Automated Inventory Management System for Income-Generating Projects

NICHOLAS KITCH JAMES S. GAJETELA, MSIT
Instructor
Jose Rizal Memorial State University – Main Campus, Dapitan City

Abstract — This study aimed to develop an Automated Inventory Management System (AIMS) for the Income Generating Projects (IGP) at Jose Rizal Memorial State University (JRMSU) main campus for the academic year 2023 to 2024. The objective was to transition from a manual to an automated system to enhance operational efficiency, reduce errors, and improve decision-making through accurate and real-time inventory data processing. The ISO/IEC 9126 framework assessed software quality across functionality, reliability, usability, maintainability, security, and acceptability.

The Agile Software Development Life Cycle (SDLC) was utilized, employing C# for application development and MySQL for scalable data management. Expert systems were integrated to enhance inventory forecasting accuracy and decision-making through advanced algorithms and real-time analytics.

The AIMS scored exceptionally well, with a grand mean of 4.57, indicating an 'Excellent' rating across all quality factors: functionality (4.63), reliability (4.55), usability (4.57), maintainability (4.59), and security (4.51). These scores reflect the system's robustness and alignment with the operational needs of the IGP.

The implementation is expected to significantly enhance managing the university's income-generating activities by optimizing tasks and workflows. Recommendations include continuously updating the system with the latest technological advancements, developing comprehensive training programs for users, integrating the system with other institutional systems, and conducting further research to explore long-term impacts on organizational efficiency and scalability.

Keywords — Automated Inventory Management System, Income Generating Projects, ISO/IEC 9126, Agile Software Development, Expert Systems

I. Introduction

In a competitive business environment, inventory management is a critical component of operational efficiency and effectiveness. Traditionally, inventory management involved manual processes that were not only time-consuming and labor-intensive but also prone to errors and inefficiencies. These traditional methods often failed to meet the constant change of demand of the modern business operations, leading to significant operational setbacks, including inaccurate stock levels, increased operational costs, and compromised decision-making capabilities.

Digital technology's rapid improvements have changed numerous business processes, with inventory management being no exception (Song et al., 2020). Today, automated inventory management systems (AIMS) represent a transformative shift from traditional methods, offering

precision, efficiency, and real-time data utilization. These systems have increased their computing power, becoming increasingly affordable and user-friendly, reshaping business models, production processes, and supply chain configurations.

Despite the clear advantages of automated systems, their implementation remains a complex challenge, particularly in public sector institutions like State Universities and Colleges (SUCs). Budgetary limitations and legacy processes often constrain these institutions. However, the Higher Education Modernization Act of 1997 (Republic Act 8292) has encouraged SUCs to engage in Income Generating Projects (IGPs) to supplement their funding. Efficient management of these projects is, indeed, crucial for their success and sustainability (Miranda et al., 2016)

Jose Rizal Memorial State University (JRMSU), through its engagement in various IGPs across its campuses, takes different approaches to managing inventories related to merchandise, rentals, and other services. The current manual systems are inadequate due to their inability to handle the complexity and scale of operations, leading to stock discrepancies and inefficiencies.

This research addresses these challenges by developing an Automated Inventory Management System (AIMS) tailored explicitly for the Income Generating Projects of JRMSU's main campus. The proposed system will create a transition from manual to automated processes, reaping the benefits of technology to enhance operational efficiency, reduce errors, and improve decision-making through accurate, real-time data.

The introduction of this system is expected to significantly benefit the JRMSU's administration, staff, and stakeholders by optimizing inventory handling, improving financial outcomes, and enhancing overall institutional efficiency. Moreover, it aligns with national policies on technological advancement and higher education efficiency.

The significance of this study extends beyond the operational improvements at JRMSU. It contributes to the broader discourse on the role of technology in transforming public education institutions and their operational framework. By demonstrating the practical benefits of an automated inventory system within an SUC, this research provides a model that can be replicated in similar institutions, potentially influencing policy and operational strategies at a national level.

