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DESIGN AND IMPLEMENTATION OF AN AUTOMATED EXAM ANALYSIS SYSTEM FOR ACADEMIC PERFORMANCE EVALUATION: EVIDENCE FROM CHIPANGALI DISTRICT, ZAMBIA

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Abstract

The digital transformation of educational administration has become essential in addressing inefficiencies associated with manual academic record management systems. This study presents the design, implementation, and empirical evaluation of an Automated Exam Analysis System developed for secondary schools in Chipangali District, Eastern Province, Zambia. Traditional manual result processing methods were found to be time-consuming, error-prone, and insecure, limiting institutional capacity for timely academic performance evaluation. The developed web-based system integrates secure authentication protocols, automated computational algorithms, statistical performance analytics, and structured reporting mechanisms to enhance efficiency and accuracy. A mixed-method research design was adopted, incorporating system performance logs, structured questionnaires, and semi-structured interviews involving 30 participants, including teachers and administrative staff. Findings revealed an 83–100% reduction in computational errors and a 94% decrease in result processing time compared to manual systems. User satisfaction scores averaged 4.7 out of 5, with 90% of respondents expressing improved confidence in data security. The system significantly reduced administrative workload, enhanced transparency, and supported data-driven academic decision-making. The study contributes to digital governance literature by demonstrating how automated analytics frameworks can be adapted to rural secondary education contexts. The proposed system offers a scalable and replicable model for improving academic performance evaluation in resource-constrained environments.

Keywords

Automated Exam Analysis System; Academic Performance Evaluation; Educational Digital Transformation; Data Validation; School Information Systems; Result Management Automation; Rural Education Technology; Secure Academic Data Systems

1. Introduction

The global transformation of education through digital technologies has fundamentally altered how academic institutions manage data, evaluate

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performance, and support decision-making processes. The integration of automation, artificial intelligence (AI), and data analytics into educational systems has shifted institutional paradigms from manual record-keeping toward evidence-based academic governance (Arockia et al., 2025). Educational institutions increasingly rely on intelligent systems to process large volumes of data, enhance transparency, and improve operational efficiency. In this context, automated examination analysis systems represent a critical innovation in academic performance evaluation. Educational digitalization is not merely an administrative modernization strategy but a structural reform that enables adaptive learning environments and institutional accountability (Venice, Vettriselvan, Rajesh, Suresh, & Abirami, 2025). The adoption of AI-driven analytical frameworks across sectors—including healthcare, marketing, and supply chain management—demonstrates measurable improvements in efficiency, predictive capability, and data accuracy (Catherine et al., 2025; Natraj et al., 2024). However, many secondary schools in rural Zambia continue to depend on manual examination processing methods characterized by delays, computational errors, and security vulnerabilities.

Manual exam result processing exposes institutions to systemic inefficiencies similar to those observed in manual healthcare documentation systems, where data fragmentation leads to decision-making delays and operational risks (Devi et al., 2025). In educational contexts, such inefficiencies undermine transparency, hinder timely feedback, and limit administrators' capacity to conduct longitudinal performance tracking. The absence of automated validation mechanisms increases the likelihood of human error, compromising data integrity and institutional credibility. Research on AI-enabled systems across industries highlights the importance of performance metrics optimization, secure data architecture, and adaptive interface design (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025). Translating these principles into educational result management systems requires integrating secure authentication protocols, automated computation engines, and real-time analytics dashboards. Such integration aligns with broader digital governance trends emphasizing accountability, data protection, and user-centered system design (Venice et al., 2026).

Furthermore, digital transformation in institutional systems has been associated with improved organizational resilience and operational sustainability (Vettriselvan, 2025). When institutions automate analytical processes, they reduce administrative burden and enable faculty to focus on instructional improvement. Similar outcomes have been documented in adaptive learning platforms and personalized analytics systems (Venice et al., 2025), reinforcing the argument that automation strengthens institutional performance ecosystems. This study responds to the urgent need for a scalable,

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secure, and user-friendly automated exam analysis system tailored to secondary schools in Chipangali District, Zambia. It seeks to design, implement, and evaluate a web-based platform that automates grade computation, statistical analysis, and performance reporting while ensuring data security and user authentication. By situating the project within broader digital transformation scholarship and leveraging insights from AI-enabled analytics frameworks, this research contributes to the advancement of educational data governance in resource-constrained environments.

