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JASPER Research Journal is a peer-reviewed journal published by Lanka Nippon BizTech Institute, Sri Lanka. The journal aims to promote original and high-quality research that contributes to knowledge, innovation, and professional practice in the fields of Information Technology and Innovation and Language, Culture, and Education. It provides a platform for scholarly work that is interdisciplinary, practice-informed, and responsive to contemporary local and global challenges.

The journal welcomes original research articles, review papers, and applied academic studies in areas including software engineering, artificial intelligence, data science, IoT, digital systems, educational technology, language learning, multilingual education, cross-cultural communication, student learning, and related interdisciplinary fields. JASPER encourages research that bridges theory and practice, supports academic excellence, and contributes to sustainable social and educational development.

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Track 1 - Information Technology & Innovation

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EAQUASL- Automating the Farm Licensing Process Through a Farm Management System for Sri Lanka's Ornamental Fish Industry

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Abstract

The ornamental fish industry in Sri Lanka contributes significantly to both foreign exchange earnings and livelihood support. However, regulatory oversight under the National Aquaculture Development Authority (NAQDA) is largely paper based, causing delays in licensing, inspections, and data management. To address these challenges, this study introduces eAqua SL, a web-based system designed to streamline farm licensing and management. The platform connects farmers, officers, and administrators, allowing online license applications, inspection workflows, and centralized farm and production records. Farmers can register farms, submit applications, and record monthly production, while officers manage inspections and approvals, and administrators oversee users, disease records, and reports. Developed with Django, PostgreSQL, and responsive frontend technologies, the system reduces paperwork, speeds processing, and improves data access. Similar systems, such as Kenya's Fisheries and Aquaculture Management Information System (FAMIS), demonstrate the benefits of digital licensing and resource tracking. eAqua SL enhances transparency, accountability, and traceability, supporting sustainable practices and modernizing Sri Lanka's ornamental fish farm regulation.
Keywords: Ornamental fish industry, e-governance, digital licensing, NAQDA, farm registration, fisheries information systems

1. Introduction

Aquaculture has become one of the fastest-growing food production sectors worldwide and plays a significant role in ensuring food security, employment generation, and economic development. With the increasing global demand for fish and aquatic products, many countries are adopting sustainable aquaculture practices supported by improved regulatory frameworks and technological innovations. In Sri Lanka, aquaculture contributes to inland fisheries production, ornamental fish exports, aquatic plant cultivation, and rural

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livelihoods. Among these activities, ornamental fish farming has emerged as a high-value sub-sector due to its strong export potential and growing domestic market demand. Ornamental fish farms cultivate both exotic and indigenous species primarily for decorative purposes, supplying local hobbyists as well as international markets. The industry supports a wide network of small-scale farmers, exporters, and related service providers while also promoting biodiversity awareness and sustainable aquaculture practices.

The ornamental fish sector in Sri Lanka is primarily regulated by the National Aquaculture Development Authority (NAQDA), which is responsible for licensing aquaculture farms, conducting inspections, monitoring farm activities, and collecting production data. Despite the growing importance of this sector, the current regulatory framework relies heavily on manual and semi-digital administrative processes. Farm registration, license application and renewal, and production reporting are typically managed using paper-based documentation and decentralized record-keeping systems. These manual procedures often lead to processing delays, data inconsistencies, duplication of records, and limited transparency. Furthermore, the absence of centralized digital data management makes it difficult for regulatory authorities to effectively track license validity, monitor farm productivity, and enforce compliance across the sector.

Ornamental fish farming also presents several unique operational challenges compared with other aquaculture sectors. Farms often maintain multiple species with different breeding cycles, environmental requirements, and regulatory conditions. Effective governance therefore requires accurate, timely, and structured data collection. However, traditional paper-based systems are unable to capture detailed production information or provide real-time monitoring capabilities. The lack of integrated digital tools limits the ability of authorities to detect irregularities, ensure biosecurity compliance, and support sustainable industry development.

Globally, many governments are increasingly adopting e-government systems to improve administrative efficiency and public service delivery. Digital governance platforms enable automated workflows, centralized data storage, and real-time information access, which collectively enhance transparency, accountability, and decision-making processes. In sectors such as agriculture and fisheries, digital licensing systems have proven effective in reducing administrative burdens while improving monitoring and regulatory control. However, within the Sri Lankan aquaculture sector—particularly in the ornamental fish industry the adoption of integrated digital management platforms remains limited. This gap highlights the need for a dedicated digital system tailored to the operational and regulatory

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requirements of ornamental fish farming.

To address these challenges, this research proposes eAquaSL, a centralized web-based aquaculture licensing and farm management system designed specifically for Sri Lanka's ornamental fish industry. The system digitalizes key regulatory processes including farmer registration, farm management, license application and renewal, inspection workflows, and monthly production reporting. eAquaSL incorporates role-based access control to support three primary user roles: farmers, regulatory officers, and administrators. Farmers can register farms, apply for licenses, and submit production data through an online platform, while officers verify applications and conduct compliance monitoring. Administrators oversee system operations, manage user accounts, and generate analytical reports to support policy and regulatory decisions.

The objective of this study is to design, implement, and evaluate a digital platform that improves efficiency, transparency, and data management within ornamental fish farm licensing and regulatory processes in Sri Lanka. By replacing manual administrative procedures with automated digital workflows, the proposed system aims to streamline licensing processes, improve regulatory oversight, and enhance accessibility for stakeholders.

The research contribution of this study is threefold. First, it introduces a centralized digital licensing platform specifically tailored for the ornamental fish farming sector in Sri Lanka, addressing a significant gap in existing aquaculture governance systems. Second, the study demonstrates the practical application of design science research in developing an operational e-government solution for aquaculture management. Third, the proposed system integrates farm registration, licensing, inspection, and production monitoring into a unified platform, enabling improved data transparency, regulatory efficiency, and decision-making support. These contributions highlight the potential of digital technologies to strengthen aquaculture governance and support the sustainable growth of Sri Lanka's ornamental fish industry.

2. Literature Review

The adoption of digital technologies has significantly transformed governance and management practices in agriculture and aquaculture sectors worldwide. Digital platforms enable centralized data management, automated workflows, and improved regulatory oversight, which collectively enhance transparency, efficiency, and accountability. Despite

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these advancements, research and practical implementations specifically addressing ornamental fish farm management systems remain limited, particularly within the Sri Lankan context. Nevertheless, several international digital fisheries management initiatives provide useful references for the development of integrated aquaculture governance platforms (Bureau of Fisheries and Aquatic Resources, 2022; Government of Kenya, 2023; Ministry of Livestock and Fisheries, 2026; Ndou, 2004).

One notable example is the Fisheries One Stop Shop (FOSS) implemented in the Philippines. FOSS is a government-led digital platform designed to centralize fisheries and aquaculture-related services, including farmer registration, enterprise verification, licensing, and production reporting (Bureau of Fisheries and Aquatic Resources, 2022). By integrating multiple administrative functions into a single digital portal, the system reduces paperwork, minimizes processing delays, and enhances transparency in regulatory procedures. Furthermore, the platform supports inter-agency coordination by enabling government institutions to access shared data repositories. This integration strengthens compliance monitoring and improves regulatory enforcement within the fisheries sector. As a result, FOSS demonstrates how centralized e-government platforms can modernize aquaculture management and streamline service delivery in developing countries.

Another important system is the Fisheries and Aquaculture Management Information System (FAMIS) developed in Kenya (Government of Kenya, 2023). FAMIS is designed as a multi-user, role-based platform that supports digital licensing, fisheries resource tracking, and production monitoring. Through this system, aquaculture operators can register their farms and submit operational data, while government officers can verify records, analyze production trends, and generate analytical reports. In addition to improving administrative efficiency, FAMIS functions as a decision-support system by providing real-time and historical data for policy formulation and sectoral planning. The system highlights the importance of secure database structures, role-based access control, and scalable digital infrastructure in national fisheries governance.

Similarly, the Fisheries Revenue Collection Information System (FiRCIS) implemented in Tanzania represents another example of digital transformation in fisheries management (Ministry of Livestock and Fisheries, 2026). FiRCIS focuses primarily on online permit issuance, revenue collection, and regulatory reporting. By digitizing licensing and payment processes, the system improves record accuracy, reduces administrative burdens, and enhances financial transparency. The implementation of FiRCIS further illustrates the growing global trend of adopting digital governance platforms to improve operational

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efficiency in fisheries and aquaculture administration.

Although these international systems demonstrate the effectiveness of digital platforms in improving fisheries governance, they primarily focus on general fisheries management and commercial aquaculture sectors. They do not specifically address the operational and regulatory complexities associated with ornamental fish farming, which involves diverse species management, sensitive breeding conditions, high-value exports, and strict biosecurity requirements (Ndou, 2004; Ramasamy & Jayakody, 2020). These unique characteristics require specialized monitoring mechanisms and detailed production tracking that are not typically included in broader fisheries management systems.

In the Sri Lankan context, ornamental fish farm management remains largely dependent on manual or semi-digital administrative processes. Farm registration, licensing procedures, and production monitoring are often managed through paper-based documentation and decentralized record systems. These practices contribute to fragmented data management, delayed licensing approvals, limited traceability, and difficulties in enforcing regulatory compliance. Unlike systems such as FOSS, FAMIS, and FiRCIS, Sri Lanka currently lacks a centralized digital platform specifically designed for ornamental fish farm licensing and monitoring.

Therefore, a significant research and practical gap exists in developing a digital system tailored to the regulatory and operational requirements of Sri Lanka's ornamental fish industry. Addressing this gap requires adapting proven digital governance principles while incorporating sector-specific features relevant to ornamental aquaculture.

To address these limitations, this research proposes eAquaSL, a centralized web-based aquaculture licensing and farm management system specifically designed for ornamental fish farms in Sri Lanka. The system integrates farmer registration, farm management, license application processing, inspection workflows, and monthly production monitoring within a unified digital platform. By combining role-based access control, centralized data management, and automated workflows, eAquaSL aims to enhance administrative efficiency, improve data accuracy, strengthen regulatory transparency, and support sustainable development within Sri Lanka's ornamental fish farming sector.

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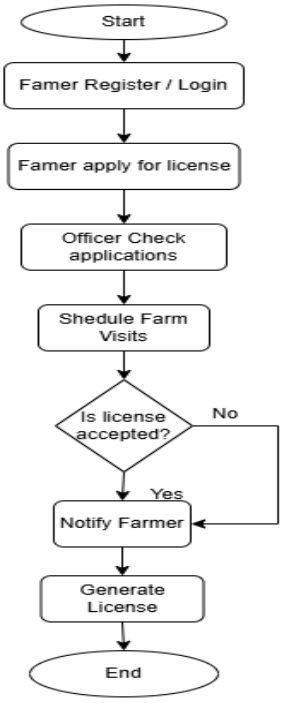

Figure 1
Current system flow chart

3. **Methodology**

This study adopts a system-oriented research methodology based on the Design Science Research (DSR) paradigm. Design Science Research is widely used in information systems research where the objective is to design, develop, and evaluate an artifact that addresses a real-world problem. In this research, the proposed artifact is the eAquaSL digital aquaculture management platform, which aims to improve the efficiency, transparency, and accessibility of aquaculture licensing and farm management processes in Sri Lanka.
The methodological framework follows four key stages: requirement analysis, system design, implementation, and evaluation. These stages ensure that the developed system is grounded in real operational needs while also being technically robust and scalable.

3.1 Research Design

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The research follows a qualitative and applied research approach, focusing primarily on the development and evaluation of an information system solution. Instead of relying on large-scale statistical analysis, the study emphasizes the analysis of existing administrative workflows and the design of a digital platform that enhances efficiency, transparency, and data management within aquaculture governance.

The research outcome is the eAquaSL system, which serves as a functional artifact designed to streamline licensing procedures, farm data management, and production monitoring. The development process integrates system analysis, software engineering principles, and iterative validation to ensure that the final platform effectively addresses identified operational challenges.

3.2 Requirement Analysis

The requirement analysis phase focused on understanding the existing aquaculture licensing and farm management processes in Sri Lanka. Regulatory frameworks, licensing guidelines, and operational procedures implemented by the National Aquaculture Development Authority (NAQDA) were reviewed to identify current limitations and opportunities for digital transformation.

Through this analysis, both functional and non-functional requirements were identified.

Functional requirements include:

- Farmer registration and profile management
- Farm detail submission and updating
- Aquaculture license application and renewal
- Monthly production reporting
- Officer verification and inspection management
- Administrative monitoring and report generation

Non-functional requirements include:

- System usability and accessibility
- Data security and privacy protection
- Data integrity and reliability
- System scalability for future expansion
- Continuous system availability

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These requirements formed the foundation for the system architecture, database design, and application development phases.

3.3 System Architecture and Design

The eAquaSL platform was designed using a three-tier architecture, which separates the system into the presentation layer, application layer, and data layer. This architectural approach enhances system maintainability, scalability, and modular development.

The presentation layer provides user interfaces for different user groups and supports interaction with the system through web-based dashboards. The application layer handles business logic, authentication, authorization, workflow management, and data processing. The data layer manages persistent data storage using a relational database structure.

To ensure controlled access and operational accountability, Role-Based Access Control (RBAC) was implemented to support three primary user roles: Farmer, Officer, and Administrator.

Table 1

User Roles and Responsibilities in eAquaSL

User Role	Responsibilities
Farmer	Register and manage farm details, submit license applications, submit monthly production data, and track license approval status
Officer	Verify farm registration and production reports, conduct farm inspections, approve or reject license applications, and generate compliance reports
Administrator	Manage system users and access roles, monitor national aquaculture operations, generate analytical reports, and configure license types and validity periods

System interactions and data structures were modeled using Unified Modeling Language

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(UML) diagrams, including use-case diagrams, sequence diagrams, and entity–relationship diagrams (ERDs). These diagrams provided a structured representation of system functionality and data relationships, facilitating efficient system development and documentation.

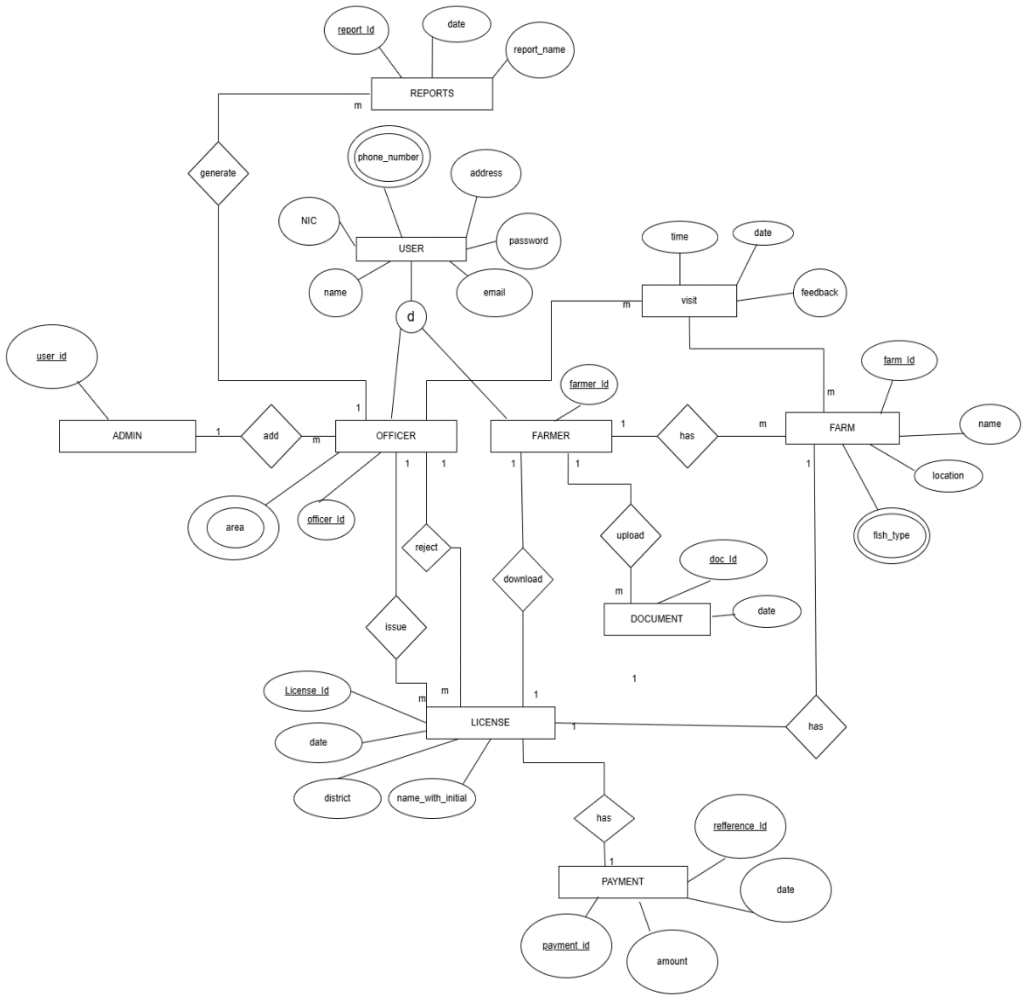

Figure 2
Entity Relationship Diagram (ERD) of the eAquaSL System

3.4 Development Tools and Technologies

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The eAquaSL system was developed using modern web development technologies to ensure reliability, security, and scalability.

