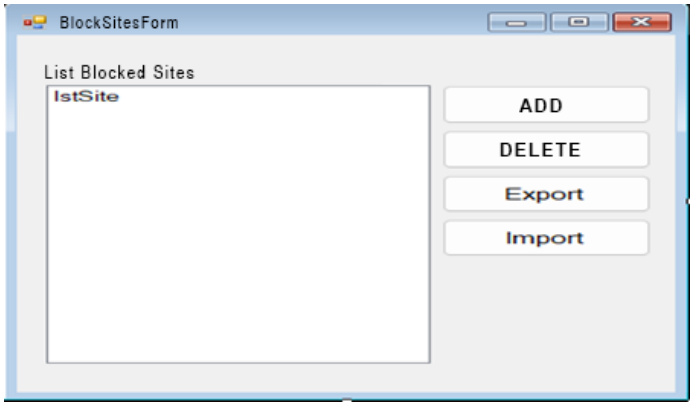


Fig. 10. Site Block View

The Restrict Application display feature, as presented in Fig. 11, is a crucial function within the lecturer's monitoring interface that enables fine-grained control over the applications running on student computers. This feature allows lecturers to restrict access to non-educational or unauthorized software—such as games, social media apps, messaging platforms, or even development tools not relevant to the current practicum session. By actively managing which applications are allowed or blocked, lecturers can ensure that students remain focused on the assigned learning tasks and avoid off-task behavior during laboratory use.

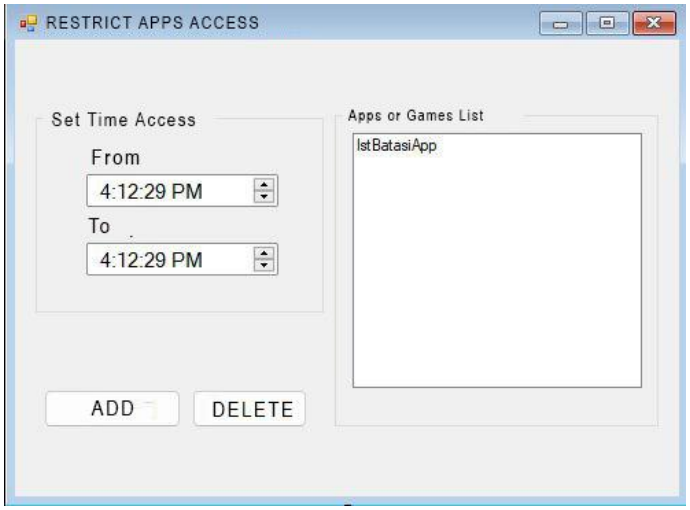


Fig. 11. Restrict Apps view

The Limit Computer Use display feature, as illustrated in Fig. 12, provides lecturers with the ability to remotely control and restrict student computer usage in a precise and authoritative manner. This feature is especially useful for enforcing time limits during lab sessions, ensuring compliance with classroom policies, and managing behavioral issues that may arise from misuse of technology. When activated, the system can issue shutdown, lock, or log-off commands to one or more student devices over the Local Area Network (LAN), effectively halting their activity on the computer.

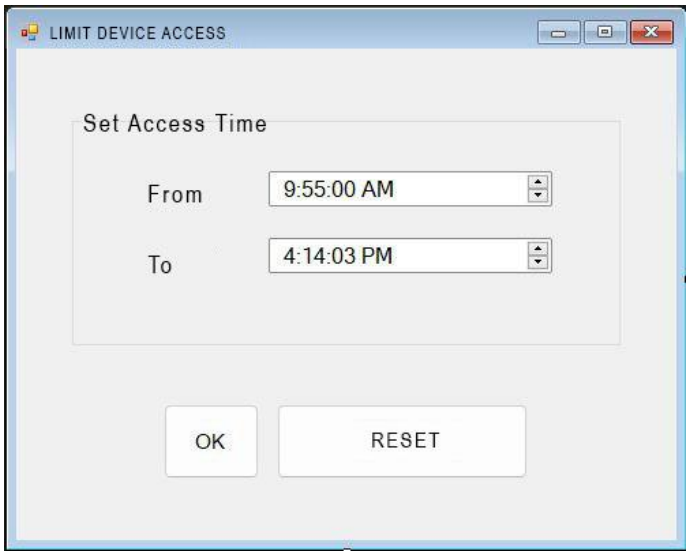


Fig. 12. Restrict Computer Use view

The Process Monitoring feature, as shown in Fig. 13, is a critical component of the real-time supervision capabilities within the system. This feature enables lecturers to track, in real time, all active processes and applications currently running on each student's computer. It provides a comprehensive view of software activity, including background services, foreground applications, and user-initiated programs, allowing for detailed oversight of how each workstation is being used during lab sessions.