Furthermore, this study serves as a valuable academic resource, offering insights into integrating technology in inventory management and the challenges and solutions related to its implementation in a public sector context.

II. Methodology

This chapter outlines the methodologies employed in this study, encompassing a comprehensive discussion of the step-by-step procedures from its inception to the final phase.

These procedures outline the entire trajectory of the study, culminating in the organization's implementation of the proposed system.

Methods Used

In this study, the Developmental Research Approach evolved the inventory management system at JRMSU's IGP from manual to automated. This methodology centers on iterative development, where feedback and performance data from early system versions were used to inform continuous modifications. Initial designs are subjected to real-world testing within the IGP, allowing the researcher to observe system performance in the actual usage environment and identify areas for improvement.

The approach was collaborative, with ongoing interactions between the researcher, users, and stakeholders. These interactions are critical for understanding the system's context and ensuring that it aligns with user needs and organizational goals. By integrating stakeholder feedback into the development process, the system can be more effectively personalized to meet the challenges and opportunities the IGP's operational landscape presents.

Research Environment

The research setting for this study was located within the esteemed Jose Rizal Memorial State University (JRMSU), specifically at its Main Campus nestled in the pleasing location of Dapitan City, a vibrant province of Zamboanga del Norte. Founded on December 15, 2009, JRMSU is a beacon of educational excellence, having evolved from its earlier iteration as the Jose Rizal Memorial State College. The university's growth trajectory has been remarkable, with its footprint extending across five campuses strategically dispersed throughout Katipunan, Tampilisan, Siocon, Dipolog, and Dapitan. Each campus plays a crucial role in enriching the region's educational landscape, with a distinct emphasis on community engagement and self-sustainability.

Research Respondents

Table 1. Respondents of the Study

Respondents	Frequency	Percentage
IT Professionals	10	25.00 %
CCS students	20	50.00 %
IGP personnel	10	25.00 %
Total	40	100.00%

Research Instrument

The research employed a customized evaluation tool derived from ISO/IEC 9126 standards designed to assess the forthcoming software's quality. This evaluation instrument scrutinized the software across five key factors indicative of quality: functionality, reliability, usability,

maintainability, and security. Five distinct criteria were evaluated to gauge the software's performance within each of these factors.

Scoring Procedure

The researcher firmly asserts that software implementation requires thorough prior research, comprehensive testing, and particular evaluation before execution. This systematic approach ensures adherence to standards but also aids the researcher in achieving precise and desired outcomes. An assessment involving a diverse pool of respondents was conducted to yield accurate results for the study. This selection encompassed IT course professionals and students, specifically chosen individuals recognized as professional evaluators, and users from the IGP Main Campus office personnel. Each participant engaged in the system study underwent an assessment process, offering their insights and opinions based on criteria accurately crafted by the researcher. This method allowed for a multi-dimensional evaluation, capturing diverse perspectives and considerations crucial to the study's success. Integrating varied respondent backgrounds and expertise enriched the evaluative process, ensuring a comprehensive assessment aligned with the study's objectives.

Data Gathering Procedure

The researcher gathered information from various sources, including online platforms and direct consultations with the Income Generating Projects Office Personnel and the Unit Head, and critically evaluated and verified this information to ensure its relevance and accuracy for the study. This thorough process was essential for forming a well-founded basis for the research, particularly in understanding the intricacies of the current inventory management practices within the organization. This involved researching processes and scrutinizing relevant reports associated with inventory management, which served as foundational elements for crafting the automated inventory management system.

An inaccurately crafted survey questionnaire was employed to accumulate data for this effort. This questionnaire, precisely designed by the researcher and scrutinized by their adviser, was tailored with appropriate queries to extract essential insights from respondents. It encompassed a comprehensive array of questions strategically formulated to prompt specific information crucial for fulfilling the study's objectives. The questionnaire was structured to encompass all necessary aspects, ensuring the researcher could effectively address the outlined aims and objectives of the study.

