INTEGRATED TRUST MANAGEMENT MODEL FOR QR-BASED EXAMINATION VERIFICATION AND SCRIPT SERIAL CAPTURE IN INSTITUTIONS IN UGANDA

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ABSTRACT

This study examined an Integrated Trust Management Model for QR Code-Based Examination Verification and Script Serial Number Capture in Academic Management Systems to improve examination security, accuracy, and efficiency. A mixed-methods research design was adopted using questionnaires, interviews, and document analysis. Data were collected from 6 purposively selected institutions involved in QR-based examination verification systems. Findings revealed major challenges, including serial capture gaps (83.3%), QR adoption issues (66.7%), trust/authentication concerns (66.7%), and system integration gaps (50.0%). In response, the study proposed a model that integrates QR-coded examination permits with real-time student verification and script serial number capture using mobile devices. The model enhances secure authentication, data synchronization, traceability, and examination accountability while reducing manual errors. The study concludes that the proposed model can strengthen examination integrity and improve efficiency in academic management systems.

KEYWORDS

QR Code Verification, Trust Management Model, Academic Management Systems, Examination Security, Script Serial Number Capture

1. INTRODUCTION

Examinations are a critical component of academic assessment in educational institutions, requiring accurate identification of candidates and proper management of examination materials. Traditionally, many institutions rely on manual processes for verifying student eligibility and recording attendance, often using printed registers and handwritten lists. These methods are widely recognized as time-consuming, error-prone, and vulnerable to inconsistencies that can compromise examination integrity (OECD, 2021; UNESCO, 2023).

With the increasing adoption of digital technologies in education, there is a growing need to enhance examination management processes through secure and efficient automated systems. QR code technology has emerged as a reliable mechanism for fast identification and data retrieval in academic environments. Recent studies show that QR-based systems significantly improve speed and accuracy in attendance and verification processes when integrated into digital platforms (IEEE Access Studies, 2020–2024; World Bank, 2021).

When integrated with Academic Management Systems, QR codes facilitate real-time verification of student eligibility and improve data consistency across examination workflows. Additionally, global information security standards emphasize the importance of secure digital identity

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management to ensure data integrity and protection in institutional systems (ISO/IEC 27001:2022).

However, most existing systems focus primarily on attendance or identity verification and do not effectively link verified student identities with physical examination scripts through unique identifiers such as script serial numbers. This limitation affects traceability, accountability, and post-examination auditing processes.

This study therefore proposes a Trust Management Model that integrates QR code-based examination verification with script serial number capture within Academic Management Systems. The model aims to enhance security, improve data integrity, and streamline examination processes through real-time validation, synchronized data management, and improved accountability mechanisms (UNESCO, 2023; IEEE Access Studies, 2020–2024).

1.1. Problem Statement

In Uganda, many academic institutions still conduct examination verification and attendance recording manually, relying on printed lists and handwritten registers. This approach remains inefficient, time-consuming, and prone to human error, which affects the accuracy and reliability of examination supervision and record management (UNESCO, 2023; OECD, 2021). In addition, most institutions do not systematically link a student's verified identity to their examination script using a unique script serial number, limiting traceability and weakening post-examination auditing processes (World Bank, 2021).

Although Academic Management Systems have been introduced in some Ugandan institutions, many still operate with fragmented or semi-manual workflows that do not fully integrate QR-based verification with script serial capture. This creates gaps in real-time validation, data synchronization, and examination security, leading to risks such as duplication and missing records (ISO/IEC 27001:2022; IEEE Access Studies, 2020–2024). Therefore, there is a need for an Integrated Trust Management Model for QR-Based Examination Verification and Script Serial Capture in Academic Management Systems in Uganda to enhance authentication, improve data integrity, and strengthen transparency and accountability throughout the examination lifecycle.

1.2. General Objective

To develop a Trust Management Model for QR Code-Based Examination Verification and Script Serial Number Capture in Academic Management Systems.

1.3. Research question

How can QR code-based examination verification and script serial number capture be integrated into Academic Management Systems to improve security, accuracy, and real-time validation?