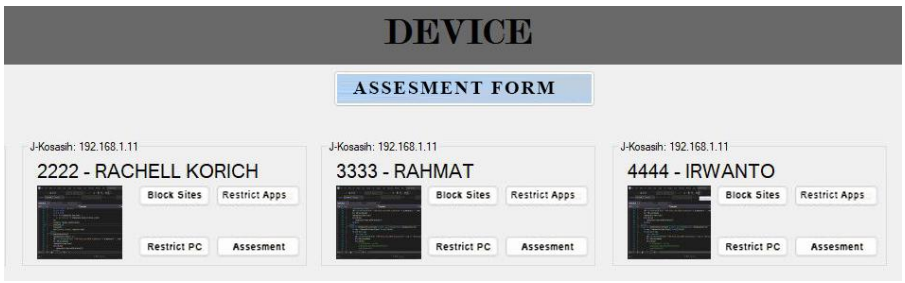


Fig. 13. Monitoring Process View

The Student Score Input display feature, illustrated in Fig. 14, serves as a vital assessment interface within the application that enables lecturers to evaluate student performance directly based on their real-time supervision during lab activities. This feature is tightly integrated with the Real-Time Viewer (RTV), allowing lecturers to monitor behavior, task completion, and application usage before assigning grades. Unlike traditional manual assessments that rely on post-activity reports or physical submissions, this system allows for immediate, on-the-spot evaluation aligned with observable actions.

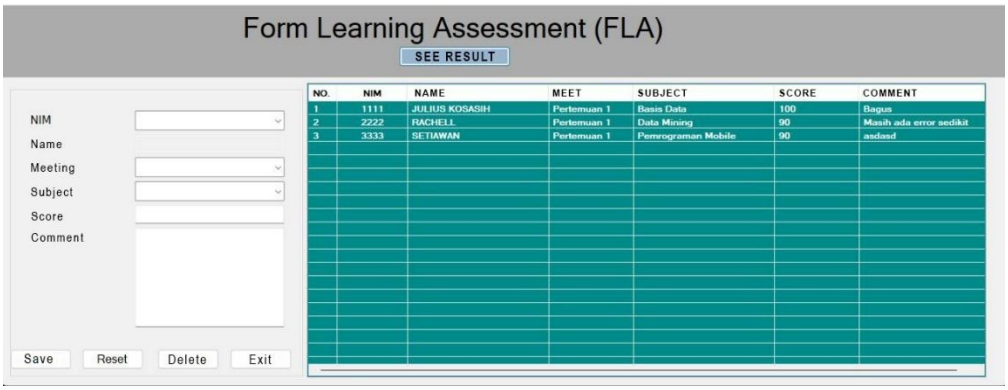


Fig. 14. Assessment input display

3.5 Application Test Result

The application testing process was conducted to ensure the system functions as intended under various scenarios. Table 2 presents the results of multiple test cases, covering key functionalities such as PIN validation, assessment form input, student identification number (NIM) entry, and computer usage restrictions. The test results indicate that the system appropriately handles missing inputs by displaying relevant error messages, preventing further actions until required data is provided. Additionally, features such as student computer usage limitations and assessment data deletion performed as expected, confirming their effectiveness. Each test scenario was validated successfully, demonstrating the system's reliability in enforcing proper controls and maintaining data integrity.

Table 2. Application testing

No	Test Scenarios	Test Case	Expected results	Test Results	Conclusion
1.	PIN Not filled by the lecturer.	"Blank" PIN	The system cannot proceed with the message "Data cannot be Empty"	As Expected	Valid
2.	Lecturer Fills Out Assessment Form But none of the students use PCs.	"Pressing the Assessment Button"	The application cannot input the assessment form and displays the message "Sorry, PC is Offline"	As Expected	Valid
3.	NIM is not filled by students.	"Pressing Button OK"	The application cannot be continued and must enter the NIM that has been entered in the database and display the message "Data cannot be empty"	As Expected	Valid
4.	Lecturers do not fill in the Meeting. or courses on the student grade data form.	"Pressing the Show Data Button"	The application cannot display the student grade data form and display the message "Data not found"	As Expected	Valid
5.	Lecturers limit the use of student computers.	"Pressing the limit PC button"	The application runs according to the feature to turn off the use of student computers and display a message on the student's computer "Sorry, Computer Usage Limit Expired"	As Expected	Valid
6.	Lecturer Deletes Student Grade Data.	“Pressing the Delete Button"	Data in the Learning Assessment Form will be deleted with the message "Data Successfully Deleted"	As Expected	Valid
7.	Students press the "OK" button when restricting the use of computer access.	“Pressing the OK Button"	The application will immediately turn off the computer and will turn on according to the time limit set by the lecturer.	As Expected	Valid