Statistical Treatment of Data

An analytical approach, utilizing the frequency count statistical technique, was employed to categorize the evaluators involved in assessing the study's software output.

Frequency Count and Percentage

This was used to assess the Automated Inventory Management System for Income Generating Projects, its challenges, and the acceptable and non-acceptable requirements users would like to see in the new system.

Weighted Mean.

Below are the formulas used to arrive at the computation used by the Statistical Tool:

1)   Frequency Distribution = n / T * 100%

Where: n = Number of respondents

T = Total number of respondents

2)   Weighted mean(x) = f (X1 + X2 + …… Xn) n / N

Where: n = Total number of criteria

Software Development Life Cycle
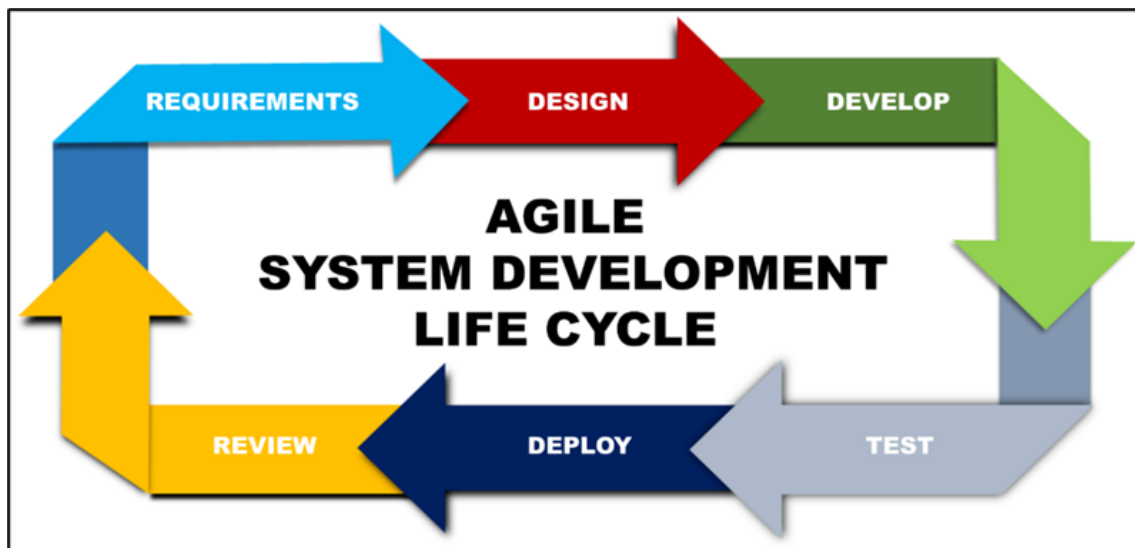

Figure 3. The Agile Software Development Life Cycle
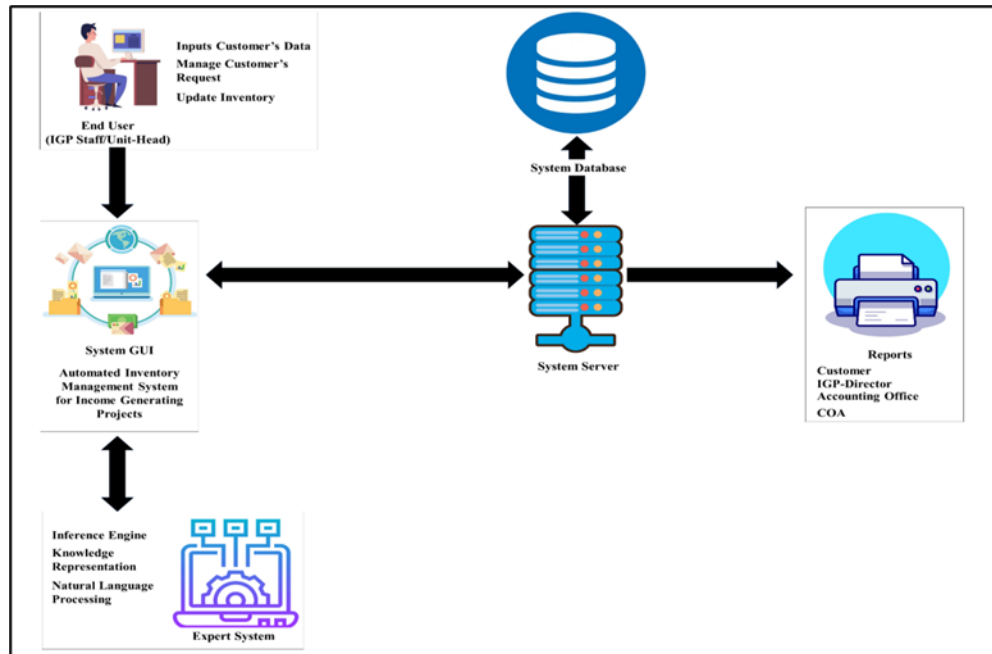
System Architecture Design