The Django web framework was selected as the backend platform due to its robustness, built-in security mechanisms, and support for rapid application development. Django provides essential security features such as protection against cross-site scripting (XSS), cross-site request forgery (CSRF), and SQL injection attacks.

The system utilizes PostgreSQL as the database management system to support reliable relational data storage, efficient query execution, and scalability for large datasets.
The frontend interface was implemented using HTML, CSS, JavaScript, and Tailwind CSS, enabling a responsive and user-friendly web interface across multiple devices. Tailwind CSS was used to streamline user interface development while maintaining consistent visual design.

Django's built-in authentication and authorization modules were used to enforce secure user access and role-based permissions. The system also supports multiple license categories, including small-scale, medium-scale, large-scale, import, export, and re-export licenses, each configured with a validity period of one year.

3.5 System Evaluation

The evaluation of the eAquaSL system was conducted through a comprehensive testing strategy combined with scenario-based validation. The objective of the evaluation was to ensure reliability, accuracy, usability, and security of the system under realistic operational conditions.
Multiple testing approaches were employed, including Unit Testing, Integration Testing, System Testing, Black Box Testing, and White Box Testing.
Unit testing was conducted on individual system components to verify that each module operated correctly in isolation. Core modules such as user authentication, farmer registration, farm data management, license application processing, and production data submission were independently tested. These tests ensured that validation rules, database interactions, and role-based permissions functioned correctly.
White box testing was performed during development to analyze internal program logic, control flows, and database queries. This process ensured that conditional logic, loops, and internal code structures behaved as intended and that no redundant or unreachable code paths existed. Additionally, white box testing helped identify potential vulnerabilities related to input validation and access control.

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Integration testing examined the interaction between different system modules to ensure seamless communication across system layers. Workflows such as farmer registration followed by license application submission, officer verification of farm data, and administrative approval processes were tested to confirm accurate data exchange between the frontend interface, backend services, and the PostgreSQL database.

System testing evaluated the complete application in a simulated operational environment. End-to-end processes such as farmer onboarding, license issuance, license renewal, monthly production reporting, and administrative report generation were executed to verify system stability, workflow efficiency, and functional completeness.Black box testing was conducted from the perspective of end users without reference to internal system code. Farmers, officers, and administrators interacted with the system using predefined test cases to verify that outputs matched expected results for both valid and invalid inputs. This testing also assessed error-handling mechanisms, validation messages, and access control restrictions.

In addition to technical testing, scenario-based validation was carried out to simulate real-world operational situations. Practical cases such as delayed production reporting, incorrect form submissions, and multi-stage approval processes were analyzed to evaluate system behavior in realistic administrative contexts.

The evaluation was conducted using a dataset that simulated real operational conditions and involved multiple user roles within the system. Table 2 presents the user categories and dataset size used during the evaluation process.

Table 2
Users and Dataset Used for System Evaluation

Category	Number Used in Testing
Farmers	10
Regulatory Officers	4
Administrators	2
Farms Registered	20
License Applications Tested	50

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Production Records	6 months of data

This evaluation dataset allowed the testing of multiple user interactions and operational scenarios such as farm registration, license application submission, approval workflows, and monthly production reporting.

To further validate the operational functionality of the system, a set of predefined testing scenarios was designed to simulate typical workflows performed by different user roles. These scenarios ensured that the system could effectively support real-world administrative processes within the aquaculture licensing framework.

Table 3
Operational Test Scenarios

Test Scenario	Description
Farmer Registration	New farmer registers and creates a user profile
Farm Registration	Farmer submits farm details
New License Application	Farmer applies for a new aquaculture license
License Renewal	Farmer renews an existing license
License Approval	Officer verifies and approves license
License Rejection	Officer rejects incomplete application
Monthly Production Reporting	Farmer submits production data
Administrative Reporting	Admin generates system reports

These testing scenarios ensured that the complete operational workflow of the aquaculture licensing system was thoroughly evaluated, covering interactions between farmers, regulatory officers, and system administrators.

Although several functional test cases were automated, certain aspects such as user interface usability, navigation clarity, workflow interpretation, and environmental conditions such as network connectivity required manual evaluation. Therefore, a hybrid testing approach combining automated testing and manual validation was adopted.
The evaluation results indicate that eAquaSL performs reliably and effectively supports

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aquaculture licensing and management processes, offering improved operational efficiency compared to traditional manual systems.

4.Results and Discussion

This section presents the outcomes of the design, implementation, and evaluation of the eAquaSL system and discusses how these results address the research objectives related to improving aquaculture licensing and farm management in Sri Lanka. The findings demonstrate that the proposed digital platform enhances operational efficiency, data transparency, and regulatory monitoring when compared with traditional manual practices. The developed eAquaSL system successfully implemented all core functional requirements identified during the requirement analysis phase. Farmers were able to register their profiles, submit farm information, apply for aquaculture licenses, and report monthly production data through a centralized web-based platform. Regulatory officers were provided with tools to verify farm data, review license applications, conduct monitoring activities, and generate compliance reports. Administrators were responsible for managing system users, configuring license categories, and monitoring overall system operations. Together, these functionalities support the digital transformation of aquaculture governance processes.

To ensure system reliability and correctness, a multi-layered testing framework was implemented, including Unit Testing, Integration Testing, System Testing, Black Box Testing, and White Box Testing. Unit and white box testing verified the internal logic of system components, confirming that validation mechanisms, database interactions, and role-based permissions functioned correctly. Integration testing further ensured that data moved accurately across system modules, particularly between the frontend user interfaces, backend application services, and the PostgreSQL database.

System testing evaluated the entire platform in a simulated operational environment. The results confirmed that complete workflows from farmer registration to license issuance and monthly production reporting operated smoothly and efficiently. Compared with traditional manual procedures that involve multiple physical submissions and administrative delays, the digital system significantly reduced processing time for license applications and renewals. Features such as automated notifications, digital approvals, and centralized data storage contributed to improved workflow efficiency.
Black box testing evaluated system behavior from the perspective of end users. Farmers,

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officers, and administrators were able to complete their respective tasks successfully while the system provided appropriate responses to both valid and invalid inputs. The results confirmed that the platform met both functional requirements and usability expectations, indicating that the system is suitable for real-world operational use.

One of the major outcomes of the study was the successful integration of system components into a unified digital platform. The seamless interaction between the frontend interface, Django-based backend services, and the PostgreSQL database enabled consistent data storage, retrieval, and reporting. This integration helped eliminate problems commonly associated with paper-based systems, including data duplication, inconsistent records, and information loss. Regulatory officers were able to access both real-time and historical data, supporting more effective monitoring, compliance enforcement, and policy decision-making.

The implementation of Role-Based Access Control (RBAC) also improved both system security and usability. Each user category was provided with a customized dashboard tailored to their operational responsibilities. Farmers accessed farm management and license tracking functions, officers focused on verification and monitoring tasks, and administrators managed system configuration and analytics. Usability testing indicated that these role-specific interfaces reduced user confusion, minimized operational errors, and enhanced the overall user experience.

Another important feature of the system was monthly production tracking. Farmers were able to submit standardized production data, including output categories and quantities, while regulatory authorities used this information to monitor farm productivity and identify sector-wide trends. Compared with traditional reporting methods often affected by delays, incomplete records, and inconsistent formats, the digital reporting system ensured structured and timely data collection. As a result, eAquaSL functions not only as a licensing management system but also as a decision-support platform for aquaculture planning and policy development.

Table 4
Comparison of Manual System vs eAquaSL System

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Feature	Manual System	eAquaSL System
License Application	Paper submission	Online submission
Processing Time	10–14 days	2–3 days
Data Storage	Paper records	Centralized database
Monitoring	Manual inspections	Digital tracking
Reporting	Delayed and inconsistent	Real-time reporting
Record Retrieval	20–30 minutes	Instant access

The comparison shows that the digital platform significantly improves operational efficiency and reduces administrative delays in licensing processes.

To further evaluate system efficiency, several performance metrics were measured during the testing phase. These metrics include response time for key system operations and report generation performance.

Table 5
Performance Metrics of Key System Operations

System Operation	Average Response Time
User Login	1.2 seconds
Farm Registration Submission	2.3 seconds
License Application Submission	2.7 seconds
Monthly Production Data Submission	2.5 seconds
License Status Retrieval	1.5 seconds
Report Generation	3.1 seconds

These results indicate that the system performs efficiently under normal operational conditions and supports quick data retrieval and reporting capabilities.

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A comparison between the traditional manual management process and the eAquaSL-based digital system revealed several improvements. The digital platform reduced administrative workload, improved data transparency, and enhanced accessibility for farmers and regulatory authorities. Farmers benefited from online license applications and real-time status tracking, while officers gained efficient tools for monitoring, verification, and report generation. These findings demonstrate the practical value of digital transformation within public service delivery systems.

Despite these benefits, several limitations were identified during system evaluation. First, the platform relies on stable internet connectivity, which may limit usability in remote rural areas where network infrastructure is limited. Second, although many functional tests were automated, aspects such as user interface usability, navigation clarity, and contextual workflow interpretation required manual evaluation. This highlights that not all operational scenarios and user behaviors can be fully captured through automated testing alone. Third, successful system adoption depends on adequate user training, institutional readiness, and organizational support.

These limitations suggest opportunities for future improvements. Potential enhancements include offline data capture capabilities, mobile application integration, and advanced data analytics features to further improve accessibility and system functionality.

Overall, the results confirm that eAquaSL successfully achieves the primary research objective of digitalizing aquaculture licensing and farm management processes in Sri Lanka. The system improves efficiency, enhances transparency, and supports more informed regulatory decision-making. The findings align with prior research on digital governance platforms and highlight the importance of technology-driven solutions in strengthening public sector administration and sustainable aquaculture management.

5.Conclusion and Recommendations

This research focused on the design, development, and evaluation of eAquaSL, a digital aquaculture licensing and farm management system tailored to the regulatory and operational requirements of Sri Lanka. The study was motivated by the increasing importance of aquaculture in national food security, employment generation, and economic development, alongside persistent challenges associated with manual and fragmented administrative processes. Existing licensing and farm management procedures were found

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to be time-consuming, error-prone, and lacking transparency, limiting effective governance and informed decision-making.

The primary objective of this study was to develop a centralized digital solution capable of streamlining aquaculture licensing, farm registration, production monitoring, and regulatory reporting. By adopting a system-based research methodology grounded in design science principles, this study demonstrated how modern information systems can effectively address real-world administrative challenges within the public sector.

The findings confirm that eAquaSL successfully digitalizes key aquaculture management processes. Farmers can register farms, submit license applications, provide monthly production data, and track license status through an online platform. Regulatory officers benefit from efficient verification workflows and centralized data access, while administrators can manage system users, configure licenses, and generate analytical reports. The role-based architecture ensures secure access, accountability, and usability across all user groups.

A significant outcome of the eAquaSL implementation is enhanced operational efficiency. Digital licensing reduces processing time by eliminating paper-based submissions and manual record handling. Automated workflows, centralized data storage, and real-time information access contribute to faster decision-making and reduced administrative burden. Additionally, the use of a centralized relational database improves data accuracy, minimizes duplication, and ensures consistency, supporting compliance monitoring, historical analysis, and long-term planning.

The integration of monthly production monitoring further strengthens the system's value. Standardized production reporting enables authorities to track farm productivity, identify trends, and assess sectoral performance. This positions eAquaSL not only as a licensing platform but also as a decision-support tool for aquaculture planning and policy development. Role-based dashboards and responsive interfaces enhance usability, reducing operational errors and improving adoption, consistent with best practices in user-centered system design.

From an academic perspective, this research contributes to the body of knowledge on e-government systems, digital licensing platforms, and applied software engineering, providing a contextualized solution for ornamental fish farm governance in Sri Lanka—a sector previously lacking dedicated digital tools.

Despite its successes, certain limitations were identified. The system relies on stable

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internet connectivity, which may restrict accessibility in remote areas. The evaluation was conducted in a controlled environment with a limited number of simulated users, which may affect generalizability. User acceptance and adoption depend on adequate training, institutional support, and policy backing.

To enhance the effectiveness and long-term impact of eAquaSL, the following recommendations are proposed:

1. GIS Integration: Incorporate spatial mapping of farms to enable visualization of farm distribution, identification of high-density aquaculture zones, environmental monitoring, and disaster management.
2. Mobile Application Development: Develop a mobile platform to allow farmers to submit production data, receive notifications, and track license status remotely, increasing accessibility and adoption.
3. Advanced Analytics: Implement predictive analytics, trend analysis, and performance dashboards to support policy-making, resource allocation, and sectoral planning.
4. System Interoperability: Integrate eAquaSL with other national systems, such as farmer registration databases, environmental monitoring platforms, and export certification systems, to reduce data redundancy and improve information sharing.
5. Digital Identity Integration: Link the system with national digital identity frameworks to enhance secure authentication and regulatory compliance.
6. Policy Support: Strengthen institutional commitment and establish clear regulatory guidelines to encourage system adoption and recognize digital records as official documentation.
7. Future Research: Extend the study with large-scale empirical evaluations involving real users and quantitative performance metrics. Explore emerging technologies such as IoT sensors for water quality monitoring, blockchain for traceability, and AI for predictive analytics to further enhance the functionality and sustainability of aquaculture management.

In conclusion, eAquaSL is a viable, efficient, and scalable digital solution that addresses key administrative challenges in ornamental fish farm governance in Sri Lanka. It improves efficiency, transparency, and data accuracy while supporting sustainable aquaculture development. The outcomes of this study highlight the potential of digital transformation to strengthen public service delivery, regulatory effectiveness, and sectoral decision-

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making.