2. Literature Review

The digital transformation of institutional systems has expanded significantly across sectors, reshaping administrative processes, decision-making mechanisms, and performance evaluation frameworks. In education, the integration of automation, artificial intelligence (AI), and data analytics has transitioned institutions from reactive record management to proactive performance intelligence (Arockia et al., 2025). Automated academic systems are no longer limited to basic data storage; they now incorporate predictive analytics, adaptive feedback loops, and secure cloud-based architectures.

2.1 Digital Transformation in Educational Administration

Educational institutions worldwide are adopting digital infrastructures that align with broader Industry 5.0 principles emphasizing resilience, automation, and human-centered technology integration (Vettriselvan, 2025). Cloud integration and adaptive system frameworks enable scalable performance monitoring and real-time access to institutional data (Venice, Vettriselvan, Rajesh, Suresh, & Abirami, 2025). These systems facilitate automated data processing, reduce administrative bottlenecks, and enhance institutional transparency. Research on AI-powered personalized learning environments demonstrates that analytics-driven systems improve performance tracking accuracy and support targeted interventions (Arockia et al., 2025). Similarly, recommendation systems and content personalization frameworks show how algorithmic processing enhances user engagement and system efficiency (Venice, Arivazhagan, Suman, Shanthi, & Swadhi, 2025). The application of these technological principles to examination management systems allows schools to automate score computation, statistical summaries, and comparative analytics.

2.2 Automation, AI, and Performance Analytics

Across sectors, automation has been associated with measurable improvements in operational efficiency and decision precision. In healthcare, AI-driven precision systems have optimized patient treatment pathways and enhanced diagnostic accuracy (Devi et al., 2025). Machine learning frameworks in digital marketing and engagement platforms

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demonstrate how automated analytics improve strategic decision-making (Catherine et al., 2025; Swadhi et al., 2025). Similarly, performance evaluation systems in blockchain-powered AI analytics emphasize the importance of accurate metric optimization and secure computational frameworks (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025). These studies highlight that automated systems must combine algorithmic efficiency with performance validation metrics to ensure reliability. Educational systems can draw parallels from such cross-disciplinary innovations. Just as AI enhances precision medicine and digital marketing analytics, automated examination systems enhance accuracy in academic evaluation by eliminating manual computational errors. Moreover, quantum-enhanced neural network optimization research illustrates how emerging computational frameworks improve data processing scalability (Basha et al., 2025). While secondary schools may not deploy quantum systems, the conceptual emphasis on computational optimization remains relevant.

2.3 Data Security and Ethical Governance

The automation of academic systems introduces critical concerns regarding confidentiality, integrity, and availability of student data. Blockchain-enabled analytics research emphasizes robust encryption, authentication protocols, and performance evaluation safeguards (Venice, Vettriselvan, Rajesh, Xavier, & Shanthi, 2025). Ethical leadership frameworks in AI governance further stress accountability and collaborative oversight mechanisms (Venice, Jio, Kant, Sharda, & Mittal, 2026). In educational contexts, safeguarding sensitive student data is paramount. Studies examining digital health systems underline the risks associated with weak data protection infrastructures (Ashifa, 2021; Vettriselvan & Anto, 2018). Although these studies focus on health data, their implications extend to academic data governance. Institutions must implement authentication layers, role-based access controls, and audit trails to prevent unauthorized access. Moreover, digital exposure research among secondary school students highlights behavioral implications of technology integration (Venice, Sripathi, & Moonga, 2025). Therefore, automated systems must balance efficiency with ethical considerations, ensuring responsible technological adoption.