Figure 4. System Architecture Designhe

III. Results and Discussion

Current Inventory System of JRMSU Main Campus' Internal Generating Projects

Table 11. Current Inventory System of IGP questionnaire

Current IGP Inventory System	1	2	3	4	5	AWV
Inventory records are often not updated promptly, leading to discrepancies.				2	1	4.3
Formal inventory audits are not conducted regularly.					3	5
Discrepancies between recorded and actual stock levels are not promptly addressed.				2	1	4.3
There is a lack of systems in place to identify and manage slow-moving or obsolete inventory.				1	2	4.67
Product turnover rates are not monitored or analyzed effectively.			1	2		3.67
There are no automated alerts for reordering inventory when stock levels reach a minimum threshold.					3	5

Inventory reports are not generated regularly or are incomplete.			1	1	1	4
Data entry errors are common in recording inventory transactions.			1	2		3.67
Overstocking or understocking of inventory items is a frequent occurrence.				1	2	4.67
The manual inventory system is inefficient and leads to delays in operations.					3	5
	Mean					4.43

Other systems that can be combined into a single composite system

A comprehensive analysis was conducted comparing the features of various inventory management systems, including the SMART Inventory Management System in the UK, the STASH Inventory Management System in Bangladesh, and the Sebio School Supplies Inventory System.

Table 12. Features of the System Software

System software Features	SMART Inventory Management System in UK	STASH Inventory Management System in Bangladesh	Sebio School Supplies Inventory System	Automated Inventory Management System for Income Generating Projects
User Log in Function	✓	✓	✓	✓
Sign up function	✓	✓		✓
User level Authentication		✓		✓
User Dashboard	✓	✓		✓
Inventory Tracking	✓	✓	✓	✓
Data Recording	✓	✓	✓	✓
Computation of Rental Charges				✓
Inventory Monitoring	✓	✓	✓	✓

Admin Dashboard	✓	✓		✓
View activity logs		✓		✓
Conduct Sales			✓	✓
Conduct Rentals Services				✓
Bad Order Stock Removal	✓	✓	✓	✓
Demand Forecasting				✓
Proposes replenishment strategies				✓
Simulate performance rates				✓
Provides analytics				✓
Provides decision support				✓
Sales Report	✓	✓	✓	✓
Rental Slips Report				✓
Forecasting & replenishment Reports				✓
Inventory Reports	✓	✓	✓	✓

Figure 15 depicts the detailed comparison of the system software features of three existing inventory management systems—Sebio School Supplies Inventory System, Smart Inventory Management System in the UK, and Stash Inventory Management System in Bangladesh—and