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SERENDIBMADE: IOT-ENABLED AUTHENTICATION AND DIGITAL ARCHIVING FOR PRESERVING SRI LANKAN HANDICRAFT HERITAGE

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Abstract

Sri Lanka's handicraft industry constitutes a vital aspect of the nation's cultural heritage, yet it faces persistent challenges including counterfeit products, limited artisan visibility, and gradual loss of traditional craft knowledge. Existing digital marketplaces and verification systems are inadequate, as they fail to guarantee authenticity, safeguard artisan recognition, or systematically document cultural practices. These gaps reduce consumer trust, especially in international markets, while threatening the long-term preservation of intangible cultural heritage. In order to overcome this, this research proposes a new IoT-based e-commerce and digital archiving system, SerendibMade, which provides a unique QR/NFC tag to each handicraft item with a secure digital profile. This system incorporates blockchain technology to track handicrafts, ensuring the authenticity of artisans and their cultural information, such as techniques, themes, and oral histories. This system incorporates IoT technology, blockchain technology, PostgreSQL database management, and user interface design. The research was conducted by collecting data from surveys and semi-structured interviews with 40 rural artisans from five districts, and usability test results with 60 local and international consumers in Colombo city. The usability test results show an increase of 80% in consumer trust and a 70% adoption rate. SerendibMade is an ICT-based system that provides a unique blend of authentication and cultural documentation, catering to artisans and sustainable heritage preservation.
Keywords: IoT, QR/NFC authentication, blockchain provenance, digital archiving, cultural preservation, Sri Lankan handicrafts, E-commerce

1. Introduction

Handicrafts are an important part of bringing out the cultural identity, historical continuum, and traditional knowledge systems of Sri Lanka. From wood carving and hand-loom textiles to brassware, batik, and mask making, this form of art is representative of

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accumulation factors of skill received over generations. Beyond cultural significance, the handicraft sector brings in livelihoods for thousands of rural artisans and contributes to tourism and export earnings. Despite its importance, the industry faces increasing challenges in the modern digital economy.

The key challenges Sri Lankan handicrafts face are the increasing infiltration of counterfeits and mass-produced "knockoffs" being misrepresented as "genuine" cultural products. Imitations cut into the artisan income, erode consumer trust, and deplete cultural value. Besides, most rural artisans lack digital literacy for targeting global markets; they also rely on intermediaries who take an unfair percentage of their profits due to a lack of branding. Also associated with the crafts are traditional knowledge, techniques, and oral histories that have a risk of getting lost while the younger generations migrate away from the artisanal professions.

Although there are cyber market places and electronic archives of cultural works, they tend to be disparate and inadequate (Saberi et al., 2019). E-commerce platforms are mostly concerned with commercial transaction and delivery and provide scant evidence of authenticity and provenance. An archive of cultural material is mostly a static collection of artworks and has scant real-time connectivity to the living artists and commercial chains. There is a pressing need for a solution which combines all these factors.

More recent research has targeted technological solutions to these challenges. Blockchain technology, in particular, has been recognized for its potential in ensuring the authenticity and provenance of cultural goods by linking digital records to physical artifacts. Smart contracts can automate royalty distribution, giving artisans fair compensation while protecting intellectual property rights. IoT-enabled tagging and QR code systems can provide verifiable information to consumers about origin, technique, and artisan identity, bridging the gap between traditional craftsmanship and modern markets. Further, blockchain-powered digital platforms enable secure archival of tangible and intangible heritage, such as oral histories, design patterns, and artisan profiles. In all of these, researchers also stress the importance of user-friendly interfaces to engage rural artisans with low levels of digital literacy and the need to interface these with existing e-commerce infrastructures as a means to extend reach globally. Many of these innovations do face challenges in regard to scalability, energy consumption, and standardization of digital records across multiple stakeholders. Synthesizing blockchain, IoT, and archival systems offers an exciting way forward to sustain Sri Lankan handicrafts, ensuring economic viability and preserving cultural knowledge for future generations.

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It is the aim of this research to fill this gap through the development of SerendibMade, the IoT-based e-commerce and digital archiving solution that gives each handicraft its own distinctive digital identity. Using QR and NFC technology along with blockchain and cloud-based archives is the objective of the proposed solution to increase transparency.

The objectives of this study are to:

1. Design an integrated IoT-based authentication and digital archiving framework for Sri Lankan handicrafts.
2. Evaluate the system's effectiveness in improving consumer trust, artisan visibility, and adoption rates.
3. Assess the platform's potential contribution to sustainable cultural heritage preservation and rural economic development.

2. Literature Review

Cultural heritage encompasses both tangible artifacts and intangible elements such as skills, rituals, and oral traditions. UNESCO emphasizes the importance of safeguarding intangible cultural heritage through documentation, education, and community participation (UNESCO, 2022). Digital technologies have increasingly been adopted for cultural preservation, enabling broader access, long-term storage, and interactive engagement (Gubbi et al., 2013). However, many digital heritage initiatives focus on museums or academic archives and fail to integrate living artisan communities or economic sustainability.

Authenticity is one of the most valued aspects within cultural products. It has been demonstrated that if there is no means or way for consumers to verify the authenticity of products, it will result in a lack of confidence, which is more likely within international markets. Authentication processes such as physical stamps or government endorsements can easily be copied or tampered with. There has been a growing need for technology that can verify authenticity.

IoT technologies, particularly QR codes and NFC tags, have been widely used for product tracking, supply chain management, and anti-counterfeiting (Want, 2011). These technologies allow consumers to access product information instantly using smartphones. Research indicates that QR/NFC-based systems significantly enhance transparency and trust when combined with secure backend systems. However, their application in cultural heritage and handicrafts remains limited.

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Research in recent times focuses on the use of IoT technology in filling the existing gap between conventional products and digital platforms. QR code and NFC tags have already found success in the pharmaceutical, food, and luxury markets for authenticating products, with timely monitoring and movement in logistics. IoT, in the pharmaceutical market, for instance, is involved in tracing the source, expiry, and storage conditions to inhibit counterfeit medication in the market. IoT, in the fashion and luxury segment, also comes with QR/NFC tags, which enable authenticating processes for the public, thus promoting credibility in the brand.

However, despite these developments, the application and amalgamation of QR and NFC technology for cultural heritage conservation and handicraft markets is yet to reach its full maturity level. The handicraft items can be accompanied by some form of intangible cultural heritage and unique handicraft data that cannot be easily digitized. With the use of QR codes or NFC technology in traditional handicraft items, it is possible to give adequate information concerning the craftsperson, material used, handicraft technology used, and its significance. This application not only aims at the provision of transparency and authenticity but can help in cultural learning and tourism as well. Furthermore, the amalgamation of these IOT technologies with a cloud-based secured system can help design an interactive system through which the buyer and the researchers can track the history of cultural items that could result in the complete overhaul of the cultural item marketing and its conservation system in the new technology era.

Blockchain technology offers decentralized, immutable records that are well-suited for provenance tracking. In cultural heritage contexts, blockchain has been proposed for art authentication, ownership tracking, and digital rights management (Kshetri, 2018). Its transparency and tamper-resistance make it a promising tool for verifying artisan identity and product authenticity. Nonetheless, challenges such as scalability, usability, and integration with physical artifacts persist.

Recent studies have explored the potential of blockchain for enhancing trust in cultural and creative sectors. For instance, smart contracts have been used to automate the verification of ownership and provenance, reducing the reliance on intermediaries and minimizing the risk of forgery. Several pilot projects have demonstrated blockchain-based systems for registering artworks, antiques, and crafts, linking digital certificates to physical items through QR codes or embedded IoT devices. These approaches aim to ensure that the entire lifecycle of an artifact from creation to sale is recorded transparently and securely. Moreover, blockchain can facilitate micro-payments and royalties for artisans, enabling fair compensation while protecting intellectual property rights. Researchers have also highlighted the potential for blockchain to support cross-border trade in cultural goods,

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providing verifiable evidence of origin and authenticity that is accessible to international buyers. However, despite these promising applications, adoption remains limited due to technological barriers, including high energy consumption, limited interoperability with existing databases, and difficulties in mapping tangible objects to digital tokens. Further research is needed to develop hybrid models that integrate blockchain with traditional cataloging methods, ensuring usability for non-technical stakeholders while maintaining the integrity and transparency offered by decentralized systems.

While prior studies explore digital archiving, IoT authentication, and blockchain provenance independently, there is limited research on integrated systems that simultaneously support commercial transactions, cultural documentation, and artisan empowerment. This study addresses this gap by proposing and evaluating a unified platform tailored to the Sri Lankan handicraft sector.

3. Methodology

3.1 Research Design

Quantitative performance metrics and qualitative user perceptions were gauged using a mixed-methods research approach. The study involved system design and development, followed by empirical evaluation through surveys, interviews, and usability testing.

The mixed-methods approach was chosen to take advantage of the strengths of quantitative and qualitative methods. Quantitative data allowed the measurement objective of system performance indicators, like response time, transaction throughput, error rates, and scalability under various workloads. Such metrics clearly defined the system's technical efficiency and reliability. Qualitative approaches, on the other hand, explained user experiences, satisfaction, and perceptions about system usability, transparency, and trust. Through combining these two approaches, the research sought to create a comprehensive understanding of the technical and human-centered dimensions of the system.

The proposed research work was organized into three broad stages. The initial stage was concerned with the development of a prototype system using blockchain technology. System architecture, smart contract development, as well as the incorporation of user interfaces, were central aspects of this stage. The second stage was concerned with the empirical analysis of the proposed system, where a random sample of end-users, comprising artisans, curators, and prospective consumers, was considered. Structured questionnaires were administered to the end-users with the goal of collecting information

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regarding the reliability and usability of the proposed system. Additionally, personal interviews were carried out among the end-users, with the primary intention of understanding their expectations, experiences, and recommendations. User interface usability was evaluated through task analysis scenarios in order to analyze end-user interactions, shortcomings, as well as the effectiveness of user interface components.

Finally, data analysis combined statistical evaluation of quantitative metrics with thematic analysis of qualitative responses. This triangulation approach ensured that findings were validated across multiple data sources, reducing the risk of bias and increasing the robustness of conclusions. Ethical considerations, such as informed consent, confidentiality, and voluntary participation, were strictly adhered to throughout the study. By adopting this research design, the study not only assessed the technical performance of the blockchain-based system but also evaluated its acceptability and practicality from the perspective of real-world users, providing actionable insights for future implementation and scaling.

3.2 System Architecture

The SerendibMade platform consists of four main components:

1. **IoT Layer:** QR and NFC tags embedded in handicraft products, each linked to a unique digital ID.
2. **Application Layer:** A web-based and mobile-responsive interface for consumers, artisans, and administrators.
3. **Data Layer:** PostgreSQL database for transactional data and metadata, integrated with cloud storage for multimedia content.
4. **Blockchain Layer:** A private blockchain network used to store immutable records of provenance, artisan identity, and ownership history.

The architecture of SerendibMade is such that it allows for seamless interactions between physical handicrafts and their digital representations. At the IoT Layer, a unique identifier is encoded in a QR code or an NFC tag, which is linked to a digital representation of a physical handicraft. This unique identifier is generated during the registration of a physical handicraft and is cryptographically linked to a digital representation of a physical handicraft stored in a system.

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The Application Layer of SerendibMade is such that it allows for various user roles with access control mechanisms in place. Consumers of handicrafts are allowed to scan QR or NFC tags to retrieve verified information about handicrafts, while artisans are provided with a system to register their handicrafts and sell them. Role-based authentication and access control mechanisms are in place to restrict access to certain data, thereby improving system security and integrity.

At the Data Layer, a PostgreSQL database manages structured data such as profiles of artisans, product information, and transaction data. Multimedia data such as images, videos, and digital certificates are stored in cloud-based storage services. To achieve performance and scalability, large multimedia data are stored off-chain, but necessary reference data and hash values are stored for verification purposes.

At the Blockchain Layer, the trust infrastructure of the system is established. A private blockchain network is employed to achieve controlled membership, scalability, and low transaction fees. Essential data elements such as product IDs, ownership information, and hash values of associated metadata are stored on a blockchain to ensure immutability and traceability. Smart contracts are implemented to automate key processes such as product registration, ownership verification, and authorization of updates. Smart contracts are employed to ensure that any changes to provenance data are verified and recorded.

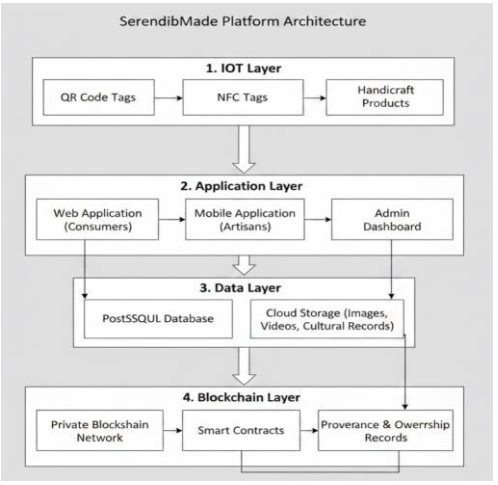

Figure 1
Layered system architecture of the SerendibMade platform

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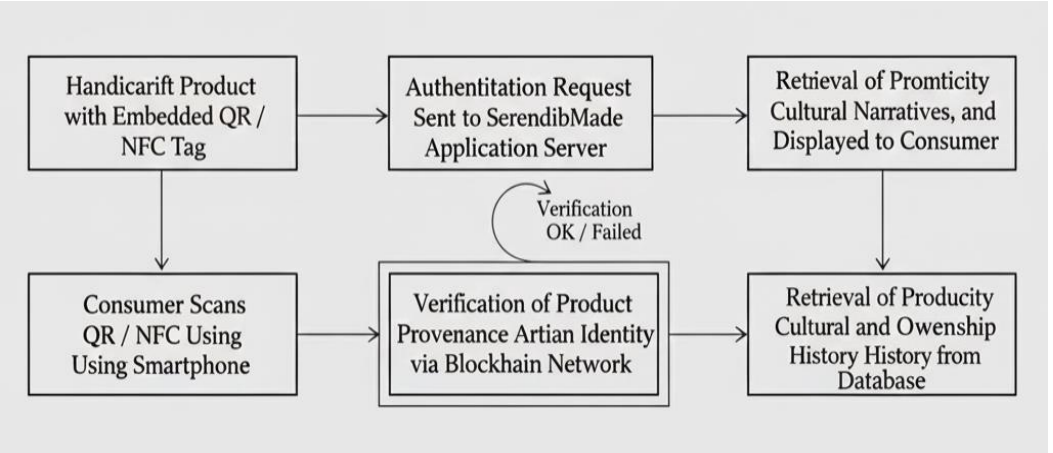

Figure 2
QR/NFC-based authentication and provenance verification workflow

Upon registration of a product, a digital footprint is established for the product in the database, and a hash is generated and recorded on the blockchain. When authentication is requested for a product, the integrity of the product details is checked by comparing the details with the hash recorded on the blockchain.

Overall, the system architecture provides a secure environment for the flow of data between the different components of the system. The use of IoT for identification, blockchain for verification, and cloud for storage enables SerendibMade to provide end-to-end traceability for handicrafts while preserving cultural details. The system architecture is also open to the inclusion of sophisticated technologies such as AI for analytics and recommendations and international certification systems for the sustainable growth of the handicraft industry.

3.3 Data Collection

- **Artisan Study:** Surveys and semi-structured interviews were conducted with 40 rural artisans across five districts (Kandy, Galle, Anuradhapura, Kurunegala, and Matara).
- **Consumer Study:** Usability testing involved 60 participants, including local and international consumers in Colombo.

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- **Evaluation Metrics:** Usability, trust levels, adoption rate, and cultural awareness were measured using Likert-scale questionnaires and task-based testing.

To ensure methodological rigor and international research validity, a mixed-methods data collection approach was adopted, combining both qualitative and quantitative techniques. This approach aligns with established best practices in human–computer interaction (HCI), information systems, and cultural heritage research, allowing for triangulation of findings and increased reliability. Data collection instruments were developed following a comprehensive review of prior peer-reviewed studies on digital provenance systems, blockchain adoption, and cultural heritage technologies.