3.6 Assessment of learning outcomes

In this section, Fig. 15 illustrates the learning assessment outcomes derived from the implementation of the real-time monitoring and evaluation system during practicum sessions in the computer laboratory. The figure presents the distribution of student scores obtained through the integrated assessment process using the Form Learning Assessment (FLA) feature. These results are the product of direct supervision by lecturers, who observed student activities using the Real-Time Viewer (RTV) and provided immediate evaluations through the system.

The data shown reflect a consistent range of student performance, with recorded scores varying from 84 to 96 and an average (mean) score of 89.6 with a standard deviation of 4.1. This indicates that the majority of students achieved good to excellent learning outcomes, suggesting a high level of engagement and task completion accuracy. The close clustering of scores around the mean also implies that the system contributed to equitable learning conditions, where students were uniformly guided and supervised throughout the session.

The visual presentation in Fig. 15 not only summarizes the effectiveness of the monitoring application in supporting assessment practices but also reinforces the pedagogical value of integrating supervision with grading. The real-time nature of the evaluation helped minimize delays, reduce subjectivity, and allowed instructors to assess based on observed behavior rather than relying solely on submitted outputs. These outcomes are consistent with previous studies that support the use of digital assessment tools in promoting transparency, immediacy, and fairness in the evaluation process. Therefore, the results illustrated in Figure 15 serve as empirical evidence of the system’s ability to enhance the quality of learning in a controlled and supervised digital environment.

Student learning assessment results range from 84 to 96, with good to excellent categories. This research is in line with [15] that learning-oriented assessment has been cited as a technique that can be used to enhance the power of assessment in the classroom and can encourage effective learning for students.

The application testing process confirmed that the developed monitoring system functions reliably across a variety of use cases. Each of the seven test scenarios was executed successfully, validating the application's ability to handle input errors, enforce time restrictions, manage access to applications and websites, and execute data operations such as deletion and retrieval. These consistent outcomes demonstrate that the system not only meets functional requirements but also ensures operational reliability in a real-time educational setting.

A notable contribution of the system is its integration of monitoring and assessment features—Real-Time Viewer (RTV) and Form Learning Assessment (FLA)—within a single platform. This integration facilitates seamless supervision and immediate performance evaluation, distinguishing the system from most existing solutions that treat supervision and assessment as separate modules. The student learning assessment results, which ranged from 84 to 96 ($M = 89.6$, $SD = 4.1$), indicate improved academic engagement and potentially greater motivation due to the

transparency and immediacy of feedback provided by the system. This supports findings from prior studies which show that real-time digital supervision enhances students' concentration and reduces off-task behavior.