the newly developed Automated Inventory Management System for Income Generating Projects at Jose Rizal Memorial State University (JRMSU).
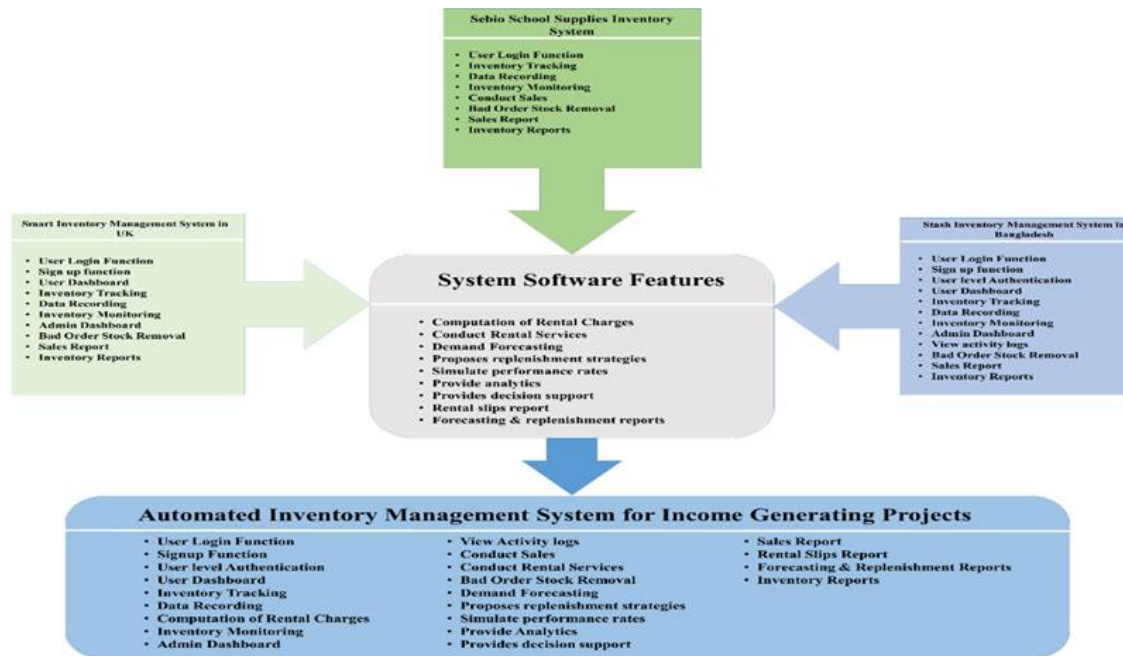

Figure 15. Integration of other Systems

Level of software quality in terms of functionality, reliability, usability, maintainability, and security

The automated inventory management system for income-generating projects (IGP) has demonstrated exceptional functionality, achieving an average weighted mean of 4.63, categorically rated as 'Excellent'. The interpretation of these results aligns with the stringent criteria established for evaluating system functionality. The system has been designed and executed to be highly efficient and user-friendly, logically integrating with the pre-existing systems at JRMSU's IGP.

Table 14. Level of Software Quality in terms of Reliability

No	Reliability	AWV	Description
1	Accurate division and handling of information within the system or processes in place to analyze and improve the software's reliability based on collected data	4.52	Excellent
2	Creation and reliability of system-generated backup files and employs techniques to ensure reliable data storage and retrieval.	4.47	Excellent
3	Consistency and reliability of the system's processing capabilities.	4.62	Excellent
4	Stability and robustness of the automated inventory management system.	4.6	Excellent
5	Ability to tolerate and handle errors gracefully for uninterrupted operation are in place.	4.55	Excellent
Mean		4.55	Excellent

The usability of the automated inventory management system for income generating projects (IGP) is critically acclaimed, with an average weighted mean of 4.57, categorizing it as 'Excellent'. This superior rating is attributed to the system's user-friendly interface, high user satisfaction, intuitive program design, efficiency in task performance, and comprehensive guidance provided to users. These elements are fundamental in ensuring that the system is not only easy to use but also effectively meets the end-user's needs in managing inventory for the university's Income Generating Project (IGP). Each aspect of usability has been carefully crafted, resulting in a system that enhances user interaction through efficient navigation and straightforward task execution, thereby significantly reducing the learning curve and increasing productivity.