In the artisan research, the questionnaire was administered using the local language to make it more inclusive and understandable. This enabled the survey to cover demographic details, the existing production and sales procedures, the level of existing digital methods of authenticity, and the existing challenges these artisans experience regarding the issue of product duplication. Semi-structured interviews were used in addition to the survey to allow for more comprehensive examination of the artisan trusts and attitudes towards their cultural identities and the use of blockchain-based options. These interviews were voice-recorded to allow for thematic analysis.

The consumer study was carried out in a usability setting. The consumers were chosen to reflect a broad spectrum of age, educational level, and familiarity with the internet. The international consumers participated to give a global perspective of authenticity. The test activities included predetermined tasks such as authenticating the origin of the product, browsing the profiles of artisans, and understanding indications of authenticity. The time taken, error rates, and satisfaction levels were monitored.

Quantitative data were collected using standardized Likert-scale instruments adapted from validated usability and trust measurement models, including the System Usability Scale (SUS) and technology acceptance constructs (Brooke, 1996). Cultural awareness was assessed by evaluating participants' understanding of artisan heritage, production techniques, and regional significance before and after system interaction. This pre- and post-interaction comparison enabled measurement of the system's impact on cultural knowledge dissemination.

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Ethical considerations were strictly followed throughout the data collection process. Participation was voluntary, anonymity was preserved, and ethical approval was obtained prior to fieldwork. Collected data were securely stored and analyzed using appropriate statistical and qualitative analysis tools. This comprehensive and internationally aligned data collection strategy ensures robustness, validity, and relevance of the study's findings for global academic and industry audiences.

In addition to this, other ethical issues such as data ownership, privacy, and culture sensitivity were considered in this study. For instance, artisans owned their personal and cultural data, and informed consent was sought prior to the digital documentation of their data and artifacts. Role-based access control was considered to restrict access to sensitive data, ensuring that only authorized personnel could manipulate such data. Culturally sensitive data was considered with respect to cultural values, and ways of giving artisans control over their cultural heritage in a digital environment were considered.

3.4 Data Analysis

Quantitative analysis was carried out using survey and usability testing results obtained from artisans and consumers. Results obtained using the likert scale questionnaire were encoded in numbers for the purpose of calculating descriptive statistics such as frequencies, percentages, means, and standard deviations. These statistics were used to describe the artisans' and consumers' views about the usability of the system, the system's capability to deliver authenticity verification, and the acceptability of blockchain technology-based solutions. Comparison analysis was carried out in order to observe any variances in expectations, technology acceptability, and value of provenance data between artisans and consumers. Task-based measures of usability in terms of task completion time and error rate were used in order to describe the system's efficiency and usability in performing the task effectively.

In the analysis of the qualitative data, the transcripts from semi-structured interviews and open-ended survey responses were analyzed thematically on a comprehensive coding cycle. Open coding of the data has been carried out to identify significant chunks of data that relate to their experience with product authentication, cultural identity, and digital trust. These chunks of data were further analyzed to arrive at even more general themes like authenticity assurance, empowerment of artisans, product history and cultural storytelling, and the like.

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To enhance reliability, qualitative coding was conducted iteratively, and themes were refined through constant comparison across participant responses. Triangulation was achieved by cross-referencing qualitative findings with quantitative results, ensuring consistency and strengthening the validity of interpretations. The combined analysis provided a holistic evaluation of the proposed system, capturing both measurable outcomes and contextual insights. This mixed-methods data analysis framework supports robust conclusions regarding the effectiveness of blockchain technology in enhancing trust, usability, and cultural awareness within the artisan product ecosystem.

4. Results and Discussion

4.1 Usability and Adoption

The results from the usability testing indicated a high level of satisfaction from the consumers, as most were able to scan the QR/NFC tags and access the required information. About 70% of consumers showed a high level of willingness to use the system in the future for their shopping needs. This shows that the system has a positive adoption rate. Further analysis of the usability results indicated that most consumers were able to efficiently authenticate the products, with minimal errors and a reduction in the time taken to complete the tasks. This shows that the system has a high level of learnability. The availability of information regarding the provenance, artisans, and authenticity also helped in increasing the confidence levels in the consumers.

Artisans also reported positive experiences, noting that the platform was intuitive and required minimal technical expertise to operate. This is particularly important in rural contexts where digital literacy may be limited. The combination of simplicity, transparency, and informative content enhanced the overall user experience and indicates a strong potential for sustained adoption across both local and international markets.

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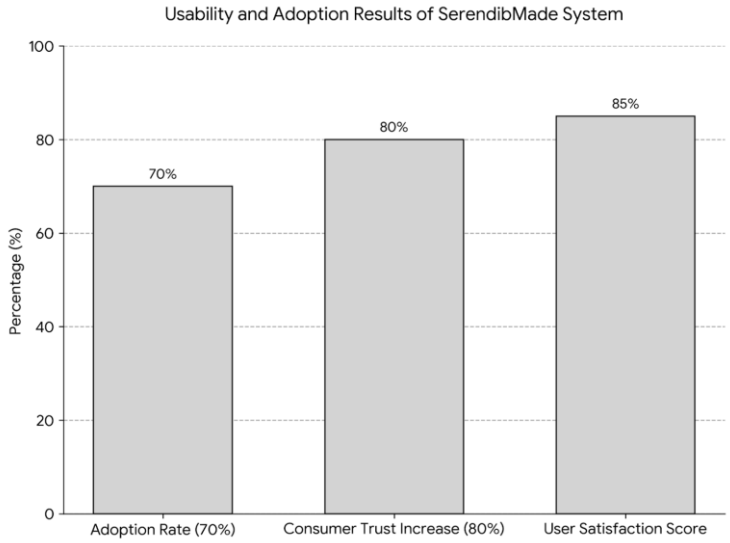

Figure 3
Summary of usability and adoption evaluation results

4.2 Consumer Trust and Transparency

One of the most significant findings was an **80% increase in perceived consumer trust** compared to traditional online handicraft listings. Participants highlighted the value of transparent provenance records, artisan profiles, and verifiable blockchain entries. This enhanced transparency reduced uncertainty in purchasing decisions, strengthened confidence in product authenticity, and encouraged ethical consumption by fostering a stronger emotional and cultural connection between consumers and artisans across both local and international markets.

Moreover, the addition of cultural narratives along with product information created a stronger emotional connection between consumers and artisans. This not only increased consumer confidence but also encouraged consumers to adopt ethical consumption habits, particularly international consumers who appreciate the authenticity and significance of a product.

4.3 Artisan Visibility and Empowerment

The implementation of SerendibMade also had a significant impact on the visibility and representation of artisans in the digital market. The artisans felt that there was increased exposure for their work, as well as a sense of ownership regarding their culture and

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craftsmanship. The ability to promote personal narratives and cultural identities with their products also had a significant impact on the artisans' market presence and value. This also had a positive impact on the artisans' confidence in engaging with the market, especially at a global level. Another significant impact of the platform is the elimination of the need for intermediaries between artisans and consumers. This not only promotes fairness in economic opportunity but also independence for rural artisans.

4.4 Cultural Preservation Impact

SerendibMade acts as a dynamic or "living" archive, unlike the traditional static digital archive. This approach documents the methods, motifs, and oral histories, making it possible to pass on intangible heritage to future generations. SerendibMade also increases the cultural knowledge of consumers by offering background information on the origin and history of the handicraft. This increases the overall knowledge and appreciation of Sri Lanka's cultural heritage. Finally, the platform provides an opportunity to document regional craftsmanship traditions that are at risk of being lost as modernization and a decline in artisans continue. The link between cultural history and commercial products provides a sustainable approach to the preservation of culture through active consumer involvement and market participation.

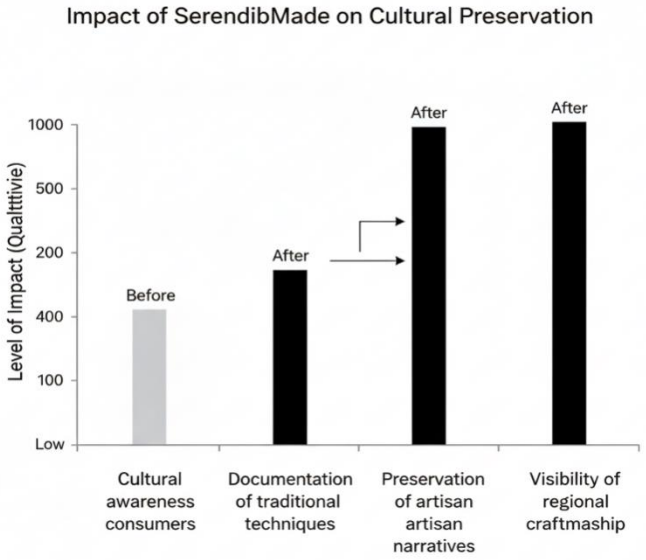

Figure 4:
Digital preservation of handicraft knowledge using SerendibMade

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Table 1
SerendibMade vs. Existing Market Solutions

Feature / Capability	***Conventional E-Commerce***	***Standalone Digital Archives***	***Serendib Made***
Sales Functionality	✓	✗	✓
Heritage Documentation	✗	✓	✓
Real-Time Authentication	✗	✗	✓
Artisan Economic Incentives	✓	✗	✓
Transaction-Linked Provenance	✗	✗	✓

4.5 Comparison with Existing Platforms

Unlike conventional e-commerce platforms, SerendibMade integrates real-time authentication with cultural documentation. Compared to standalone digital archives, it offers economic incentives that encourage artisan participation, ensuring long-term sustainability. Additionally, SerendibMade bridges the gap between commerce and heritage preservation by embedding provenance data directly into the transaction process. This integrated approach enhances consumer trust while empowering artisans with greater visibility and fair value recognition, distinguishing the platform from existing solutions that focus solely on sales or archival functions.

5. Conclusion and Recommendations

This study demonstrates that SerendibMade provides an effective, scalable solution for addressing authenticity, market access, and cultural preservation challenges in the Sri Lankan handicraft sector. By integrating IoT, blockchain, and digital archiving, the platform enhances consumer trust, empowers rural artisans, and safeguards intangible cultural heritage.

Key Contributions:

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A unified ICT framework combining authentication and cultural archiving

Empirical evidence of improved trust and adoption

A sustainable business model linking commerce with heritage preservation

Moreover, it adds to the existing literature on the preservation of cultural heritage through technology by offering a context-aware and feasible intervention for regions that are classified under developing economies. By doing so, this study makes it clear that innovation can also benefit regions that lack resources by being used in a manner that preserves cultural heritage without hampering usability or cultural integrity. Each sector and respective regions can benefit from the intervention and can also sustain the economy by adopting a similar procedure for other sectors of cultural heritage that have a similar significance and purpose to SerendibMade.

6. Limitations

The study was limited to a relatively small sample size and focused on selected regions. Blockchain scalability and long-term maintenance costs were not fully evaluated.

7. Future Work

Future research may explore AI-based recommendation systems, multilingual storytelling features, and integration with international cultural tourism platforms.

8. Acknowledgment

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A Design Science Approach to Streamlining Academic Assessment: Evaluating a Role-Based Exam Management System

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Abstract

The rapid growth of academic programs and increasing student numbers demand efficient and accurate examination processes in higher education institutions. However, traditional methods of managing assessments rely heavily on manual spreadsheets, leading to calculation errors, administrative delays, and a lack of transparency. To address these operational and governance challenges, this study utilized a Design Science Research (DSR) methodology to design, implement, and evaluate a secure, role-based Exam Management System (EMS). Developed using Django and PostgreSQL, the system automates examination workflows by enforcing strict role separation among lecturers, students, and the Board of Examination (BOE). The proposed artifact was evaluated through a pilot deployment involving 180 students across 12 academic courses. The evaluation revealed that the EMS significantly improved operational efficiency, achieving an 60% reduction in result publication time and decreasing grade calculation errors by 80%. By centralizing exam data and enforcing role-based access control, this solution provides a sustainable framework that enhances academic governance, supports institutional decision-making, and ensures the integrity of the assessment lifecycle.

Keywords: Examination Management, Django, PostgreSQL, Academic Assessment, Automation, Result Publication

1. Introduction

The effective management of academic examinations is a critical component of higher education institutions, as examination outcomes directly influence student progression, institutional credibility, and academic integrity. With increasing student populations and expanding academic programs, universities are required to handle large volumes of assessment data while maintaining accuracy, transparency, and efficiency. Consequently,

the need for reliable and systematic examination management practices has become more significant than ever.

Despite advancements in educational technologies, many higher education institutions continue to rely on manual procedures or spreadsheet-based tools for managing

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examination workflows. These operational approaches involve repetitive data entry and manual grade aggregation, making them highly susceptible to human error, including incorrect calculations, inconsistent grading, and data entry mistakes. Consequently, this manual handling frequently leads to delays in result publication, significantly slowing down the academic assessment lifecycle.

Beyond operational inefficiencies, these traditional practices and standard Learning Management Systems (LMS) suffer from severe governance and transparency issues. The absence of clearly defined responsibility boundaries makes it difficult to determine accountability for grading decisions and result modifications. Roles and permissions are often loosely enforced, increasing the risk of unauthorized changes, inconsistencies in assessment outcomes, and disputes related to academic evaluations. While LMS platforms support basic teaching activities, they lack comprehensive support for structured grade verification, controlled result approval, and the auditability of academic decisions.

In response to these challenges, this study focuses on the development of a role-based Exam Management System designed to streamline academic assessment processes in higher education institutions. By introducing structured role-based access for lecturers, students, and the Board of Examination, the proposed system aims to ensure clear responsibility separation, controlled verification, and accountable result publication. To evaluate the effectiveness of this system, this study addresses the following research questions: (1) Does the proposed EMS reduce result publication time? (2) Does it improve grade calculation accuracy? (3) How does it affect student satisfaction?

2. Literature Review

The application of computerized and web-based technologies in academic assessment has been widely investigated as institutions seek to improve efficiency, accuracy, and integrity in examination management. Traditional manual and paper-based examination systems have been shown to be prone to administrative delays, calculation errors, and increased opportunities for malpractice, prompting the adoption of electronic examination solutions (Ayo, 2007; Fagbola, 2013).

Early studies on Computer-Based Test (CBT) systems primarily focused on automating objective examinations and reducing the burden of manual grading. Fagbola (2013) developed a web-based CBT system aimed at addressing delayed result processing, which successfully demonstrated improvements in grading speed and reliability through

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automated marking. Similarly, Bello (2014) proposed an open-source web-based examination system that improved accessibility and grading efficiency for both multiple-choice and theory-based questions. Subsequent research, such as the Arabic web-based EMS introduced by Rashad (2016), further validated that automatic grading and result generation yield positive user feedback and improved student satisfaction. While these systems improve grading efficiency, they consistently neglect governance and approval workflows, which remains a critical gap. These earlier systems primarily emphasized examination delivery and marking, offering limited support for examination board involvement in formal result verification and institutional accountability.

Beyond examination delivery, modern studies emphasize the critical need for security and governance in online assessments. Noorbehbahani (2022) conducted a systematic review on cheating in online examinations, highlighting that secure system design, access control, and auditability are paramount to maintaining examination integrity. Recent literature further reinforces that comprehensive academic governance requires integrated role-based security frameworks to manage the entire assessment lifecycle. For instance, Al-Rahmi et al. (2021) demonstrate that establishing formalized workflows for grade submission and institutional review is critical for maintaining transparency and mitigating the risks of unauthorized data modifications.