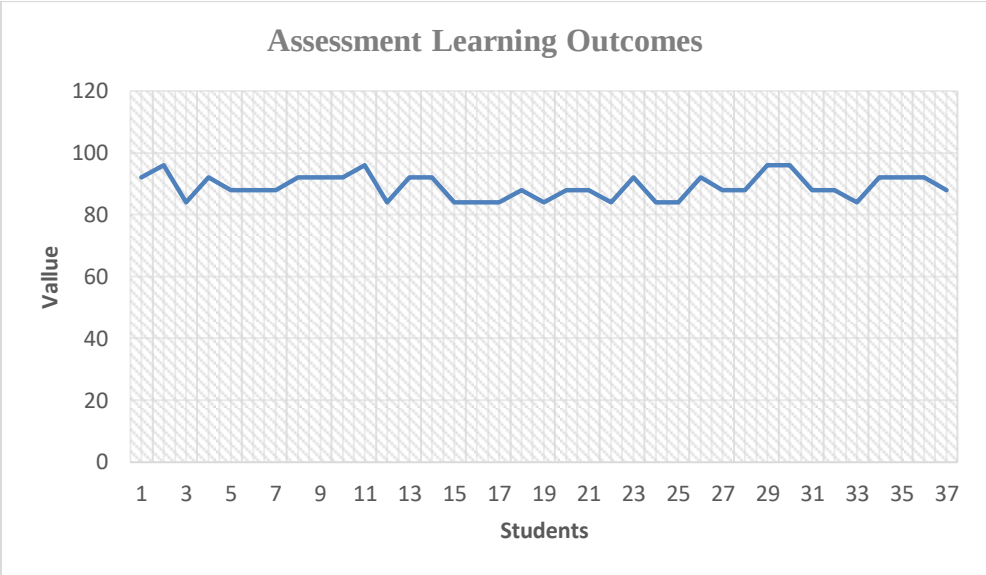


Fig. 15. Learning Assessment Outcomes

Furthermore, the Block Inappropriate Websites (BIW) and Manage Computer Time (MCT) features empowered lecturers to minimize distractions and enforce digital discipline, which are often cited as challenges in lab-based learning environments. By limiting access to non-educational content and managing computer usage duration, these features contributed to a more controlled and pedagogically effective setting.

Overall, the system offers a comprehensive solution for addressing multiple pain points in computer lab management—supervision, discipline, and assessment—through an integrated, scalable, and user-friendly application. These findings demonstrate not only the technical feasibility but also the pedagogical value of the system in improving student outcomes. Future work may explore expanding the system's capabilities to web-based or cross-platform environments, and integrating learning analytics to support adaptive feedback mechanisms.

4. Conclusion

This study successfully designed, developed, and tested a desktop-based laboratory monitoring system using the SDLC approach, which includes the Real-Time Viewer (RTV), Block Inappropriate Websites (BIW), Manage Computer Time (MCT), and Form Learning Assessment (FLA) features. Beginning with the identification of key problems in lab supervision and assessment, the study proceeded through stages of requirements analysis, system design using UML, implementation, black-box testing, and evaluation. The system effectively fulfilled its intended functionality, as confirmed by the successful execution of seven test scenarios. Moreover, the deployment of the system led to improved student learning outcomes, with assessment scores ranging from 84 to 96 (M = 89.6), and demonstrated enhanced monitoring efficiency for instructors. The integrated approach to supervision and assessment presents a novel solution to long-standing challenges in computer-based learning environments. Future research may enhance this framework by integrating adaptive analytics and enabling cloud-based scalability.

Author Contributions Statement

Wilda Susanti – Conceptualization, methodology, system design, and writing – original draft preparation.
Nicholas Renaldo – Software development, implementation of the real-time monitoring system, and data collection
Gusrio Tendra – Data analysis, validation, and visualization of results.
Torkis Nasution – Literature review, framework development based on SDLC, and writing – review & editing
Johan – Testing, system evaluation, and quality assurance
Rahma Widi – Project administration, supervision, and funding acquisition
Yulvia Nora Marlim – Final review, proofreading, and manuscript editing.
All authors have read and agreed to the published version of the manuscript.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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Data Availability Statement

Availability of Data and Materials.

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Declarations

This study did not involve any experiments on humans or animals. The data used in this research were collected in accordance with institutional guidelines. If applicable, informed consent was obtained from all participants involved in the study.

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Declaration of Generative AI in Scholarly Writing

During the preparation of this manuscript, the authors used AI-assisted tools to support language refinement, grammar checking, and improving the clarity of the text. The authors carefully reviewed and edited all AI-generated content to ensure accuracy, validity, and compliance with academic standards. The final content remains the sole responsibility of the authors.

Abbreviations

The following abbreviations are used in this manuscript:

RTV - Real-Time Viewer
MCT - Manage Computer Time
FLA - Form Learning Assessment
SDLC - System Development Life Cycle
BIW - Block Inappropriate Websites
WMI - Windows Management Instrumentation
LAN - Local Area Network

Appendix

None

References

[1] N. F. Hassan, S. Puteh, A. M. Sanusi, and N. H. C. M. Zahid, "Student perspective on technology enabled/enhanced active learning in educational: Rasch measurement model," Int. J. online Biomed. Eng., vol. 16, no. 6, pp. 34–47, 2020, doi: 10.3991/ijoe.v16i06.13575.

[2] B. Kurent and S. Avsec, "Examining pre-service teachers regulation in distance and traditional preschool design and technology education," Heliyon, vol. 9, no. 2, p. e13738, 2023, doi: 10.1016/j.heliyon.2023.e13738.

[3] J. Komar, J. Y. Chow, M. Kawabata, and C. Z. Y. Choo, "Information and Communication Technology as an enabler for implementing Nonlinear Pedagogy in Physical Education: Effects on students' exploration and motivation," Asian J. Sport Exerc. Psychol., vol. 2, no. 1, pp. 44–49, 2022, doi: 10.1016/j.ajsep.2022.02.001.