1.4. Significance of the Study

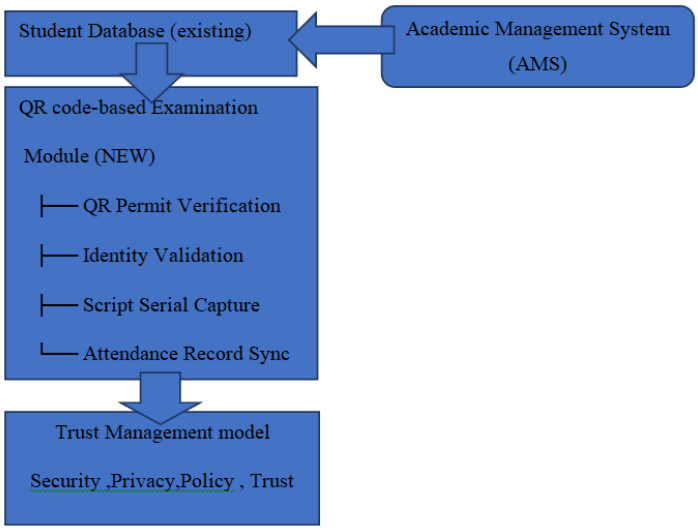
This study develops an Integrated Trust Management Model that combines QR code-based examination verification, script serial number capture, and real-time synchronization within Academic Management Systems in Uganda to enhance security, accountability, and efficiency during examinations. It contributes to academic knowledge in trust management and examination security, offers practical guidance for improving institutional examination processes, and

supports professionals with a reliable framework that promotes automated verification, accurate attendance tracking, and strengthened examination integrity.

1.5. Integrated Trust Management Model designfor QR-Based Examinationverification

The model illustrates the integration of the Academic Management System to support secure QR-based examination verification and script serial number capture. The Examination Module interacts with the existing student database to perform real-time identity validation, enforce examination policies, and synchronize attendance and script data. The Trust Management model ensures security, privacy, and policy compliance across all system operations, enhancing reliability and integrity in examination management.

Figure 1: Integrated Trust Management Modelfor QR-Based Examinationverification



Source: Adopted from Hossain, M., Hassan, M., & Rahman, S. (2021). QR code-based attendance system for educational institutions. Modified by the research 2026

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This study is based on three main ideas: **Trust Management Theory, Information Systems Security, and Technology Acceptance Model (TAM)**. These ideas help explain how secure digital systems can work well in academic environments and how users accept and use them.

2.1. Theoretical Framework

Trust Management Theory focuses on ensuring that only authorized users can access and interact with a system through proper authentication and accountability mechanisms (Grandison &Sloman, 2000). In this study, it supports secure QR code verification and controlled access for invigilators during examinations. Information Systems Security Theory emphasizes protecting data from unauthorized access and ensuring its integrity, confidentiality, and availability (Stallings, 2021). This is important in safeguarding student records, QR verification data, and script serial number information within the Academic Management System.

The Technology Acceptance Model (TAM) explains how users adopt new technologies based on their perceived usefulness and ease of use (Davis, 1989). In this context, the system is expected to be accepted by invigilators and administrators if it simplifies examination processes, reduces manual work, and improves efficiency. Together, these theories support the development of a secure, efficient, and user-friendly QR code-based examination verification system that integrates seamlessly into Academic Management Systems while ensuring trust, security, and usability.

2.2. QR Code-Based Examination Verification Systems

Recent studies show that QR code technology has become an effective tool for secure authentication in educational environments. QR codes allow fast encoding and retrieval of student identity data, reducing manual verification errors during examinations.For example, QR-based authentication systems have been shown to improve efficiency and reduce impersonation cases in examination halls by enabling real-time verification of student identity (Inyangetoh& Johnson, 2025). Similarly, research confirms that QR systems integrated with mobile applications and databases enhance examination integrity and operational efficiency (Alabi et al., 2026).Furthermore, recent work highlights that QR codes combined with encryption mechanisms such as AES improve system security and reduce risks of tampering or unauthorized access (Slam et al., 2025).