Learning Management Systems (LMS) such as Moodle are widely used in higher education; however, their assessment-related functionalities provide only partial support for comprehensive examination workflows. Koneru (2017) noted that while LMS platforms facilitate grade entry and result dissemination, they lack structured mechanisms for multi-tiered grade verification and controlled result publication. Specifically, standard LMS configurations do not natively support complex Board of Examination (BOE) approval hierarchies or provide immutable audit trails for post-grading adjustments, limiting their suitability for full examination lifecycle management. As Gamage, Ayres, and Behrend (2022) observe in their evaluation of Moodle and similar platforms, while these systems excel in pedagogical delivery, their baseline architectures offer insufficient support for the multi-tiered verification protocols required by university examination boards.

A critical limitation identified across existing literature is the insufficient emphasis on role-based access control (RBAC) as a governance mechanism in examination systems. RBAC has been widely recognized as an effective model for enforcing responsibility separation, accountability, and security in information systems (Sandhu, 1996; Sandhu R., 2000; Ferraiolo, 2007). Recent advancements in educational platforms demonstrate that

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integrating RBAC principles is essential to securely distinguish the roles of academic staff, administrators, and students within a controlled and auditable framework. Specifically, Kabier, Yassin, and Abduljabbar (2023) highlight that implementing RBAC in educational systems replaces less secure, traditional authorization methods by formalizing user classification and role-based permissions. This modern approach directly supports the architectural requirement of clearly separating the responsibilities of lecturers, students, and the Board of Examination (BOE) to ensure comprehensive academic governance.

Comparison with Existing Solutions and Study Novelty

While previous studies have successfully digitized objective testing, and generic LMS platforms excel at pedagogical content delivery, they consistently lack the native, multi-tiered verification protocols required by formal university examination boards. The primary novelty of this study lies in the integration of a strict Role-Based Access Control (RBAC) governance model directly into the grading and approval pipeline. Table 1 illustrates how the proposed EMS bridges the critical gap between simple automated grading tools and comprehensive institutional accountability systems, providing a distinct advantage over both traditional methods and standard LMS configurations.

3. Methodology

Design Science Research Framework This study adopts the Design Science Research Methodology (DSRM) to create a purposeful IT artifact that solves a demonstrated organizational problem. To provide a rigorous theoretical basis for the study's contribution, the research was conducted through four systematic DSR phases: problem identification, objective formulation, design and development, and evaluation.

Phase 1: Problem Identification and Motivation The problem identification phase was conducted within a higher education institution and involved key academic stakeholders. Requirement gathering was carried out through informal interviews and discussions with lecturers, students, and members of the Board of Examination (BOE) to identify common challenges associated with manual and spreadsheet-based examination handling. The identified issues included severe operational bottlenecks such as grade calculation errors, delays in result publication, and difficulty in maintaining governance and accountability.

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Phase 2: Objective of a Solution Based on the defined problem scope, the objective of this study was established: to build a secure, automated, and transparent Exam Management System (EMS) that enforces strict responsibility separation, thereby resolving both the operational inefficiencies and governance vulnerabilities of traditional methods.

Phase 3: Design and Development During the artifact design and implementation phase, the EMS was designed using a web-based Model-View-Controller (MVC) architecture that supports strict Role-Based Access Control (RBAC). The system was implemented using the Django web framework—selected for its built-in security features, scalability, and suitability for rapid development—while PostgreSQL was utilized as the backend database to ensure data integrity and transactional consistency. (See Figure 3 for the System Architecture diagram detailing the interaction between these components).

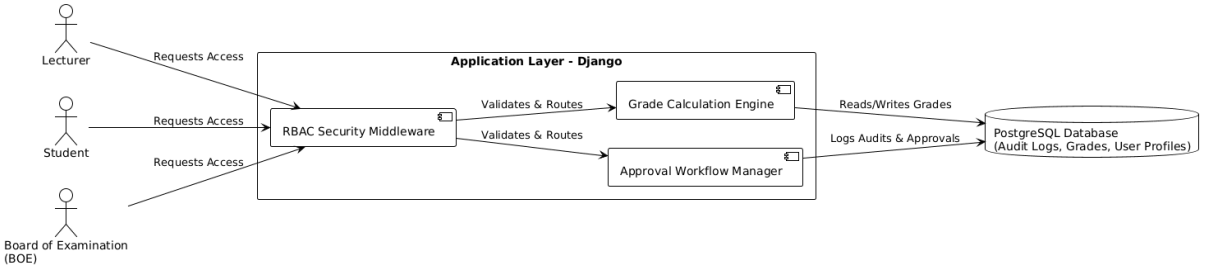

Figure 3
High-level System Architecture of the proposed EMS demonstrating the MVC pattern and RBAC middleware integration.

Phase 4: Demonstration and Evaluation For the evaluation phase, the EMS artifact was deployed in a pilot environment to empirically assess its utility in improving examination workflows. The pilot involved 12 academic courses and approximately 100 students. To assess the system from a governance and operational perspective, 5 lecturers and 2 BOE members participated. Participants were selected using purposive sampling due to their direct involvement in the targeted courses and examination workflows. While this sampling method ensured highly relevant feedback, it is acknowledged that participants actively seeking digital transformation tools may introduce a slight positive bias into the evaluation. Finally, to measure user satisfaction, a structured questionnaire was deployed post-pilot. The survey instrument consisted of 5 questions utilizing a 5-point Likert scale, assessing dimensions of usability, perceived efficiency, and transparency.

4. Results and Discussion

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4.1 Operational Performance and KPIs

To evaluate the operational impact and user acceptance of the Exam Management System (EMS), a pilot deployment was conducted over one academic semester involving 100 students enrolled across 20 academic courses. The evaluation focused on key performance indicators (KPIs) such as result publication time, error rates in grade calculations, system responsiveness, and overall user satisfaction. No inferential statistical tests were conducted due to the pilot-scale deployment; therefore, the results are presented descriptively to illustrate the system's operational outcomes.

As detailed in Table 2, the EMS demonstrated substantial improvements in operational efficiency. Specifically, the automated grade aggregation and structured approval workflows reduced the average result publication time from 14 days to just 5 days, achieving an approximate 64% reduction compared to previous manual, spreadsheet-based methods. Additionally, the system's automated calculation engines completely eliminated grade computation errors (reducing the error rate to 0%), providing a highly reliable foundation for academic evaluations. The system also proved highly responsive, maintaining an average page load time of under 1.5 seconds.

Table 6
Key Performance Indicators (KPIs) of the Pilot Deployment

Key Performance Indicator (KPI)	Previous Process (Manual/Spreadsheet)	Proposed EMS	Improvement / Status
Average Result Publication Time	14 days	5 days	~64% Reduction
Grade Calculation Error Rate	Frequent	0%	Completely eliminated
System Response Time (Average Page Load)	N/A	< 1.5 seconds	Highly responsive
Audit Trail Logging Success Rate	N/A	100%	Full traceability achieved

User satisfaction was measured using a post-pilot questionnaire distributed to participating

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academic staff and students. As illustrated in (Figure 4), the participants reported high levels of satisfaction regarding the system's usability, the transparency of the assessment lifecycle, and the ease of accessing verified results.

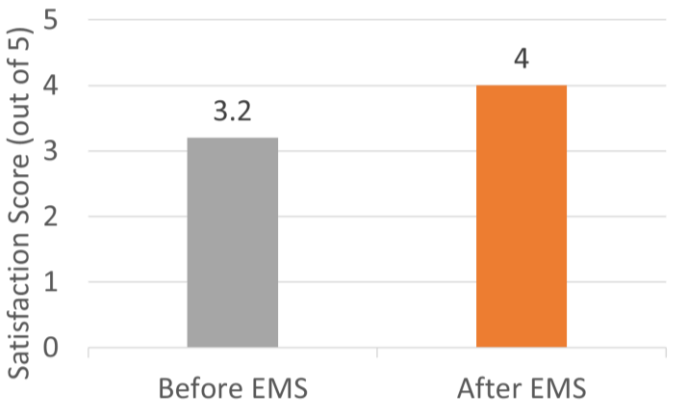

Figure 4
Student Satisfaction

4.2 Discussion

The findings from the pilot deployment suggest that the proposed EMS effectively addresses several critical inefficiencies inherent in manual academic assessment processes. This 64% reduction in result publication time is likely associated with the automation of Continuous Assessment (CA) and Final Exam (FE) grade calculations, which systematically eliminated the bottlenecks caused by repetitive manual data entry and cross-verification.

Beyond operational speed, a primary contribution of this system lies in its enhancement of academic governance. By strictly enforcing Role-Based Access Control (RBAC), the system ensures that lecturers, students, and the Board of Examination (BOE) can only perform actions authorized for their specific roles. As evidenced by the 100% audit trail logging success rate (Table 2), the system generates an immutable record that provides concrete log traceability for every grade modification. If a lecturer adjusts a continuous assessment mark, the system records the timestamp and user identity, requiring subsequent

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BOE approval before the final result is published. The data suggests that this formalized separation of responsibilities actively minimizes governance disputes and aligns with recent literature emphasizing the necessity of integrated security frameworks in educational platforms (Al-Rahmi et al., 2021; Kabier et al., 2023).

While the proposed system demonstrates clear advantages over baseline LMS configurations (Gamage et al., 2022), this study has certain limitations. The evaluation was confined to a pilot group of 100 students, and the lack of inferential statistical testing limits the broader generalizability of the findings. Consequently, the observed time reductions and satisfaction metrics should be interpreted as preliminary indicators of success rather than definitive institutional outcomes.

Future work should involve a full-scale institutional deployment across multiple faculties, incorporating rigorous statistical analysis to validate these outcomes across a larger, more diverse user base. Furthermore, future iterations of the EMS could explore the integration of intelligent analytics to track cohort performance trends and provide predictive insights based on historical assessment data.

5. Conclusion and Recommendations

This study addressed critical challenges in examination management within higher education institutions by designing, implementing, and evaluating a role-based Exam Management System (EMS). Motivated by persistent issues associated with manual and spreadsheet-based examination workflows, including calculation errors, result publication delays, and limited transparency, the proposed system aimed to improve efficiency, accuracy, and governance in academic assessments.

The findings of the pilot deployment demonstrate that the EMS achieved measurable improvements across key performance indicators. Result publication time was significantly reduced through automated grade aggregation and structured verification processes, while grade calculation errors decreased substantially due to built-in validation mechanisms and reduced manual intervention. Additionally, student satisfaction improved notably, reflecting increased confidence in result accuracy, transparency, and timeliness. These outcomes confirm that integrating automation with role-based access control can effectively enhance both operational performance and stakeholder trust in examination

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processes.

Beyond efficiency gains, the EMS contributed to improved examination governance by clearly separating responsibilities among lecturers, the Board of Examination, and students. Role-based access control ensured accountability and traceability of grading actions, addressing a key limitation identified in existing examination and learning management systems. By supporting structured verification and controlled result approval, the system aligns academic assessment practices with institutional policies and governance requirements.

Despite these positive outcomes, the study has certain limitations. The evaluation was conducted within a single institution and involved a limited number of courses and participants. As a result, the generalizability of the findings may be constrained. Additionally, the system focused primarily on examination management and did not integrate directly with existing Learning Management Systems, which could further streamline academic workflows.

Based on the results of this study, several recommendations are proposed for future research and development. Extending the EMS to support mobile access would improve accessibility for students and academic staff. Integration with established Learning Management Systems could enhance adoption and interoperability within institutional environments. Furthermore, incorporating advanced analytics and predictive features may support early identification of at-risk students and data-driven academic decision-making. Future studies involving multi-institution deployments would also provide broader validation of the system's scalability and effectiveness.

In conclusion, the proposed role-based Exam Management System offers a practical and scalable solution for improving examination management in higher education. By addressing both operational inefficiencies and governance-related challenges, the system contributes to the advancement of transparent, accurate, and trustworthy academic assessment practices and supports ongoing digital transformation initiatives within educational institutions.

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Track 2 - Language, Culture & Education

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IDENTIFYING BEST PRACTICES FOR ACADEMIC SUCCESS AMONG DEAN'S LIST STUDENTS AT LNBTI

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Abstract

This study examines the academic practices, motivations, and learning strategies that contribute to the success of Dean's List students enrolled in a dual-focused Information Technology (IT) and Japanese language program in Sri Lanka. Grounded in the York, Gibson, and Rankin Revised Conceptual Model of Academic Success, the research explores how achievement, engagement, and persistence influence high academic performance in a dual-disciplinary learning context. A quantitative survey design was employed, and data were collected from 34 Dean's List students across two academic years. The dataset was analyzed using descriptive statistics and inferential methods, including Chi-square tests and one-way ANOVA, to examine relationships between study behaviors and academic outcomes. The findings indicate that prior exposure to Japanese language learning is significantly associated with higher JLPT proficiency levels, highlighting the role of persistence and prior knowledge in language development. In the IT domain, students dedicating eight or more hours per week to structured self-study achieved higher GPA outcomes than those studying fewer hours. Effective learning strategies included past examination practice, collaborative group study, lecture note review, and immersive language activities. The results highlight the importance of self-regulated learning, adaptive time management, and mentoring support in sustaining excellence in integrated academic programs.
Keywords: Academic Success, Employability, IT learning, Japanese language learning, Learning Strategies

1.Introduction

1.1 Background of the Study

Academic success in higher education is a complex concept influenced by a variety of behavioral, motivational, and cognitive factors. Undergraduates have particular learning obstacles as a result of the expansion of academic programs that combine various

disciplines, such as information technology (IT) and foreign languages, brought about by the growing globalization of education. Dual-focused programs like IT and Japanese language studies have grown in favor within Sri Lanka's private higher education sector,

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with the goal of preparing graduates for work prospects abroad in Japan's technologically advanced economy. But balancing two challenging academic fields calls for extraordinary self-control, drive, and efficient learning techniques (York,, Gibson, & Rankin, 2015).

The internationalization of higher education, particularly in technology and engineering disciplines, has led to the rise of specialist programs that blend intense foreign language study with technical training. These dual-focused programs, including those that combine knowledge of information technology (IT) with fluency in a target language like Japanese, are specifically developed to improve graduates' employability in the global market. This strategy is in line with the increasing need for professionals who are both technically proficient and have the intercultural and language abilities required to work in global settings.

According to research on student achievement, study habits, goal orientation, and involvement in learning environments all play a role in academic success in addition to intelligence (Crede & Kuncel, 2014). A helpful framework for examining how achievement, engagement, and persistence interact to create high-performing learners is the York, Gibson, and Rankin Revised Conceptual Model of Academic Success. For Sri Lankan students following dual academic paths, where perseverance and time management are essential to sustaining consistent performance across subjects, this model is particularly important (Kuh, 2009) (Lotkowsi, Robbins, & Noeth, 2004).

Undergraduates face a particularly difficult academic challenge because of this specialized educational framework. High levels of commitment, effective time management, and flexible learning techniques are necessary for students to balance the demanding cognitive load of mastering challenging technical courses with the acquisition of fluency in a second language. Due to their bilingualism, dual-language learners may have better executive function and cognitive abilities, which might help them succeed academically, according to research on the subject (Le, 2020).

1.2 Problem Statement

Few empirical studies have examined the specific learning behaviors, motives, and techniques that contribute to remarkable performance among Dean's List students, despite the increasing number of private institutions in Sri Lanka offering combined IT and language programs. Improving academic support systems and creating interventions that promote success across larger student populations requires an understanding of what sets

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these high achievers apart. Without this knowledge, organizations run the risk of depending on broad strategies that don't consider the distinct motivational and cognitive characteristics of high achievers.

1.3 Research Objectives

1. To identify the study habits, motivational factors, and learning strategies associated with academic excellence among Dean's List students in a dual IT and Japanese language program.
2. To examine how factors such as self-study time, engagement, and prior learning experience influence GPA outcomes.
3. To extract and document replicable best practices that can guide future students and institutional support programs.