2.4 User Acceptance and Institutional Adoption

Technology adoption in institutional settings depends significantly on user acceptance, perceived usefulness, and ease of integration. Organizational adaptation frameworks in human resource management emphasize strategic alignment and workforce readiness (Swadhi, Velmurugan, Gayathri, & Catherine, 2026). Resistance to change can undermine even technically robust systems if training and stakeholder engagement are insufficient. Research on occupational health

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and institutional stress further indicates that poorly implemented systems may increase cognitive burden rather than reduce it (Gayathri et al., 2025; Ranganathan et al., 2024). Therefore, automated academic systems must prioritize user-centric design and iterative feedback mechanisms. Additionally, rehabilitation robotics and adaptive motion systems demonstrate the importance of adaptive system feedback loops to enhance user outcomes (Venice et al., 2026). Translating this principle into educational software design suggests that automated exam systems should incorporate adaptive interfaces and customizable reporting tools.

2.5 Broader Societal and Institutional Implications

Automation in institutional systems contributes to broader social sustainability goals. Studies on sustainability and digital responsibility emphasize the need for technology to promote equitable access and transparency (Vijayalakshmi et al., 2025). Digital inclusion frameworks also stress the importance of accessible technological systems in rural and resource-constrained settings (Swadhi, 2025). Furthermore, educational automation indirectly supports student well-being by reducing result dissemination delays that contribute to stress and uncertainty (Elkin et al., 2025). Institutional efficiency improvements enhance administrative capacity, enabling educators to focus on pedagogical quality rather than manual record compilation.

2.6 Research Gap

Despite extensive research on AI-driven analytics, digital transformation, and performance evaluation systems, limited scholarship addresses automated exam analysis systems in rural secondary school contexts within developing regions. Most existing studies focus on higher education, healthcare, or corporate environments. There is insufficient empirical evidence examining the design, deployment, and evaluation of automated academic result systems in resource-limited secondary schools. Additionally, cross-sector innovations in blockchain analytics, adaptive systems, and secure AI governance have not been systematically translated into educational examination management frameworks. This study addresses this gap by integrating digital transformation theory, performance optimization principles, and ethical governance models into the development of a context-specific automated exam analysis system for Chipangali District.

3. Research Methodology

This study adopted a mixed-method research design integrating system development methodology with empirical evaluation techniques. The objective was not only to design and implement an automated exam

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analysis system but also to evaluate its operational efficiency, user acceptance, and data security performance within a real-world rural secondary school context in Chipangali District, Zambia. The integration of qualitative and quantitative approaches ensured methodological robustness and enhanced internal validity through triangulation.

3.1 Research Design Framework

The research design was grounded in applied systems development combined with performance evaluation analytics. Digital transformation research emphasizes that technological implementation must be assessed across three dimensions: functional performance, institutional integration, and user adaptation (Arockia et al., 2025; Vettriselvan, 2025). Accordingly, this study incorporated:

- System design and development (technical component)
- User perception assessment (behavioral component)
- Performance evaluation metrics (analytical component)

This multidimensional approach aligns with adaptive digital system evaluation models used in AI-driven analytics environments (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025).

3.2 System Development Methodology

An Agile-based Software Development Life Cycle (SDLC) methodology was employed to design and implement the automated exam analysis system. Agile methodology supports iterative development, continuous user feedback, and modular scalability, making it appropriate for institutional digital transformation projects (Venice, Vettriselvan, Rajesh, Suresh, & Abirami, 2025).

The development process involved the following structured phases:

Planning Phase

Requirements were gathered through consultations with teachers and administrators. Key requirements included automated grade computation, subject-wise statistical summaries, gender-based analysis, division classification, and printable report generation.

Design Phase

The system architecture was structured into three integrated components:

1. User Interface Layer
2. Application Logic Layer
3. Database Layer

The architectural logic followed secure data processing models similar to those employed in AI-driven performance systems (Venice, Vettriselvan, Rajesh, Xavier, & Shanthi, 2025).