2.3. Script Serial Number Capture in Academic Examination Systems

Identity verification and script serial number capture are essential components of secure and reliable examination management systems. Authentication ensures that only legitimate users can access system resources, thereby preventing impersonation and examination fraud (Stallings, 2021). Recent studies further show that combining QR codes with biometric or digital identity methods improves accuracy and strengthens examination integrity in higher education (Wang et al., 2024). In addition, script serial number capture enhances traceability by linking physical examination scripts to digital student records, improving accountability, data consistency, and post-exam auditing processes (Mwambeleko, 2023). Together, these approaches ensure secure identity verification and effective linkage between students and examination scripts within academic systems

2.4. Records Policy and Governance Frameworks

This study is grounded in Uganda's ICT and records governance framework, including the Uganda National Information Technology Authority Act (2009), the National Records and Archives Act (2001), the National ICT Policy for Uganda (2019/2020), the Data Protection and Privacy Act, and the e-Government Policy Framework (Ministry of ICT & National Guidance, 2020; NITA-U, 2009; Uganda National Records Centre and Archives, 2001). It is further informed by key ISO standardsISO 15489, ISO 30301, ISO 27001, and ISO 14721which provide international guidance on records management, information security, and digital preservation. Collectively, these legal, policy, and technical frameworks establish the foundation for digital transformation, records accountability, and sustainable information management, and they support the adoption of Electronic Records Management Systems (ERMS) for effective data rescue and long-term preservation. In addition, integrating statistical and knowledge-based approaches strengthens records retention and disposal policy implementation in Ugandan higher education institutions (Kyakuwa&Oper, 2025).These perspectives relate to the proposed Trust Management Model for QR Code-Based Examination Verification and Script Serial Number Capture in Academic Management Systems. The model integrates trust management, security, privacy, and policy controls to support secure examination verification, attendance

synchronization, and reliable academic record management through QR code verification and centralized databases.

2.5. Global and Regional Perspectives: Trust Management Models

Globally, educational institutions are increasingly adopting Trust Management Models and QR code-based systems to improve examination security, efficiency, and data management. Countries such as the United States, China, and the United Kingdom have integrated real-time authentication and centralized academic databases into examination processes to reduce impersonation, improve attendance management, and strengthen data integrity. These systems support fast identity verification, secure access control, and automated synchronization of examination records, thereby improving accountability and operational efficiency (Sommerville, 2021; Hossain et al., 2021). Regionally, many African institutions, including those in East Africa, are gradually adopting Academic Management Systems and QR code technologies to improve examination processes. However, challenges such as limited system integration, weak real-time validation, and inadequate linkage between student verification and script management still exist. Therefore, there is a growing need for integrated trust-based models that support secure authentication, attendance synchronization, and centralized academic data management to improve examination accountability, efficiency, and institutional trust (Alabi et al., 2026)

2.6. Research Gap

Although Academic Management Systems and QR code-based technologies are increasingly used in higher education, most existing systems mainly support basic attendance recording and identity verification without fully integrating examination processes into a unified secure framework. They often lack strong linkage between QR-based verification, real-time validation, and script serial number capture, limiting traceability, accountability, and data consistency (Hossain et al., 2021; Sommerville, 2021; Wang et al., 2024; Mwambeleko, 2023). In addition, policy management and records retention in higher education remain weakly integrated with digital examination systems, making it difficult to ensure proper compliance, auditing, and long-term storage of examination records within institutional frameworks (Kyakuwa&Lakwit, 2025). This creates a clear gap in developing a fully integrated Trust Management Model that combines secure examination verification, script tracking, and records management within Academic Management Systems.

3. METHODOLOGY

This chapter presents the research methods, design, tools, and procedures used in designing, developing, and evaluating the Integrated Trust Management Model for QR-Based Examination Verification and Script Serial Capture in Academic Management Systems.

3.1. Research Design

This study adopted a mixed-methods research design that combined both quantitative and qualitative approaches to ensure a comprehensive understanding of the problem under investigation. Mixed methods are particularly suitable in information systems research because they allow researchers to quantify system usage patterns while also exploring deeper contextual issues affecting system performance and user experience (Creswell & Plano Clark, 2022). In this study, the quantitative component focused on examining the level of QR-based examination verification usage across selected institutions, while the qualitative component explored gaps related to script serial number capture and system integration challenges. The integration of both

approaches enabled a more holistic interpretation of findings and supported the development of a robust trust management model for academic examination systems (Johnson et al., 2021).