The system's exceptional usability score underlines its design viewpoint, which prioritizes the user experience at every stage of interaction. The high marks in user satisfaction reflect the system's ability to align with the users' expectations, offering a whole experience that supports the users rather than complicating their tasks. This is particularly important in an educational setting like JRMSU, where the diversity of users can range from technically savvy individuals to those who may require more guidance. The thoughtful integration of detailed system design and user support ensures that all users, regardless of their technical expertise, can navigate and utilize the system efficiently, thereby maximizing the operational efficiency and effectiveness of the IGP's inventory management processes.

Table 15. Level of Software Quality in terms of Usability

No	Usability	AWV	Description
1	User-friendly interface that promotes ease of use for inventory management tasks	4.72	Excellent
2	High user satisfaction with the system's usability and overall experience.	4.65	Excellent
3	Intuitive and straightforward program design for easy navigation and task execution.	4.42	Excellent
4	Efficient accomplishment of basic tasks through a well-designed graphical interface	4.65	Excellent
5	Provision of detailed system design and guidance to users for effective utilization	4.4	Excellent
Mean		**4.57**	**Excellent**

The maintainability of the automated inventory management system for income-generating projects (IGP) has been evaluated with an impressive average weighted mean of 4.59, falling within the 'Excellent' category. This rating emphasizes the system's strong design, facilitating easy updates, modifications, and customization without disrupting ongoing operations. Key aspects contributing to this high maintainability include the system's diagnostic capabilities to identify and address failures, ease of configuration to adapt to changing requirements, and the flexibility to accommodate new updates or enhancements as needed. Each feature ensures that the system can

evolve alongside the changing needs of the university's Income Generating Project (IGP), while maintaining its performance and reliability.

The high maintainability score is crucial for the long-term success and scalability of the inventory management system. It ensures that as the IGP grows and its needs become more complex, the system can be efficiently modified and extended without substantial overhauls or downtime. This ability helps reduce long-term maintenance costs and supports continuous improvement and adaptation in response to user feedback and technological advancements. The system's design, which follows best practices for documentation and version control, further aids the researcher in making these updates flawlessly. Frequent updates ensure the system remains compatible with the latest technological trends. This strategic approach to maintainability is essential for maintaining the system's alignment with the university's operational goals and ensuring it continues to provide value over time.

Table 16. Level of Software Quality in terms of Maintainability

No	Maintainability	AWV	Description
1	The system possesses diagnostic capabilities to identify and address system failures effectively within the system	4.67	Excellent
2	Ease of configuration for seamless adaptation to changing requirements implemented by the office.	4.42	Excellent
3	Customization of the software and its ability to function reliably despite modifications introduced by client	4.72	Excellent
4	Flexibility for system modifications and updates to accommodate evolving needs as required by client	4.6	Excellent
5	Timely correction of program defects and bugs for improved system performance.	4.52	Excellent
Mean		**4.59**	**Excellent**

The security of the automated inventory management system for income-generating projects (IGP) is well built, as evidenced by an average weighted mean of 4.51, rated as 'Excellent'. This assessment confirms the system's effectiveness in safeguarding sensitive data, implementing strong authentication protocols, and employing comprehensive measures to protect against common vulnerabilities. The security features include secure error handling, clear documentation of security protocols, robust user authentication and authorization systems, integrated encryption mechanisms, and careful input validation processes. These measures are critical in preventing unauthorized access and ensuring data integrity and confidentiality are maintained across the system.

This excellent rating in security is aligned with the continuum used for interpretation, indicating that the system demonstrates exceptional security measures. These include advanced encryption protocols, secure authentication mechanisms, and thorough protection against vulnerabilities such as data breaches. The system's security architecture meets and surpasses expectations by providing a highly secure environment that mitigates risks and defends against

potential threats. Regular security audits and updates ensure that the system remains resilient against emerging threats, crucial for maintaining the beneficiaries' trust. The comprehensive security framework thus plays an essential role in supporting the Jose Rizal Memorial State University's income-generating activities by ensuring that all transactions and data handling within the Income Generating Projects are conducted within a secure and reliable infrastructure.