Development Phase

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ASET JOURNAL OF MANAGEMENT SCIENCE
Peer Reviewed & Open Access Journal
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The system was developed using:

- HTML and CSS for interface design
- PHP for server-side logic
- MySQL for database management

Secure login authentication and role-based access control were embedded to ensure confidentiality and data integrity. These measures align with secure data governance frameworks emphasized in digital analytics research (Venice et al., 2026).

Testing Phase

System testing included:

- Functional testing
- Module testing
- User acceptance testing
- Performance validation testing

Testing ensured reliability, scalability, and computational accuracy.

3.3 Study Population and Sampling

The study was conducted in two schools within Chipangali District:

- Eastern Girls Secondary School
- Lunkhuswe Primary School

A purposive sampling technique was adopted to select participants directly involved in result management processes. The sample included:

- 20 Teachers
- 10 Administrative staff members

Total Sample Size: **30 respondents**

This sampling approach ensured inclusion of key stakeholders with direct interaction with the manual and automated systems, supporting contextual accuracy in evaluation.

3.4 Data Collection Instruments

Multiple data collection tools were utilized:

3.4.1 Structured Questionnaires

Quantitative surveys measured:

- Perceived usefulness
- Ease of use
- Accuracy improvement
- Processing speed
- Security satisfaction

3.4.2 Semi-Structured Interviews

Interviews captured qualitative insights on:

- Operational challenges
- Adoption barriers
- System usability
- Institutional impact

3.4.3 System Performance Logs

Objective metrics were extracted from system execution logs, including:

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- Result processing time
- Error rate comparison (manual vs automated)
- Data retrieval latency

This triangulation approach aligns with digital system evaluation practices used in adaptive AI frameworks (Catherine et al., 2025; Swadhi et al., 2025).

3.5 Quantitative Data Analysis

Descriptive statistical techniques were applied to survey responses:

- Mean scores
- Standard deviation
- Frequency distribution
- Percentage analysis

Comparative analysis was conducted between manual system metrics and automated system metrics. This approach mirrors performance optimization validation techniques used in AI analytics research (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025).

Additionally, error rate reduction percentages were calculated using:

Error Reduction (%) = ((Manual Error Rate – Automated Error Rate) / Manual Error Rate) × 100

Processing time reduction was computed similarly.

3.6 Qualitative Data Analysis

Interview transcripts were analyzed using thematic coding techniques. Themes identified included:

- Efficiency improvement
- Reduced workload
- Enhanced transparency
- Security confidence
- Initial resistance to change

These findings were interpreted in alignment with institutional adaptation frameworks discussed in human resource transformation research (Swadhi, Velmurugan, Gayathri, & Catherine, 2026).

3.7 Validity and Reliability

To ensure construct validity:

- Triangulation was applied across survey, interview, and system logs.
- Member checking was conducted with selected participants.
- Standardized questionnaires ensured measurement consistency.

Reliability was enhanced through:

- Repeated system testing
- Controlled data entry simulations
- Consistent statistical computation methods

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ASET JOURNAL OF MANAGEMENT SCIENCE
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Performance validation parallels evaluation metrics in blockchain-enabled AI analytics systems (Venice, Vettriselvan, Rajesh, Xavier, & Shanthi, 2025).

3.8 Ethical Considerations

Ethical safeguards included:

- Informed consent from participants
- Confidential handling of academic data
- Secure system authentication
- Role-based access control

The importance of ethical data governance is widely emphasized in AI regulation and institutional accountability research (Venice et al., 2026). Moreover, protecting student academic records aligns with broader concerns about data privacy and institutional responsibility in digital systems (Ashifa, 2021; Vettriselvan & Anto, 2018).

5. Results and Analytical Findings

This section presents the empirical evaluation of the automated exam analysis system implemented at Eastern Girls Secondary School and Lunkhuswe Primary School in Chipangali District. The findings compare manual and automated systems across performance metrics, computational accuracy, user satisfaction, and security perception. The analysis integrates quantitative survey results, system log performance data, and qualitative insights, ensuring triangulated evaluation.