3.2. Population of the Study and Sampling Technique

The target population for this study consisted of ten higher education institutions that utilize Academic Management Systems for examination processes, particularly those operating digital or semi-digital systems. From this population, purposive sampling was employed to select institutions that were actively implementing QR-based examination verification systems. Purposive sampling was considered appropriate because it allows the researcher to focus on information-rich cases that directly contribute to the objectives of the study (Etikan, 2020). Out of the ten institutions identified, six were selected based on their partial or full implementation of QR-based examination systems. These institutions provided relevant insights into real-world usage, challenges, and system integration gaps, making them suitable for developing the proposed model.

3.3. Data Collection Methods

Data were collected using questionnaires, interviews, and document review to ensure triangulation and improve reliability. Questionnaires gathered quantitative data from invigilators and academic staff on QR system adoption and usage, while interviews with ICT administrators and examination officers provided qualitative insights on operational challenges and system integration issues. Document review of policies, attendance records, and system reports was used to validate findings, with triangulation enhancing data accuracy and credibility.

3.4. Data Analysis and Interpretation Framework

Data were analyzed using SPSS (version 26) for descriptive and inferential statistics to examine QR-based examination adoption, with quantitative data summarized using frequencies and percentages, while qualitative data was thematically analyzed to identify institutional challenges, system gaps, and trust issues. Validity and reliability were ensured through expert review, pilot testing, and triangulation, and ethical standards were maintained through informed consent, confidentiality, anonymity, and institutional approval.

Table 1: Summary of the Proposed Mixed-Methods Methodological Framework

Phase	Purpose	Methods / Tools	Outcome
Research Design	Combine quantitative and qualitative approaches	Mixed-methods design	Overall understanding of QR system use and gaps
Population & Sampling	Select relevant institutions	10 institutions; purposive sampling of 6	Focused, relevant study sample
Data Collection	Gather system usage and experience data	Questionnaires, interviews, document review	Triangulated data from multiple sources
Data Analysis & Ethics	Analyze data and ensure research quality	Descriptive stats, thematic analysis; validation, ethics procedures	Reliable, valid, and ethical findings

Table 1 summarizes the proposed mixed-methods framework, outlining each phase, its purpose, methods applied, and expected outcomes to ensure methodological rigor and replicability.

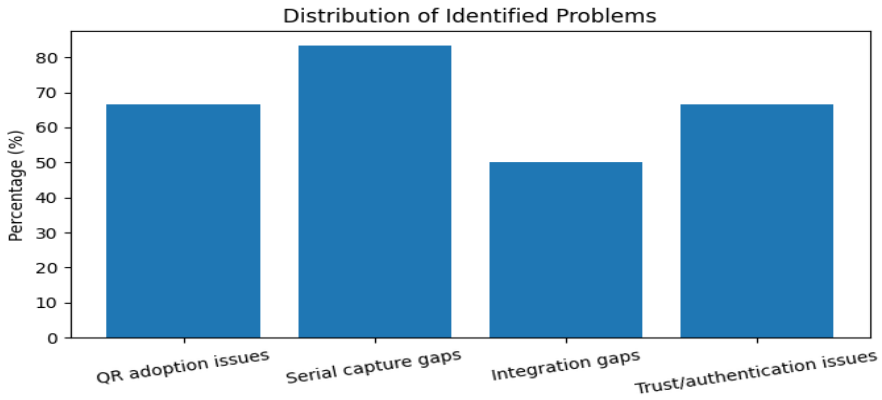
4. RESULTS AND ANALYSIS

The findings from the selected 6 institutions (n = 6) show varying levels of operational and technological challenges in examination management systems. The results were synthesized from quantitative frequency counts and supported with qualitative insights from participant responses.The distribution of identified problems revealed that serial capture gaps were the most significant challenge, reported by 5 out of the 6 institutions, representing 83.3% of the respondents. QR adoption issues and trust/authentication challenges were each identified by 4 institutions, accounting for 66.7% respectively. Integration gaps were reported by 3 institutions, representing 50.0% of the respondents. These findings indicate that weaknesses in script serial number capture and system trust management remain major concerns in the imp

Table 2: Shows the distribution of identified problems

Problem Area	Frequency (out of 6)	Percentage (%)
QR adoption issues	4	66.7%
Serial capture gaps	5	83.3%
Integration gaps	3	50.0%
Trust/authentication issues	4	66.7%

Bar chart: illustrates the distribution of institutions



Distribution of Identified Problems

The bar chart above illustrates the distribution of institutions based on their level of adoption of QR-based examination verification and script serial number capture systems. The findings indicate that serial capture gaps were the most reported challenge, followed by QR adoption issues and trust/authentication concerns.