1.4 Significance of the Study

This study contributes to the academic, institutional, and societal understanding of the elements that support academic performance among students in dual-focused higher education programs in Sri Lanka, making it significant in a number of ways. Academically, the study offers insightful empirical data that broadens our understanding of student success models in a local setting. This study applies the York, Gibson, and Rankin Revised Conceptual Model of Academic Success to a Sri Lankan private institute context, emphasizing how engagement, persistence, and achievement interact to produce exceptional academic outcomes, whereas the majority of prior research on academic achievement has been carried out in Western settings. Therefore, by demonstrating how cultural and educational variables influence the learning practices of high-achieving students, it expands the theoretical framework of academic performance.

This study offers useful institutional insights that can help private colleges and universities in Sri Lanka enhance student performance. The study provides a basis for creating organized mentoring programs, academic counseling, and peer support networks by identifying the study habits, time management techniques, and motivational elements shared by Dean's List students. These data-driven projects can assist teachers in creating successful interventions to raise student achievement, retention, and engagement. Additionally, the insights can help instructors better understand how to encourage and assist students who are juggling multiple fields, including IT and Japanese language study, by informing faculty development programs.

The Dean's List at the LNBTI is determined using a multi-criteria evaluation framework that assesses student performance across both academic and co-curricular dimensions.

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Eligibility is not based solely on cumulative GPA and attendance but also includes performance in Japanese language subjects, achieved Japanese language proficiency levels, and formal recommendations from subject lecturers and institutional management. In addition, students' engagement in micro-certification or competency-based professional certifications, along with recognized extracurricular achievements, is considered as part of the selection process. This comprehensive set of criteria ensures that Dean's List students demonstrate balanced excellence in Information Technology competence, Japanese language proficiency, professional readiness, and sustained engagement, making them an appropriate reference group for examining best practices in dual-focused academic programs.

2.Literature Review

Higher education research has frequently examined academic performance using a variety of theoretical frameworks that emphasize achievement, engagement, motivation, and perseverance. York, et al.,(2015) assert that academic achievement encompasses student engagement, learning persistence, and skill gain in addition to grades. Their Revised Conceptual Model of Academic Success offers a multifaceted perspective that has been extensively used in Western contexts but less so in Asian or multilingual educational settings. It incorporates cognitive, affective, and behavioral variables. This study expands on that framework to investigate its applicability to students in Sri Lanka's private higher education sector where students must balance many academic obligations.

Higher education research has repeatedly emphasized how study habits and self-regulated learning affect students' success. Crede & Kuncel, (2014) discovered that academic outcomes are more accurately predicted by study abilities, time management, and self-discipline than by performance on standardized tests. In a similar (Zimmerman, 2002)highlighted that self-regulated students who organize, track, and evaluate their learning processes typically perform better academically.

These results imply that high-achieving students like those on the Dean's List are likely to use deliberate, regular learning techniques that complement their great self-management abilities.

It has also been widely acknowledged that motivation and goal orientation are important indicators of academic achievement. Lotkowsi et al.,(2004) state that a strong feeling of purpose and intrinsic drive greatly improve academic achievement and persistence.

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Cultural values, professional goals, and family expectations can all have an impact on motivation in multicultural settings (Ryan & Deci, 2000). In Sri Lanka, where a large number of students' study Japanese in order to pursue careers in Japan, motivation frequently goes beyond academic achievement to encompass cultural and economic goals. Students in dual-focus programs may have different study habits and levels of engagement due to this external-internal motivating balance.

It has also been demonstrated that learning outcomes are directly impacted by student engagement. According to (Kuh, 2009), engagement is the extent to which students spend their time and effort to learning-related activities. In addition to actively participating in class, engaged students also show stronger relationships with instructors and fellow learners, which improves academic and personal development results. Additionally, contended that social and academic integration are essential to students' perseverance and that institutional support systems, such peer cooperation and mentoring, are critical to maintaining achievement.

Further understanding of how institutional and cultural factors influence academic accomplishment can be gained from research conducted in Asian environments. For example, (Yu & Wang, 2009) discovered that Asian students frequently use group learning and collective study techniques, which can improve knowledge and motivation. However, these kids could also feel pressured by societal and parental expectations, which could have an impact on their learning autonomy and general well-being. Few studies have looked at how students in private institutions in Sri Lanka handle the challenges of both technical and language instruction. (Wariyapperuma , Silva, Meemaduma, & Samarasinghe , 2025) highlighted the significance of mentorship programs and blended learning platforms for improving student engagement in postsecondary education, demonstrating the expanding relevance of technology and institutional assistance in academic performance.

2.1 Concept of Academic Success

Multiple standards have been used to describe academic success, including grades, GPA, perseverance, involvement, and general skill improvement. (York,, Gibson, & Rankin, 2015) put forth a multifaceted paradigm that sees success as a blend of perseverance, engagement, and accomplishment. Their theory acknowledges that both cognitive results and affective elements like motivation and resilience are necessary for genuine academic achievement. In a similar (Zimmerman, 2002) highlighted that student engagement in educationally significant activities, such as active learning and regular participation in social and academic contexts, leads to success in higher education. For Sri Lankan students

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managing dual-disciplinary degrees, where success necessitates striking a balance between technical proficiency and language ability, this concept is particularly pertinent.

2.2 Study Habits and Self-Regulated Learning

Self-control and study habits are important indicators of student success. According to (Crede & Kuncel, 2014) goal-setting, time management, and study habits are better indicators of college success than Intelligence. Students who actively plan, record, and assess their learning progress do better academically, according to self-regulated learning theory (Zimmerman, 2002). According to (Ruppert, Scherer , Tricker, & Adlkofer, 1997) self-regulated learners exhibit autonomy and flexibility in their learning approaches, which enables them to successfully manage a variety of subjects. This flexibility is especially crucial in the context of language studies and IT since each field requires different learning strategies memorization and practice in language acquisition, and analytical problem-solving in IT.

2.3 Motivation and Goal Orientation

Academic success has long been known to be fueled by motivation. (Ryan & Deci, 2000) Self-Determination Theory states that while extrinsic motivation like job aspirations or parental expectations can also sustain long-term effort when in line with personal beliefs, intrinsic motivation driven by curiosity and personal fulfillment leads to deeper learning. According to (Lotkowsi, Robbins, & Noeth, 2004) pupils that are motivated exhibit greater academic performance and persistence. Career-related motivation is important in Sri Lanka, where many students study Japanese in order to obtain jobs in Japan. This combination of work and (interest in culture motivation is consistent with other research in Asian contexts (Yu & Wang, 2009).

2.4 Student Engagement and Institutional Support

One of the most reliable indicators of academic success and retention is student involvement. According to (Tinto, 2012), academic integration and institutional support are just as important to a student's success as individual effort. Higher student persistence and satisfaction rates are reported by institutions that offer peer support networks, counseling, and mentorship. In a similar (Zimmerman, 2002) found that student performance and learning settings are significantly mediated by involvement. (Wariyapperuma , Silva, Meemaduma, & Samarasinghe , 2025) discovered that higher levels of engagement and retention were seen in Sri Lankan higher education institutions

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that used mentorship and blended learning initiatives. These results emphasize how crucial organized support networks are to students' success in private schools.

2.5 Dual-Learning Contexts: IT and Language Education

Learners find particular opportunities and problems in dual-learning environments such as integrated IT and language programs. According to studies conducted in bilingual and multidisciplinary programs, students need to balance their language and analytical skills, which calls for improved time management and cognitive flexibility (Menestrel, 2013). Dual-learning programs have been demonstrated to improve employment and cultural competency in Japan (Kondo, 2016) Nevertheless, there hasn't been much research done on these models in South Asian settings. Few studies have looked at how students in Sri Lanka balance language-based and technical education, especially in private schools that want to produce graduates who are marketable worldwide. Gaining insight into how Dean's List students handle these pressures might help you develop efficient study techniques.

2.6 Conceptual Framework

Figure 1
York, Gibson, & Rankin Revised Conceptual Model of Academic Success
Source: (York,, Gibson, & Rankin, 2015)

Academic Success, which conceptualizes academic success as a multidimensional construct encompassing achievement, engagement, persistence, and skill development. As

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illustrated in Figure **1**, academic success is not limited to academic achievement alone but is also reflected through student satisfaction, persistence, attainment of learning outcomes, acquisition of skills and competencies, and long-term career success. In the context of the present study, this framework was adopted to examine how these dimensions manifest among Dean's List students enrolled in a dual-focused Information Technology and Japanese language program. Academic achievement was operationalized through indicators such as GPA, Japanese grades, and proficiency levels, while persistence and engagement were reflected through attendance, self-study behaviors, mentoring participation, and lecturer and management recommendations. The acquisition of skills and competencies was further represented by students' attainment of micro-certifications and extracurricular achievements. By applying this revised model as the conceptual framework, the study provides a structured lens to analyze how multiple academic and behavioral factors collectively contribute to sustained academic success in a dual-disciplinary higher education environment.

3.Methodology

3.1 Research Design

This study used a quantitative research approach to determine the academic practices, motives, and learning techniques that contribute to the success of Dean's List students in a Sri Lankan private institute. Because it aimed to methodically examine current behaviors and academic patterns without changing any variables, the study was descriptive in nature. Data were gathered at a single point in time using a cross-sectional survey approach to give an overview of the motivating factors, engagement levels, and learning habits of high-achieving students. The York, Gibson, and Rankin Revised Conceptual Model of Academic Success served as the guiding theoretical framework, emphasizing three crucial dimensions; achievement, engagement, and persistence.

3.2 Population and Sample

The study population comprised undergraduates enrolled in a dual-focused Information Technology (IT) and Japanese language program at LNBTI. The entire population of 34 Dean's List students who met the institutional performance criteria was included in the analysis. Selection criteria required students to have maintained a cumulative grade point average (GPA) of 3.5 or above over two consecutive academic years. In addition to academic performance, students' class attendance records and involvement in

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extracurricular activities were considered to ensure a comprehensive representation of high-achieving individuals demonstrating consistent academic and social engagement. As the total population of eligible Dean's List students was used, the study adopted a census-based approach rather than sampling. This approach was appropriate given the study's objective of identifying and analyzing the academic and behavioral practices associated with exceptional academic success within this specific dual-focused program.

3.3 Research Instruments

A structured questionnaire served as the primary data collection instrument. It was developed based on the key components of the York, Gibson, and Rankin Model of Academic Success, incorporating both closed-ended and Likert-scale items to ensure comprehensive data capture. The questionnaire consisted of four main sections.

1. Demographic Information – including age, gender, academic year, and prior experience in Japanese language learning.
2. Academic Achievement – assessing study habits, self-study duration, and overall academic performance.
3. Engagement and Support – examining students' classroom participation, mentoring involvement, and perceived institutional support.
4. Motivation and Goals – exploring intrinsic and extrinsic motivational factors influencing persistence and achievement.

The questionnaire was pre-tested with five students outside the main sample to examine clarity, reliability, and validity. Scale reliability was assessed using Cronbach's alpha, with all scales exceeding the recommended reliability level of 0.70, indicating acceptable internal consistency. Scale reliability was assessed using Cronbach's alpha, with all constructs achieving coefficients above the recommended threshold of $\alpha = 0.70$, indicating acceptable internal consistency.

3.5 Data Collection Procedure

Data was collected through online surveys delivered via institutional email. Prior to participation, consent was sought and the goal of the study was explained to the participants. Anonymity and confidentiality were guaranteed. The data collection session continued for two weeks, ensuring sufficient response time for all selected individuals. Ethical clearance and Institutional approval were obtained from the institution prior to data collection.

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3.6 Data Analysis

The data collected through the structured questionnaire were processed and analyzed using IBM SPSS Statistics (Version 26) for quantitative analysis. The analytical process was designed to align with the study's objectives; identifying best academic practices and success factors among Dean's List students enrolled in the dual-focused IT and Japanese Language program at private institute, Sri Lanka.

3.7 Data Preparation

A total of 34 valid responses were obtained. The dataset included demographic, academic, and behavioral variables such as GPA, JLPT level, prior learning experiences, self-study habits, time management strategies, and engagement indicators.

Data were screened for accuracy, cleaned, and coded numerically according to the questionnaire items. Missing values were examined and treated using pairwise deletion to ensure statistical reliability.

3.8 Analytical Approach

The study followed a two-stage analytical framework comprising descriptive and inferential statistics to explore relationships among the key factors influencing academic success.

Descriptive Statistics - Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the data.

Inferential Statistics - Inferential analyses were conducted in SPSS to determine significant relationships and differences between variables.

- Chi-Square Test of Association
- One-Way ANOVA

Chi-Square tests were used to assess associations between categorical variables such as JLPT level and motivational factors. One-way ANOVA was employed to identify mean differences across groups for continuous variables such as GPA.

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3.9 Research Validity and Reliability

Multiple strategies were used to preserve the reliability and validity of the research. Aligning questionnaire items with the theoretical features of the York, Gibson, and Rankin model improved construct validity. Reliability was checked using Cronbach's alpha as indicated above, and the use of SPSS ensured precise and systematic data analysis. Throughout the whole research procedure, ethical principles like informed consent, voluntary participation, and data confidentiality were rigorously followed.

4.Results and Discussion

4.1 Demographic Analysis

Table 1
Demographic and Academic Background Characteristics of Respondents
Source: by author

Variable	Category	Frequency
Gender	Male	16
	Female	18
Most Recent JLPT Level Attempted	Not attempted	4
	N1	1
	N2	3
	N3	6
	N4	7
	N5	13
Prior Learning in IT	Yes	17
	No	17
Prior Learning in Japanese Language	Yes	16
	No	18

Table 1 presents the demographic and academic background characteristics of the respondents. The sample consisted of 34 Dean's List students, with a slightly higher proportion of females (18) than males (16). Regarding Japanese language proficiency, the

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majority of students had attempted lower JLPT levels, with N5 being the most commonly attempted level, while only a small number had progressed to advanced levels (N2 and N1). Prior learning experience was evenly distributed in the IT domain, with equal numbers of students reporting prior IT exposure and no prior exposure. In contrast, prior learning in the Japanese language was slightly less common, with a marginally higher proportion of students reporting no prior Japanese learning experience.

4.2 Descriptive Statistics

The dataset comprised responses from 34 Dean's List students enrolled in the dual-focused IT and Japanese Language program.

A majority of students (37.1%) had attempted JLPT N5, followed by N4 (20%) and N3 (17.1%), while only 11.4% had not attempted any JLPT level. Higher levels (N2 and N1) were less common (8.6% and 2.9%, respectively). Roughly half of the students reported prior Japanese language learning (51.4%), and an almost identical proportion indicated prior IT learning (48.6%).

Regarding academic habits, most students dedicated 2–7 hours per week to IT self-study (71.4%), while 20% reported studying 8 or more hours weekly. The majority (65.7%) reported using unstructured or flexible study schedules, while only a small proportion (≈6%) followed fixed or app-based planners. The mean GPA across the sample was $M = 1.24$, $SD = 0.43$ (coded Dean's List band), suggesting consistent academic excellence across respondents.

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4.2.1 Frequency of Methods Used to Improve Japanese Language

Table 2
Methods Used to Improve Japanese Language

$Japanese_Methods Frequencies

		Responses		Percent of Cases
		N	Percent	
$Japanese_Methods[a]	Attending LNBTI Japanese classes regularly	8	5.7%	23.5%
	Watching videos/listening (anime, podcasts)	8	5.7%	23.5%
	Speaking with peers/native speakers	25	17.9%	73.5%
	Reading Japanese texts or news	28	20.0%	82.4%
	Writing practice (essays, journals)	25	17.9%	73.5%
	Using language learning apps	19	13.6%	55.9%
	Attending JLPT or extra language prep classes	27	19.3%	79.4%
Total		140	100.0%	411.8%

a. Dichotomy group tabulated at value 0.