[4] B. Hu et al., "A pilot study of Global ICT strategy applications in sustainable continuing education," Procedia Comput. Sci., vol. 183, pp. 849–855, 2021, doi: 10.1016/j.procs.2021.03.009.

[5] Hardika, E. N. Aisyah, K. M. Raharjo, and D. U. Soraya, "Transformation the meaning of learning for millennial generation on digital era," Int. J. Interact. Mob. Technol., vol. 14, no. 12, pp. 69–81, 2020, doi: 10.3991/IJIM.V14I12.15579.
[6] W. Susanti, R. Ry, and T. Nasution, "Online Learning Innovation in the Era and Post Covid-19 Pandemic," vol. 608, no. Ictvet, pp.35–41,2021, [Online]. Available: https://books.google.co.id/books?id=dn9XEAAAQBAJ&source=gbs_slider_cls_metadata_7_mylibrary&redir_esc=y.
[7] M. Sailer, F. Schultz-Pernice, and F. Fischer, "Contextual facilitators for learning activities involving technology in higher education: The C ♭ -model," Comput. Human Behav., vol. 121, no. October 2020, p. 106794, 2021, doi: 10.1016/j.chb.2021.106794.
[8] T. T. Meum, T. B. Koch, H. S. Briseid, G. L. Vabo, and J. Rabben, "Perceptions of digital technology in nursing education: A qualitative study," Nurse Educ. Pract., vol. 54, 2021, doi: 10.1016/j.nepr.2021.103136.
[9] C. Antonietti, A. Cattaneo, and F. Amenduni, "Can teachers' digital competence influence technology acceptance in vocational education?," Comput. Human Behav., vol. 132, no. March, p. 107266, 2022, doi: 10.1016/j.chb.2022.107266.
[10] H. M. Al-Hattami, "Understanding perceptions of academics toward technology acceptance in accounting education," Heliyon, vol. 9, no. 1, p. e13141, 2023, doi: 10.1016/j.heliyon.2023.e13141.
[11] M. Limniou, T. Varga-Atkins, C. Hands, and M. Elshamaa, "Learning, student digital capabilities and academic performance over the COVID-19 pandemic," Educ. Sci., vol. 11, no. 7, 2021, doi: 10.3390/educsci11070361.
[12] T. Huizinga, A. Lohuis, J. Zwerver-Bergman, and R. van der Meer, "Student and teacher perceptions of community of inquiry in hybrid virtual classrooms," Heliyon, vol. 8, no. 12, p. e12549, 2022, doi: 10.1016/j.heliyon.2022.e12549.
[13] U. Verawardina, D. Ramadhani, W. Susanti, A. L. Lubis, A. Simeru, and Ambiyar, "Studying technology-based XXI century learning using Mooc in education," Int. J. Psychosoc. Rehabil., vol. 24, no. 9, pp. 2644–2649, May 2020, doi: 10.37200/IJPR/V24I9/PR290297.
[14] A. Syahman, "Parental Control System for Children on Wireless Network," vol. 5, no. August, pp. 14–20, 2020. Available: https://jtec.org.my/index.php/JTeC/article/view/236.
[15] D. Sukenti and S. Tambak, "Developing Indonesian language learning assessments : Strengthening the personal competence and Islamic psychosocial of teachers," vol. 9, no. 4, pp. 1079–1087, 2020, doi: 10.11591/ijere.v9i4.20677.
[16] N. A. Rahmah, Real Time System Practical Module. Bandung: Fakultas Ilmu Terapan Universitas Telkom, 2018. Available: https://openlibrary.telkomuniversity.ac.id/pustaka/146335/modul-praktikum-sistem-waktu-nyata.html.
[17] C. L. Aldea, R. Bocu, and R. N. Solca, "Real-Time Monitoring and Management of Hardware and Software Resources in Heterogeneous Computer Networks through an Integrated System Architecture," *Symmetry (Basel)*, vol. 15, no. 6, 2023, doi: 10.3390/sym15061134..
[18] W. Susanti, G. Tendra, S. Siswati, T. Nasution, Panyahuti, and A. Simeru, "Virtual Programming Laboratory in Collaborative Inquiry Learning to Improve Higher Order Thinking Skills for Work Readiness in the Industrial World," *Paper Asia*, vol. 39, no. 6, pp. 63–70, Nov. 2023, doi: 10.59953/paperasia.v39i6(b).51.

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