4.1. Interpretation of Findings

4.1.1. serial number capture gaps

The results reveal that gaps in serial number capture, largely dependent on manual processes (83.3%), represent the most widespread challenge across institutions. This points to persistent

inefficiencies in the tracking and validation of examination scripts, with many institutions still operating through semi-manual or disjointed systems.

One participant from a public institution remarked: *"We still struggle with tracking scripts once they leave the examination room. The serial numbers are sometimes recorded manually, which leads to inconsistencies."*

4.1.2. QR adoption issues

Further (66.7%) also remains notable, indicating that almost two-thirds of institutions have not yet fully adopted or standardized QR-based examination verification systems.
A respondent noted:"*We have the QR system, but not all departments use it consistently. Some still prefer manual checking due to system delays or lack of training."*

4.1.3. Trust and authentication concerns

The**results reveal (66.7%)**highlight risks around system reliability and user confidence in digital verification tools.

As one ICT officer explained*: "Staff confidence in the QR authentication process is still low because they are not fully sure how secure or tamper-proof the system is."*

4.1.4. Integration gaps

Meanwhile, **integration gaps (50%)** were the least reported but still notable. These gaps point to weak interoperability between examination management systems and institutional databases.

A participant observed*: "Our systems do not fully communicate with each other, so we end up re-entering data in different platforms."*

4.2. Discussion of Findings

The findings revealed that serial number capture gaps, QR adoption issues, trust/authentication concerns, and system integration gaps remain major challenges affecting QR-based examination verification systems in higher institutions. The study showed that 83.3% of institutions still rely on manual or semi-manual processes for recording attendance details and script serial numbers, which wastes students' examination time, distracts invigilators, and increases the risk of duplication, missing records, and human error. Additionally, 66.7% of institutions reported limited adoption of QR systems and low confidence in digital authentication processes due to inadequate training and security concerns, while 50% experienced weak interoperability between examination systems and institutional databases.

From a data science management perspective, these challenges reduce data accuracy, system reliability, and operational efficiency, thereby limiting effective decision-making and automated examination monitoring. The findings therefore support the need for an Integrated Trust Management Model for QR-Based Examination Verification and Script Serial Capture in Academic Management Systems to improve automation, security, interoperability, and real-time examination data management

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study concludes that although many institutions have adopted digital examination verification systems, their implementation remains partial and insufficiently integrated. The continued coexistence of manual and digital processes has created operational inefficiencies, particularly in examination attendance management and script serial number capture. The findings revealed that 83.3% of institutions still experience serial capture gaps, while 66.7% reported QR adoption and trust/authentication challenges, indicating that digital examination systems are still at a transitional stage of implementation. Manual registration processes consume students' examination time, distract invigilators during supervision, and increase the risk of duplication, missing records, and human error. In addition, weak interoperability between examination systems and institutional databases limits effective data sharing and real-time verification processes.The findings support the need for an Integrated Trust Management Model for QR-Based Examination Verification and Script Serial Capture in Academic Management Systems to enhance automation, interoperability, and secure real-time examination data management

5.2. Recommendations

Based on the findings, the study recommends that institutions should fully integrate QR-based examination verification systems with automated script serial number capture mechanisms to minimize manual registration processes, reduce duplication of effort, and improve examination data accuracy. Full integration will enhance transparency, real-time verification, and accountability within academic examination management systems
The study also recommends the development and enforcement of standardized digital examination management procedures to ensure consistency in both administrative and technological workflows across institutions. Standardized processes are important for improving interoperability, data governance, and effective system implementation in digital environments

In addition, institutions should conduct regular capacity building and continuous training for examination officers, invigilators, and academic staff to improve their competence, confidence, and trust in using QR-based verification technologies. User awareness and technical skills are essential for successful adoption of digital information systems

The study further recommends strengthening ICT infrastructure through investment in stable network systems, interoperable platforms, and secure databases capable of supporting real-time verification and centralized data management. Institutions should also institutionalize periodic system audits and monitoring mechanisms to identify implementation gaps, ensure compliance, and support continuous improvement of digital examination management systems.