5.1 Error Rate Comparison: Manual vs Automated System

One of the primary objectives of the system was to reduce computational and data entry errors common in manual result processing.

Table 5.1: Error Rate Comparison

Performance Indicator	Manual System	Automated System	Improvement (%)
Average Data Entry Errors per Term	18 errors	3 errors	83.3%
Calculation Errors in Totals	12 cases	0 cases	100%
Division Misclassification	6 cases	0 cases	100%
Missing Record Incidents	9 cases	1 case	88.9%

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ASET JOURNAL OF MANAGEMENT SCIENCE
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The automated system reduced total data entry and computational errors by over 80%, with complete elimination of calculation and classification errors. This validates the effectiveness of automated validation mechanisms and structured computation engines.

These findings align with performance optimization outcomes reported in AI-driven analytics systems, where automated computation significantly improves metric accuracy (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025). Similar improvements in operational accuracy have been observed in healthcare AI systems where automated processing eliminates manual miscalculations (Devi et al., 2025).

5.2 Result Processing Time Analysis

Manual systems required extended periods to compile and verify examination results.

Table 5.2: Processing Time Comparison

Activity	Manual System (Hours)	Automated System (Minutes)
Grade Entry Compilation	6 hours	45 minutes
Total & Division Computation	4 hours	5 minutes
School-Level Aggregation	3 hours	3 minutes
Report Generation	2 hours	Instant (≤ 1 minute)
Total Processing Duration	**15 hours**	**~54 minutes**

Processing Time Reduction

Reduction (%) = ((15 hours – 0.9 hours) / 15 hours) × 100 = 94%

The system reduced overall result processing time by approximately **94%**. This dramatic improvement demonstrates how automation transforms administrative efficiency.

Digital transformation research consistently indicates that automated systems increase operational responsiveness and reduce processing latency (Arockia et al., 2025; Catherine et al., 2025). Similar efficiency gains are documented in digital supply chain systems utilizing automated workflows (Natraj et al., 2024).

5.3 User Satisfaction Analysis

User perception was measured using Likert-scale questionnaires (1 = Very Dissatisfied, 5 = Very Satisfied).

Table 5.3: User Satisfaction Metrics (n = 30)

Evaluation Criteria	Mean Score	Standard Deviation
Ease of Use	4.6	0.48

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Accuracy of Computation	4.8	0.36
Processing Speed	4.7	0.41
Report Clarity	4.5	0.52
Data Security Confidence	4.4	0.57
Overall System Satisfaction	4.7	0.39

All evaluation metrics scored above 4.4, indicating strong user acceptance and satisfaction. The highest-rated component was computational accuracy (Mean = 4.8), confirming trust in automated calculation mechanisms. Technology adoption research emphasizes that perceived usefulness and reliability strongly influence system acceptance (Swadhi, Velmurugan, Gayathri, & Catherine, 2026). The high satisfaction scores suggest that the system meets core user expectations.

5.4 Security Perception Evaluation

Participants were asked whether they felt academic data was safer under the automated system.

Table 5.4: Data Security Perception

Response Category	Percentage
Strongly Agree	60%
Agree	30%
Neutral	7%
Disagree	3%
Strongly Disagree	0%

90% of respondents expressed confidence in improved data security. The implementation of authentication protocols, password hashing, and restricted access contributed to enhanced trust. This finding aligns with digital governance research emphasizing secure AI frameworks and accountability structures (Venice, Jio, Kant, Sharda, & Mittal, 2026).

5.5 Qualitative Findings

Thematic analysis of interviews revealed five major themes:

1. Reduced Administrative Burden
2. Increased Transparency
3. Faster Feedback to Students
4. Initial Resistance to Change
5. Need for Continuous Training

Teachers reported that automation allowed them to allocate more time to instructional activities. Similar workload reduction effects are documented in digital transformation studies (Vettriselvan, 2025). Initial resistance was primarily due to unfamiliarity with digital systems, consistent with institutional adaptation research (Gayathri et al., 2025).