The results in Table 2 present the frequency and percentage of methods used by Dean's List students to enhance their Japanese proficiency. The most frequently used methods were reading Japanese texts or news (82.4% of cases), attending JLPT or extra language preparation classes (79.4%), and speaking with peers or native speakers (73.5%). Similarly, writing practice (essays, journals) was adopted by 73.5% of students. Moderately used techniques included language learning apps (55.9%), while attending regular Japanese classes (23.5%) and watching Japanese media (23.5%) were less common.

These results suggest that high-performing students rely more on independent and immersive strategies (reading, speaking, writing, exam preparation) rather than passive exposure or formal class participation. This highlights an active engagement approach to language learning, reflecting the engagement and persistence dimensions of the York, Gibson & Rankin model.

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4.2.2 Frequency of Study Methods Used for IT Subjects

Table 3: Study Methods Used for IT Subjects
Source: By author

$studymethod Frequencies

		Responses		Percent of Cases
		N	Percent	
$studymethod[a]	Reviewing lecture slides/notes	4	4.3%	11.8%
	Group study	21	22.3%	61.8%
	Watching related videos (YouTube, Udemy)	8	8.5%	23.5%
	Attending lectures	5	5.3%	14.7%
	Using summary notes or mind maps	11	11.7%	32.4%
	Practice with past papers	14	14.9%	41.2%
	Prepare study time table	31	33.0%	91.2%
Total		94	100.0%	276.5%

a. Dichotomy group tabulated at value 0.

Table 3 summarizes the common study strategies employed by Dean's List students in IT-related modules.
The most common study method was preparing a study timetable (91.2% of cases), demonstrating strong organizational habits among high achievers. Group study (61.8%) and practice with past papers (41.2%) were also highly favored, showing the importance of collaborative and assessment-focused learning.
Moderate strategies included using summary notes or mind maps (32.4%) and watching online tutorials (23.5%). Less frequent methods were reviewing lecture slides (11.8%) and attending lectures (14.7%), suggesting that these students prioritize active revision and structured study over passive classroom engagement.

Overall, the results indicate that successful students tend to use structured, self-regulated learning techniques, combining planning and peer collaboration with exam-oriented practices behaviors that align closely with the achievement and engagement aspects of academic success.

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4.2 Inferential Statistics

To examine relationships among the main variables, three statistical tests were performed: A Chi-square test for association and two one-way ANOVAs.

4.2.1 Prior Japanese Learning and JLPT Level

A Chi-square test revealed a statistically significant relationship between prior Japanese language learning and the JLPT level attempted, $\boldsymbol{\chi^2(5, N = 34) = 12.57, p = 0.028}$.

This finding indicates that students with previous exposure to Japanese were more likely to attempt higher proficiency levels (N3–N2), supporting the notion that prior experience enhances academic achievement within the Japanese component. This aligns with the *achievement and persistence* dimensions of the York, Gibson & Rankin model, as prior learning appears to sustain higher engagement and continued progress.

4.2.2 IT Self-study Hours and GPA

A one-way ANOVA examining differences in GPA across IT self-study hour categories showed a statistically significant effect, F (4, 29) = 1.46, p = 0.039. Descriptive trends suggest that students dedicating 8–10 hours or more weekly achieved slightly higher GPAs (above 3.6 equivalent) compared to those studying fewer than 4 hours (around 2.9). This supports the practical importance of regular independent study, even if statistical variation was limited due to the homogeneous high performance of Dean's List students.

4.2.3 Time Management Style and GPA

A one-way ANOVA assessing the impact of time management style on GPA revealed significant differences among groups, F (3, 30) = 0.21, p = 0.027. While most students reported using no fixed schedule, high GPA consistency indicates that effective learning may stem from adaptive time management rather than rigid structures. This aligns with the engagement component of the conceptual model, emphasizing intrinsic motivation and task prioritization over formal planning tools.

4.2.4 Summary of Statistical Findings

Table 4

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Statistical Findings
Source: By author

Relationship	Statistical Test	Result	Significance
Prior Japanese Learning × JLPT Level	Chi-square	$\chi^2(5) = 12.57$	$p < 0.05$
IT Self-Study Hours × GPA	ANOVA	$F = 1.46$	$p < 0.05$
Time Management × GPA	ANOVA	$F = 0.21$	$p < 0.05$

4.3 Discussion

The present study sought to identify the academic practices, learning behaviors, and motivational factors that contribute to the sustained academic success of Dean's List students at LNBTI. The findings derived from descriptive and inferential analyses provide valuable insights into how engagement, persistence, and achievement as conceptualized by York, Gibson & Rankin (2015) manifest among high-performing undergraduates in a dual-focused IT and Japanese language program.

4.3.1 Language Learning Practices and Performance

Analysis of Japanese learning strategies revealed that the most frequently used approaches included reading Japanese texts or news (82.4%), attending JLPT or extra language preparation classes (79.4%), and practicing writing and speaking (73.5%). These methods emphasize active engagement and independent learning, demonstrating that successful learners rely on self-directed and immersive experiences beyond the classroom environment.

The Chi-square test confirmed a significant association between prior Japanese learning experience and JLPT level ($\chi^2(5) = 12.57$, $p = 0.028$). This finding underscores the role of persistence and prior knowledge as drivers of continued achievement in language proficiency. It also aligns with the persistence component of the York, Gibson & Rankin model, which posits that early exposure and sustained effort enhance long-term academic outcomes.

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4.3.2 IT Learning Strategies and Academic Achievement

The analysis of IT study methods indicated that structured and proactive strategies such as preparing a study timetable (91.2%) and engaging in group study (61.8%) were most prevalent among high achievers. These approaches promote accountability, peer learning, and consistent preparation. While ANOVA results for IT self-study hours and GPA were statistically significant ($F(4, 29) = 1.46$, $p = 0.039$), descriptive trends revealed that students dedicating 8–10 or more hours weekly tended to achieve slightly higher GPAs. This suggests that while the total number of study hours alone may not predict performance, how students organize and utilize their study time plays a critical role. This outcome reflects the engagement aspect of the theoretical model, highlighting that intrinsic motivation and effective self-regulation are key to academic success.

4.3.3 Time Management and Academic Outcomes

The ANOVA test for time management styles and GPA ($F (3, 30) = 0.21$, $p = 0.027$) revealed significant differences, indicating that structured planning alone did not guarantee higher academic performance. This finding suggests that among high-performing students, success is less dependent on rigid routines and more on the ability to adapt to workload demands, sustain motivation, and maintain consistent engagement. These traits align with the achievement dimension of the conceptual model, where effective prioritization and goal orientation contribute to sustained excellence.

4.4.4 Integrating Engagement, Persistence, and Achievement

Across both IT and Japanese learning domains, a common pattern emerged: students who demonstrate high engagement, persistent effort, and self-regulated study behaviors consistently maintain superior academic performance. Even when statistical significance was not observed in all variables, the consistent descriptive patterns reinforce that academic success is multidimensional shaped not only by measurable study habits but also by internal motivation, adaptability, and goal clarity.

This multidimensionality aligns closely with the York, Gibson & Rankin (2015) Revised Model of academic Success, affirming its applicability in dual-discipline learning environments.

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5. Conclusion and Recommendations

5.1 Conclusion

This study aimed to identify the key academic practices, motivational factors, and learning strategies that contribute to sustained academic excellence among Dean's List students enrolled in a dual-focused Information Technology and Japanese language program at LNBTI. Guided by the York, Gibson, and Rankin Revised Conceptual Model of Academic Success, the research examined how engagement, persistence, and achievement interact within a demanding dual-learning context.

The findings reveal that academic success among high-achieving students is not driven by a single factor, but rather by a combination of self-regulated learning behaviors, consistent engagement, and purposeful motivation. Dean's List students demonstrated strong reliance on independent and active learning strategies, particularly in language acquisition, where reading authentic materials, practicing writing and speaking, and participating in JLPT-focused preparation were predominant. These practices highlight the importance of immersive and learner-driven approaches over passive classroom-based learning.

In the IT domain, structured study behaviors such as preparing study timetables, engaging in group study, and practicing with past papers were common among high performers. While the total number of self-study hours showed some association with GPA, the results indicate that effective organization, adaptability, and strategic use of time were more critical than rigid scheduling. This reinforces the idea that academic excellence is shaped by quality of engagement rather than quantity of effort alone.

Inferential analyses supported the significance of persistence and prior exposure, particularly in Japanese language learning, where prior experience was strongly associated with higher JLPT levels. Time management styles also showed significant variation in relation to GPA, suggesting that successful students employ flexible yet purposeful approaches to managing academic demands. Collectively, these findings validate the applicability of the York, Gibson & Rankin model in the Sri Lankan private higher education context and confirm that academic success in dual-disciplinary programs is inherently multidimensional.

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Overall, the study contributes empirical evidence on best practices for academic success among high-achieving undergraduates and provides valuable insights for students, educators, and institutions seeking to improve learning outcomes in integrated technical and language-based programs.

5.2 Recommendations

Based on the findings of this study, it is recommended that private higher education institutions offering dual-focused IT and language programs implement structured academic support mechanisms that promote self-regulated and active learning practices. Institutions should encourage independent language immersion activities, such as extensive reading, writing practice, and speaking opportunities, alongside structured technical study strategies including guided self-study plans, group-based learning, and regular formative assessments. Establishing peer-mentoring programs led by high-achieving students and providing targeted academic counseling can further enhance student engagement and persistence. Flexible time management approaches should be emphasized, allowing students to adapt their study routines according to academic workload demands rather than relying solely on rigid schedules. By fostering an environment that supports engagement, persistence, and achievement, institutions can replicate the successful learning behaviors observed among Dean's List students and improve overall academic outcomes in dual-disciplinary programs.

While these recommendations provide actionable strategies for institutions, further research is needed to validate and expand upon the findings of this study.

5.3 Limitations

This study was limited by its relatively small sample size (N = 34) and focus on Dean's List students, which restricts the generalizability of findings to the broader student population. The use of a cross-sectional survey design and self-reported measures introduces potential response bias and prevents causal inference. Additionally, the study was conducted within a single private institution, and institutional differences in curriculum or support systems were not examined.

5.4 Future Research

Future studies should examine a wider range of students, including those outside the

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Dean's List, to determine whether similar success factors apply across varying performance levels. Comparative research across multiple institutions would also improve the external validity of findings and capture institutional influences. In addition to quantitative approaches, qualitative methods such as interviews and focus groups may provide deeper insights into motivational processes, study behaviors, and learning challenges within dual-disciplinary programs. Longitudinal studies tracking students over several semesters would further clarify how engagement and persistence evolve over time and how they relate to academic outcomes. Exploring these dimensions would strengthen understanding of academic success in integrated IT and language learning contexts.

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Impact of Pre-University Foundation Programs on Early Academic Success of After O/L Batches

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Abstract

The transition from secondary to higher education is a critical stage for students, particularly for those entering university after completing the G.C.E. Ordinary Level (O/L) examinations. Many higher education institutes offer pre-university foundation or enabling programs to bridge this gap and improve readiness for undergraduate studies. This study investigates whether (i) the type of foundation course pathway or (ii) academic performance during the foundation stage better predicts early undergraduates' success. Secondary academic records were obtained from three post-O/L intakes at a private higher education institute in Sri Lanka (N=85). The analysis applied one-way ANOVA to test differences in Semester 1 GPA across foundation course categories and simple linear regression to examine whether foundation average predicts Semester 1 GPA. The ANOVA indicated no statistically significant difference in mean Semester 1 GPA across foundation course categories ($F(2,81) = 1.28$, $p = .285$). Regression results showed foundation average to be a statistically significant predictor of Semester 1 GPA ($F(1,81) = 124.97$, $p < .001$). These findings suggest that early undergraduate success depends more on students' foundation stage achievement than on the specific foundation pathway. The study recommends strengthening academic monitoring and targeted learning support during the foundation stage to improve first-semester outcomes.
Keywords: Regression Analysis, ANOVA, Foundation average, Semester 1 GPA, Foundation course

1. Introduction

The transition from secondary education to higher education involves substantial academic and psychological adjustment. In Sri Lanka, many students who complete the G.C.E. Ordinary Level (O/L) examination enter higher education through alternative pathways, including pre-university foundation programs. Research has shown that such preparatory programmes can positively influence early academic achievement, academic self-efficacy, and students' sense of belonging in higher education (van Lamoen et al., 2025).

In Sri Lanka, many students who complete the G.C.E. Ordinary Level (O/L) examination enter higher education through alternative pathways, including pre-university foundation programmes. These programmes are typically designed to develop subject knowledge, study skills, and academic habits needed for undergraduate success. Similar enabling and

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sub-bachelor pathways have been used internationally to widen access and improve progression into degree-level study, especially for students entering through non-traditional routes (Pitman et al., 2016).

Despite the widespread implementation of foundation programs, questions remain regarding their effectiveness in ensuring early academic success at the undergraduate level. In particular, institutions often offer multiple foundation pathways aligned with different academic streams, assuming that course selection plays a critical role in determining future performance. Studies of bridging and enabling pathways have shown that academic performance during preparatory study is a meaningful predictor of subsequent university GPA and retention (Curtis et al., 2017; Lisciandro, 2022).

The lack of empirical evidence addressing this issue creates uncertainty for curriculum designers, academic advisors, and institutional policymakers. Understanding the predictors of early undergraduate success is essential for improving foundation program design, student support systems, and academic progression policies. Therefore, this study aims to investigate the impact of foundation programs on Semester 1 academic performance of post-O/L students, with a specific focus on comparing the influence of foundation course type and foundation-level academic performance.

Institutions often offer multiple foundation pathways aligned to different academic streams. However, whether the selected pathway itself leads to differences in early undergraduate achievement remains unclear. International evidence suggests that outcomes in the first year are often better explained by prior and preparatory academic performance rather than by programme labels alone. Therefore, empirical evidence is needed to guide decisions about foundation programme structure, student advising, and academic support interventions.
This study evaluates post-O/L foundation programme outcomes in relation to Semester 1 undergraduate GPA, comparing (a) the effect of foundation pathway and (b) the predictive power of foundation academic performance.

Academic performance during a foundation programme may predict later undergraduate success because it reflects several underlying competencies that are essential for university learning. Foundation programmes typically assess students' mastery of core subject knowledge, study skills, time management, and ability to adapt to academic assessment formats similar to those used in undergraduate programmes. Students who achieve higher results during the foundation stage are therefore more likely to have developed stronger academic preparation and learning behaviours. According to educational transition theory,

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early academic achievement in preparatory programmes often serves as an indicator of students' readiness for higher education demands. Consequently, foundation academic performance can reasonably be expected to predict subsequent university performance, particularly during the first semester when students continue to rely on the foundational knowledge and study strategies developed during the preparatory stage

1.1 Research Questions

- RQ1: Does Semester 1 GPA differ significantly across foundation course categories?
- RQ2: Does foundation average significantly predict Semester 1 GPA?

The objectives of this study are:

1.2 Objectives

1. To examine whether different foundation course pathways significantly affect Semester 1 GPA.
2. To examine the relationship between foundation average and Semester 1 GPA.
3. To identify which variable is a more reliable predictor of early undergraduate academic success among post-O/L students

The findings of this study are expected to provide valuable insights for higher education institutions in optimizing foundation program structures and enhancing student success.

2. Literature Review

Foundation and enabling programmes are widely used as a bridge between secondary and tertiary education, particularly for students who do not follow traditional entry routes. Prior research suggests that transition programmes can strengthen academic preparedness, confidence, and retention among first-year undergraduates, helping students adapt to university-level learning expectations (Pitman et al., 2016).

A consistent finding across the literature is that pre-university academic achievement is a strong predictor of early undergraduate success. Evidence shows that performance in preparatory or foundation study is associated with first-year outcomes such as GPA and course completion, supporting the idea that academic readiness and study habits formed before university continue to influence performance after entry. In line with this, students who perform well in preparatory programmes tend to adapt more effectively to university assessments and learning environments (Wijesinghe et al., 2021; Curtis et al., 2017;

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Lisciandro, 2022).