Table 17. Level of Software Quality in terms of Security

No	Security	AWV	Description
1	Secure error handling and robust logging mechanisms are applied in the system	4.5	Excellent
2	Clear documentation of security	4.52	Excellent
3	Users are authenticated (proving their identity) and authorized (permissions and access levels) to interact with the software system.	4.42	Excellent
4	The system integrates encryption mechanisms to protect sensitive data from unauthorized access and ensure that data remains secure both at rest and in transit.	4.57	Excellent
5	User inputs are validated and sanitized to prevent common vulnerabilities like alteration of data, disclosure of data, and others.	4.52	Excellent
Mean		4.51	Excellent

In the comprehensive assessment of the automated inventory management system for income-generating projects (IGP), the grand mean calculated for the key software quality factors—functionality, reliability, usability, maintainability, and security—stands at 4.57. According to our tailored acceptability table, this score categorizes the software's performance as 'Excellent', indicating superior overall quality. Each factor contributing to this mean score has individually met or exceeded the high expectations, demonstrating the software's robust capability to serve the university's Income Generating Project (IGP) efficiently and effectively. The 'Excellent' rating reflects the software's adherence to high-quality standards and its potential to enhance operational processes significantly.

Given this 'Excellent' rating, the software is deemed 'Fully Acceptable' for deployment without the necessity for immediate improvements. This acceptability status confirms that the system is ready to be utilized in its current form, offering high reliability and user satisfaction while ensuring security and ease of maintenance. Such a high level of performance across all evaluated criteria suggests that the software can support the Jose Rizal Memorial State University Income Generating Project's objectives by optimizing tasks and workflows, thus fostering a more productive and secure environment. Implementing this system should lead to measurable improvements in managing the university's income-generating activities, highlighting the effectiveness of using a structured and rigorous software quality assessment framework like ISO/IEC 9126 to guide development and evaluation processes.

Table 18. Summary of Software Acceptability

Software Quality Factor	Mean	Descriptive Rating
Functionality	4.63	Excellent
Reliability	4.55	Excellent
Usability	4.57	Excellent
Maintainability	4.59	Excellent
Security	4.51	Excellent
Grand Mean	4.57	Excellent

IV. Conclusion

The research conducted to develop and assess the Automated Inventory Management with an Expert System Empowerment for Jose Rizal Memorial State University's Income Generating Projects (IGP) conclusively demonstrates that the system is highly effective, aligning flawlessly with the operational requirements of the IGP. The evaluation using the ISO/IEC 9126 framework provided an in-depth analysis of the system's performance across crucial software quality parameters, including functionality, reliability, usability, maintainability, and security. The exemplary ratings confirm the AIMS's capability to meet and exceed the existing needs of JRMSU's IGP, ensuring that the transition from manual to automated processes significantly enhances efficiency, accuracy, and the strategic management of resources.

Implementing the system could provide potential benefits of integrating advanced software solutions in managing university-led income-generating projects. The system's design and adaptive capabilities make it a valuable model for similar institutions looking to utilize technology for better inventory management.

V. Recommendations

Based on the findings and conclusions, the following key recommendations are proposed:

1. Continuously update and enhance the system to incorporate the latest technological advancements, ensuring the system remains efficient and relevant. Focus on integrating new features such as cloud-based services or advanced analytics that can provide deeper insights and improve operational efficiency.

2. Develop comprehensive training programs and user manuals to ensure that all end-users can utilize the system efficiently. Establish a routine schedule for training sessions and create an ongoing support system to assist users with technical issues, ensuring high user satisfaction and system usability.

3. Integration of the system with other institutional systems, such as financial and accounting systems, to provide an all-inclusive view of the IGP's operations. This integration will further enhance decision-making.

4. Future researchers are encouraged to look into the long-term impacts on organizational efficiency and the adoption of similar systems in similar contexts. Support future studies that could explore the scalability of the system to other campuses or institutions and its long-term sustainability and effectiveness.