5.6 Overall Performance Impact

The system demonstrated measurable improvements in:

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ASET JOURNAL OF MANAGEMENT SCIENCE
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- Accuracy (83–100% error reduction)
- Speed (94% time reduction)
- User Satisfaction (Mean score 4.7/5)
- Security Confidence (90% positive perception)

These results confirm that automated exam analysis systems provide scalable, reliable solutions for rural educational institutions. By integrating structured computational logic and secure architecture, the system bridges the technological gap between rural schools and global digital education standards.

Summary of the Study

This study examined the design, implementation, and evaluation of an Automated Exam Analysis System for Academic Performance Evaluation in Chipangali District, Zambia. The research addressed the operational inefficiencies, computational inaccuracies, and data security vulnerabilities inherent in manual examination result processing systems commonly used in rural secondary schools. Grounded in digital transformation frameworks and performance optimization principles (Arockia et al., 2025; Vettriselvan, 2025), the study integrated system development methodology with empirical evaluation to assess functional performance, institutional impact, and user acceptance. The automated system was developed using a three-tier architecture consisting of presentation, application logic, and database layers, supported by secure authentication mechanisms and structured statistical computation modules.

Empirical findings demonstrated significant performance improvements:

- **Error Reduction:** Over 80% reduction in data entry errors and 100% elimination of calculation and division misclassification errors.
- **Processing Speed:** Approximately 94% reduction in result processing time.
- **User Satisfaction:** High acceptance levels, with overall satisfaction mean score of 4.7/5.
- **Security Confidence:** 90% of respondents reported improved confidence in data security.

These outcomes validate the effectiveness of automated validation algorithms and structured computational frameworks, consistent with performance improvements documented in AI-enabled analytics systems (Venice, Vettriselvan, Jain, Madusudanan, & Aarthy, 2025) and precision digital platforms (Devi et al., 2025). The integration of automated reporting, gender-disaggregated analytics, and hierarchical aggregation capabilities enhances institutional transparency and decision-making capacity. This aligns with broader digital governance principles emphasizing accountability, performance measurement, and system optimization (Venice, Jio, Kant, Sharda, &

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Mittal, 2026). Moreover, qualitative findings indicated reduced administrative burden, faster feedback cycles, and improved instructional focus. These results support digital transformation scholarship suggesting that automation enhances institutional resilience and operational sustainability (Vettriselvan, 2025).

Conclusion

The findings of this study confirm that automated exam analysis systems represent a transformative innovation in educational administration, particularly within resource-constrained rural contexts. By replacing manual computational processes with secure, algorithm-driven analytics, the implemented system significantly improved accuracy, efficiency, and data governance standards. The study contributes theoretically by extending digital transformation and AI-enabled analytics frameworks into secondary school examination management systems. While prior research predominantly focused on higher education or healthcare sectors (Catherine et al., 2025; Devi et al., 2025), this research demonstrates that similar principles can be successfully adapted to rural secondary education environments. Practically, the system offers a scalable and replicable model for schools across Zambia and similar developing regions. Its modular architecture supports expansion to district-level aggregation and integration with broader educational management information systems.

However, sustainable implementation requires:

- Continuous user training
- Institutional policy alignment
- Infrastructure strengthening
- Ethical governance frameworks

Technology alone cannot guarantee transformation; institutional readiness and leadership commitment remain critical determinants of long-term success (Swadhi, Velmurugan, Gayathri, & Catherine, 2026). In conclusion, the automated exam analysis system developed in this study provides empirical evidence that structured digital solutions can modernize academic performance evaluation in rural schools. By integrating secure computation, automated validation, and real-time analytics, the system bridges the technological divide and positions rural educational institutions within the broader global movement toward data-driven governance and digital accountability.

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