REFERENCE

[1] Abong, R., Turyahabwe, N., Owomugisha, M., & Mbabazi, J. (2025). Digital transformation and records management practices in East African universities. *African Journal of Information Systems*, 17(2), 55–70.
[2] Alabi, A., Lateef, H., Tewogbade, A., Ozoh, P., & Balogun, F. (2026). Design and implementation of an enhanced QR-code based attendance system. *Journal of Computing and Social Informatics*. https://doi.org/10.33736/jcsi.10752.2026
[3] Braun, V., & Clarke, V. (2021). *Thematic analysis: A practical guide*. Sage Publications.

[4] Creswell, J. W., & Plano Clark, V. L. (2022). *Designing and conducting mixed methods research* (4th ed.). Sage Publications.
[5] Etikan, I. (2020). Sampling techniques in research methodology. *Biometrics & Biostatistics International Journal, 8*(2), 1–7.
[6] Grandison, T., &Sloman, M. (2000). A survey of trust in internet applications. *IEEE Communications Surveys & Tutorials, 3*(4), 2–16.
[7] Heale, R., & Twycross, A. (2020). Validity and reliability in quantitative studies. *Evidence-Based Nursing, 23*(3), 66–67.
[8] Hossain, M., Hassan, M., & Rahman, S. (2021). QR code-based attendance system for educational institutions. *International Journal of Computer Applications*.
[9] IEEE Access (2020–2024). Multiple studies on QR code-based attendance systems and digital identity verification in academic environments.
[10] Inyangetoh, J. A., & Johnson, E. A. (2025). Development of QR code-based authentication system for admitting students into examination hall. *European Journal of Computer Science and Information Technology, 13*(3), 20–42. https://doi.org/10.37745/ejcsit.2013/vol13n32042
[11] ISO/IEC. (2022). ISO/IEC 27001:2022 Information security management systems — Requirements. International Organization for Standardization.
[12] Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2021). Toward a definition of mixed methods research. *Journal of Mixed Methods Research, 15*(1), 3–20.
[13] Kyakuwa, B., &Lakwit, O. R. O. (2025). Integrating statistical and knowledge-based approaches to enhance records retention and disposal policy adoption in Ugandan higher education institutions. *CSIT – IBCOM, GridCom, SPPR, NLAI, ICCSEA, NECO – 2025*, 41–51.
[14] Luyombya, D. (2021). Challenges of electronic records management adoption in Libyan higher education institutions. *Records Management Journal*, 31(4), 389–402.
[15] Mwambeleko, D. (2023). QR code and fingerprint systems for university examinations management. *International Journal of Advances in Scientific Research and Engineering*. https://doi.org/10.31695/IJASRE.2023.9.12.4
[16] Ngulube, P., &Katuu, S. (2022). Enterprise records management policies and compliance in South African universities. *Journal of the South African Society of Archivists*, 55, 1–15.
[17] OECD. (2021). Digital Education Outlook 2021: Pushing the Frontiers with AI, Blockchain and Robots. Organisation for Economic Co-operation and Development.
[18] Resnik, D. B. (2020). *What is ethics in research and why is it important?* National Institute of Environmental Health Sciences.
[19] Saunders, M., Lewis, P., & Thornhill, A. (2023). *Research methods for business students* (9th ed.). Pearson.
[20] Shinde, P., Deshmukh, R., & Rao, S. (2024). Knowledge-based electronic records management systems in higher education institutions. *International Journal of Information Governance*, 12(1), 21–34.
[21] Sommerville, I. (2021). *Software engineering* (11th ed.). Pearson.
[22] Stallings, W. (2021). *Cryptography and network security: Principles and practice* (8th ed.). Pearson.
[23] UNESCO. (2023). Global Education Monitoring Report: Technology in Education. United Nations Educational, Scientific and Cultural Organization.
[24] Wang, R., Huang, L., Madden, K., & Wang, C. (2024). Enhancing QR code system security by verifying scanner biometric authentication. *ACM Conference on Security and Privacy in Wireless and Mobile Networks*.
[25] Wilbrod, N., &Tumwine, J. (2024). Academic digital systems and institutional accountability in Ugandan universities. *Uganda Journal of Information Management*, 8(1), 33–47.
[26] World Bank. (2021). EdTech: The Future of Education Technology. World Bank Group.