REFERENCES

[1] Ajay; Dasari, C., Reddy; Deshini, N. ;, &Mamidi, S. (2015). Smart Inventory Management System (Vol. 154). http://opus.govst.edu/capstoneshttp://opus.govst.edu/capstones/154

[2] Akca, Y., & Ozer, G. (2014). Diffusion of Innovation Theory and Animplementation on Enterprise Resource Planning Systems. International Journal of Business and Management, 9(4). https://doi.org/10.5539/ijbm.v9n4p92

[3] Amijaya, H. T., Fajar, G. N., &StudiKomputerisasiAkuntansi STMIK Mardira Indonesia Bandung, P. (2023). Quality Measurement of Accurate-5 Accounting Software Using the Iso 9126 Model (Study on Accurate Workshop for D3 Computerized Accounting STMIK Mardira Students). JurnalComputech&Bisnis, 17(1), 32–41.

[4] Firdaus, A.Md., S.T., B., &LintangYuniarBanowosari, S.Kom., M.Sc., Dr. (2021). QUALITY ANALYSIS OF PAYROLL INFORMATION SYSTEM BASED ON ISO 9126 IN PT KARYA PRIMA USAHATAMA. International Journal of Research Publications, 71(1). https://doi.org/10.47119/ijrp100711220211754

[5] Miranda, A. T., Tenedero, L. E., Fiel-Miranda, J. L., &Celestino, E. R. (2016). The income-generating projects of a government academic institution in The Philippines. Asia Pacific Journal of Innovation and Entrepreneurship, 10(1), 5–16. https://doi.org/10.1108/apjie-12-2016-006

[6] Misu, M. A. (2019). STASH-An Inventory Management System.

[7] Ortiz Bas, Á., & Franco, R. D. (2014). An Expert System for Inventory Replenishment Optimization. In IFIP AICT (Vol. 322).

[8] Rizad, H., Sapry, M., L'WieyAnakTawi, L., Ahmad, A. R., &Baskaran, S. (2018). The Effectiveness of MRP System to Forecast the Accuracy Inventory Requirement. In International Journal of Engineering & Technology (Vol. 7, Issue 1). www.sciencepubco.com/index.php/IJET

[9] S, S. (2022). A Review of Inventory Management of Small-Scale Enterprise in India. Multidisciplinary Journal for Applied Research in Engineering and Technology, II(5). https://doi.org/10.54228/mjaret07220003

[10] Salih, H. S., Ghazi, M., &Aljanabi, M. (2023). Implementing an Automated Inventory Management System for Small and Medium-sized Enterprises. Iraqi Journal for Computer Science and Mathematics, 4(2), 238–244. https://doi.org/10.52866/ijcsm.2023.02.02.021

[11] Singh, N. (2023). AI and IoT: A Future Perspective on Inventory Management. International Journal for Research in Applied Science and Engineering Technology, 11(11), 2753–2757. https://doi.org/10.22214/ijraset.2023.57200

[12] Song, J. S., van Houtum, G. J., & van Mieghem, J. A. (2020). Capacity and inventory management: Review, trends, and projections. In Manufacturing and Service Operations Management (Vol. 22, Issue 1, pp. 36–46). INFORMS Inst.for Operations Res.and the Management Sciences. https://doi.org/10.1287/msom.2019.0798

[13] Triyanto, A., Prisilia, G., &Saputra, Y. (2023). Implementing ISO 9126 in Quality Testing for Information Systems for Menu Ordering Using QR Codes in Panongkrongan Shop (Vol. 1, Issue 1).

[14] Wang, X., & Petropoulos, F. (2016). To select or to combine? The inventory performance of model and expert forecasts. International Journal of Production Research, 54(17), 5271–5282. https://doi.org/10.1080/00207543.2016.1167983

[15] Ziukov, S. (2015). A literature review on models of inventory management under uncertainty. Business Systems & Economics, 5(1), 26. https://doi.org/10.13165/vse-15-5-1-03