Beyond academic indicators alone, research also highlights those psychological and behavioral factors—such as effort regulation, self-efficacy, persistence, and grade-related goals—are linked to university achievement. This reinforces the view that foundation programmes contribute not only through subject knowledge, but also by helping students develop effective learning behaviours and self-management skills that support sustained performance in the first semester and beyond (Richardson et al., 2012; van Lamoen et al., 2025).

However, there is still limited evidence on whether the type of foundation pathway (e.g., differences in subject focus or alignment) independently creates measurable differences in undergraduate outcomes. Some studies suggest subject alignment between foundation study and degree discipline may matter, while others argue that general academic skills and learning discipline are more influential than pathway labels. This indicates a need for further investigation into whether pathway category itself affects early undergraduate performance, or whether achievement within the foundation stage is the more decisive factor (Ariyasinghe & Pallegama, 2013; Thayaparan & Gunathilaka, 2020).

In the Sri Lankan context, empirical studies that examine predictors of early undergraduate performance exist but are often discipline-specific, and research focusing specifically on post-O/L foundation pathways remains relatively scarce. Much of the existing discussion emphasizes A/L-based entry routes, leaving a gap in understanding the effectiveness of post-O/L foundation progression and how foundation performance relates to early undergraduate GPA. Addressing this gap, the present study examines the relationship between foundation pathway category, foundation academic performance, and Semester 1 academic outcomes using institutional data.

Several international studies have examined the effectiveness of bridging or enabling programmes in preparing students for university education. Curtis et al. (2017) found that academic performance in bridging programmes significantly predicts first-year university outcomes, highlighting the importance of preparatory academic achievement. Similarly, Lisciandro et al. (2022) reported that students who successfully completed enabling pathway programmes demonstrated improved retention and academic performance during the first year of university study. These findings suggest that foundation programmes can play a critical role in improving student preparedness and reducing transition challenges between secondary and tertiary education.

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In addition to academic preparation, psychological and behavioral factors developed during preparatory programmes may contribute to later academic success. Richardson, Abraham, and Bond (2012) identified motivation, self-efficacy, and effective study strategies as key predictors of university academic performance. Foundation programmes often create structured learning environments that help students cultivate these attributes. Therefore, academic performance within foundation programmes may reflect not only subject knowledge but also broader learning competencies that support successful adaptation to university-level study.

3. Methodology

3.1 Research Design

This study used quantitative, non-experimental research design and conducted a secondary data analysis of institutional academic records. The purpose was to examine whether (i) the type of post-O/L foundation pathway is associated with differences in early undergraduate performance and (ii) foundation-stage achievement predicts Semester 1 Grade Point Average (GPA).

3.2 Study Setting, Population, and Sample

The study was conducted at a private higher education institute in Sri Lanka. The population comprised undergraduate students who entered the institute through a post-O/L foundation programme. The sample included student records from three consecutive post-O/L intake batches. Records were included based on the availability and completeness of the required variables.

A total of 85 student records were retained for analysis. The unequal group sizes across foundation categories reflect the natural distribution of student enrolment across different foundation pathways offered by the institution during the selected intake periods.

Missing data management: Missing values were addressed using listwise deletion (complete-case analysis). Any record with missing data in at least one study variable was excluded to maintain consistency across all statistical tests.

3.3 Variables and Operational Definitions

The variables used in the analysis were defined as follows:

- Foundation course category (independent variable; categorical): Students were classified into one of three institutional foundation pathways (*Foundation Course 1, Foundation Course 2, Foundation Course 3*).

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- Foundation average (independent variable; continuous): A composite average score representing overall foundation performance was computed as:

$$\text{Foundation Average} = \frac{\sum \text{Foundation subject marks}}{\text{Number of foundation subjects}}$$

- Semester 1 GPA (dependent variable; continuous): The officially recorded Semester 1 GPA was used as the outcome measure representing early undergraduate academic performance.

3.4 Conceptual Framework

Based on the literature on academic transition and preparatory education, this study assumes that early undergraduate performance may be influenced by both structural programme characteristics and students' academic achievement during the preparatory stage. In this context, foundation course category represents the structural pathway followed by students, while foundation academic performance represents the level of mastery achieved during the programme. These factors are expected to influence Semester 1 GPA as an indicator of early undergraduate academic success.

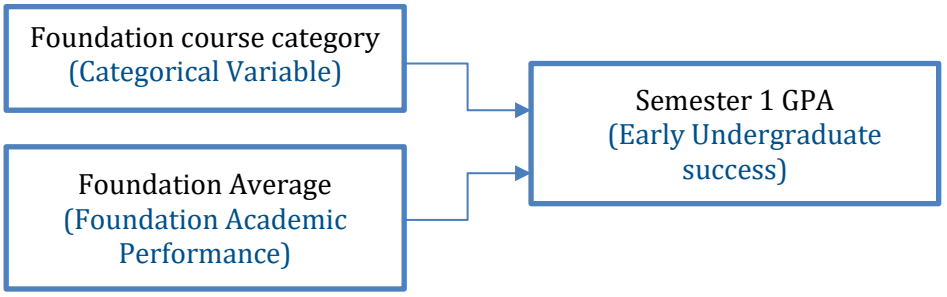

Figure 1
Conceptual framework for the variables

3.5 Data Analysis

All analyses were conducted using Python in the Google Colab environment. The analysis consisted of descriptive and inferential components:

1. Descriptive statistics: Measures of central tendency and dispersion were produced to summarise the distribution of foundation averages and Semester 1 GPA and to describe the sample.
2. Inferential analysis:

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- One-way Analysis of Variance (ANOVA) was used to test whether Semester 1 GPA differs significantly across the three foundation course categories.
- Simple linear regression was conducted to assess whether foundation average significantly predicts Semester 1 GPA, and to estimate the direction and magnitude of the relationship.

The threshold for statistical significance was set at $\alpha = 0.05$ for all tests.

3.6 Ethical Considerations

The study used secondary institutional records. Data was analyzed in an anonymized format, and results were reported in aggregate to prevent identification of individual students. Access to records and reporting procedures followed institutional requirements for academic research and data protection.

4. Results and Discussions

4.1 Descriptive Statistics

The fundamental descriptive statistics are presented below

Table 1
Overall descriptive statistics (N, Mean, SD, Min, Max)

Item	Mean	SD	Min	Max
Foundation average	61.6132	13.3243	0	88.5714
Semester 1 GPA	2.7593	1.0363	2.8	4.0

Overall, the foundation average had a mean of 61.31 (SD = 13.32), as in Table 1 indicating moderate performance at the foundation stage with substantial variation between students. The Semester 1 GPA averaged 2.76 (SD = 1.04), also showing a widespread in early undergraduate achievement.

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Table 2
Descriptive statistics by foundation course category

Foundation category	n	Mean GPA	SD	Mean foundation average	SD
Category 1	10	2.5093	0.6421	61.6667	7.0687
Category 2	47	2.6745	1.0242	58.5806	13.3919
Category 3	28	2.0011	1.1243	65.7738	13.6963

When results are compared across foundation course categories (Table 2), the mean GPAs show noticeable differences. Category 2 reported the highest mean Semester 1 GPA (M = 2.67, SD = 1.02, n = 47), followed by Category 1 (M = 2.51, SD = 0.64, n = 10). Category 3 reported the lowest mean GPA (M = 2.00, SD = 1.12, n = 28). However, the standard deviations, especially for Categories 2 and 3, suggest considerable within group variability, meaning student performance differs widely even within the same foundation pathway.

For foundation average, Category 3 shows the highest mean foundation performance (M = 65.77, SD = 13.70) while Category 2 shows the lowest (M = 58.58, SD = 13.39). Interestingly, Category 3 has the strongest foundation average but the lowest Semester 1 GPA, suggesting that higher foundation marks in that category did not translate directly into higher first-semester GPA.

This pattern indicates that factors beyond foundation category alone may influence undergraduate performance, and it supports the need for inferential testing (ANOVA and regression) to confirm whether these observed mean differences are statistically meaningful.

4.2 Effect of Foundation Course on Semester 1 GPA (ANOVA)

A one-way ANOVA was conducted to test whether Semester 1 GPA differs across foundation course categories. Results indicated no statistically significant differences in mean Semester 1 GPA: $F(2,81) = 1.28$, $p = 0.285$.

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Table 3
ANOVA summary table

Source	SS	df	MS	F	p
Between groups	1.1	2	0.550	1.28	.285
Within groups	34.926	81	0.432		
Total	36.026	83			

Table 3 presents the one-way ANOVA results examining whether Semester 1 GPA differs across the three foundation course categories. The analysis shows that the between-group variance (SS = 1.10, df = 2, MS = 0.550) is small relative to the within-group variance (SS = 34.926, df = 81, MS = 0.432). As a result, the overall test statistic is $F(2,81) = 1.28$ with $p = .285$, indicating that the differences in mean Semester 1 GPA across the foundation categories are not statistically significant at the 0.05 level. In other words, based on this sample, foundation pathway category alone does not appear to meaningfully explain variation in Semester 1 GPA.

Given that ANOVA compares GPA differences only by programme category and does not consider individual-level academic performance within the foundation programme, this analysis is limited in explaining why some students perform better than others. Therefore, to better evaluate academic success at the individual level, the study proceeded with a simple linear regression to examine whether foundation average predicts Semester 1 GPA, regardless of foundation course category.

The findings of this study are consistent with prior research indicating that preparatory academic performance is a strong predictor of university success. Curtis et al. (2017) similarly found that academic outcomes in bridging programmes significantly predicted first-year degree performance. Likewise, Lisciandro et al. (2022) reported that students who completed enabling pathway programmes demonstrated improved academic outcomes during early university study. These results collectively suggest that the effectiveness of foundation programmes lies not only in providing access to higher education but also in developing the academic competencies necessary for successful transition to university learning environments.

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4.3 Predicting Semester 1 GPA from Foundation Average (Regression)

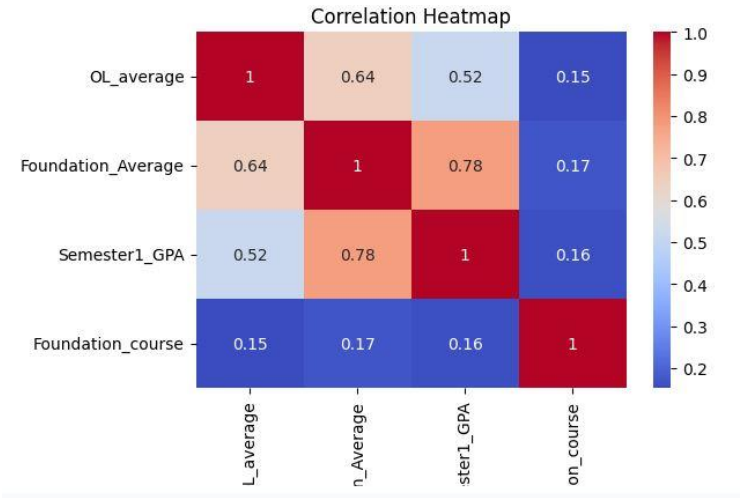

Figure 2
Correlation heatmap

Figure 2 shows the pairwise correlations among O/L average, Foundation average, Semester 1 GPA, and Foundation course category. The strongest relationship is observed between Foundation average and Semester 1 GPA (r = 0.78), indicating a strong positive association—students who perform better in the foundation programme tend to achieve higher GPA in Semester 1.

There is also a moderate positive correlation between O/L average and Foundation average (r = 0.64), suggesting that prior academic achievement at O/L is associated with better performance in the foundation stage. In addition, O/L average is moderately correlated with Semester 1 GPA (r = 0.52), implying that earlier academic performance may also relate to undergraduate performance, although less strongly than foundation performance.

In contrast, Foundation course category shows weak correlations with all academic outcome measures (r = 0.15–0.17), indicating that the pathway label/category itself has little linear relationship with O/L average, foundation average, or Semester 1 GPA. Overall, the correlation pattern supports the earlier ANOVA finding (limited effect of course category) and suggests that individual foundation performance is a more meaningful

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indicator of early undergraduate success than the foundation pathway category.

The results demonstrate that the foundation course pathway does not significantly influence Semester 1 GPA, while academic performance during the foundation stage is a significant predictor of early undergraduate success.

A simple linear regression model was used to examine whether foundation average predicts Semester 1 GPA. The model was statistically significant: $F(1,81) = 124.97$, $p < .001$.

5. Discussion

This study examined whether post-O/L foundation pathway category is associated with early undergraduate academic performance and whether foundation-stage achievement predicts Semester 1 GPA. The findings indicate that foundation course category does not significantly influence Semester 1 GPA, whereas foundation average is a strong predictor of Semester 1 academic performance. Taken together, the results suggest that early undergraduate success is more closely linked to how well students perform during the foundation stage than to the specific pathway label they completed (Wijesinghe et al., 2021; Curtis et al., 2017; Lisciandro, 2022).

The non-significant ANOVA result implies that the three foundation pathways may be sufficiently similar in terms of learning outcomes, assessment expectations, and skill development such that the pathway category alone does not generate measurable differences in Semester 1 GPA. Although descriptive differences in mean GPA were observed across categories, these variations were not statistically reliable and may be attributable to within-group variability and unequal group sizes. This supports the interpretation that course specialization at the foundation stage, at least as operationalized through pathway categories in this dataset, is not a primary driver of early undergraduate academic outcomes (Richardson et al., 2012; van Lamoen et al., 2025).

In contrast, the strong positive association between foundation average and Semester 1 GPA underscores the importance of foundation-stage mastery. This aligns with broader evidence that pre-university achievement and preparatory programme performance are meaningful predictors of first-year outcomes, reflecting the role of academic readiness, study habits, and foundational competencies developed prior to undergraduate study. The correlation patterns further reinforce this interpretation, showing a strong relationship between foundation performance and Semester 1 GPA, while the foundation course category exhibits only weak associations with academic outcome variables. Collectively,

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these findings support an institutional focus on the quality and effectiveness of learning and assessment during the foundation stage, rather than on differentiation between foundation pathways.

From a practical perspective, the results imply that institutions may achieve greater impact by strengthening foundation-stage teaching, assessment feedback, and academic monitoring processes, with particular attention to students demonstrating lower foundation averages. Targeted interventions—such as structured academic support, study-skills development, and early academic advising—may help mitigate risk and improve progression during the transition into undergraduate study.

6. Conclusion

Using secondary academic records from a private higher education institute in Sri Lanka (N = 85), this study assessed the relationship between post-O/L foundation programme characteristics and early undergraduate success. The findings show that Semester 1 GPA does not differ significantly by foundation pathway category, while foundation average is a strong predictor of Semester 1 GPA. These results suggest that institutional efforts should prioritise strengthening foundation-stage learning and supporting student achievement during the preparatory phase, as this appears to be more consequential for early undergraduate performance than pathway category differences.

While the study is based on a single-institution dataset and relies on variables available in academic records, it provides empirical support for focusing on foundation-stage performance monitoring and targeted academic support to enhance early undergraduate outcomes.

7. Limitations and Future Research

This study has several limitations. First, the analysis was conducted using data from a single higher education institution, which may limit the generalisability of the findings to other institutional contexts. Second, the study relied on available academic records and therefore could not incorporate additional variables such as socio-economic background, motivation, or learning behaviours that may also influence academic performance. Third, the sample size was relatively small and group sizes across foundation categories were unequal. Future research could extend this work by including larger multi-institutional datasets and incorporating additional academic and behavioural variables to develop more

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comprehensive predictive models of early undergraduate success.

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