Journal of Applied Engineering and Technological Science
Vol 7(1) 2025: 569-581

IMPLEMENTATION OF SOFTWARE FOR EFFICIENT INVENTORY MANAGEMENT AT A NATIONAL PERUVIAN UNIVERSITY

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Received: 11 February 2025, Revised: 28 July 2025, Accepted: 10 September 2025
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ABSTRACT
This study presents the design and implementation of a multiplatform inventory management system developed for a public university in Peru, aiming to improve process efficiency and user satisfaction. Following an agile development methodology (SCRUM), the system was designed using modular architecture and responsive interfaces to ensure compatibility across devices and browsers. The usability evaluation was carried out using the CSUQ questionnaire, and the results were transformed to the SUS scale to assess the overall experience. A descriptive quantitative methodology was used, supported by surveys and technical compatibility testing. The findings reveal high user satisfaction, a SUS score of 93.75 ("Best imaginable"), and strong performance across all functionalities, particularly in navigation and inventory tracking. These results confirm the effectiveness of agile development in higher education contexts and highlight the importance of user-centered design in administrative systems.
Keywords : *Inventory Management, Usability Evaluation, CSUQ, SUS Scale, Agile Development, Public University, Multiplatform System.*

1. Introduction

Efficient inventory management is a critical necessity in public institutions, including universities, where asset traceability and resource planning are often constrained by outdated systems or manual processes. Previous studies indicate that the absence of digital solutions tailored to institutional contexts can lead to financial losses, record-keeping errors, and audit-related difficulties (Aditya & Efendi, 2022; Tong, 2025).

Despite the growing adoption of digital technologies in the education sector, many public universities continue to face challenges in implementing accessible, compatible, and user-centered management systems (Makelana et al., 2022). Proprietary platforms such as SAP or ERP systems are often inaccessible due to high costs, while open-source tools like Odoo or handcrafted solutions lack sufficient empirical validation and customization (Chumpitaz-Caycho et al., 2023; Gamidullaeva et al., 2023).

In this context, the development of a cross-platform inventory management system based on agile methodologies such as SCRUM—validated through structured instruments like the CSUQ emerges as a viable strategy to modernize resource administration in universities (Al Saeed et al., 2020; Rafida et al., 2022). However, academic literature reveals a gap in studies that integrate empirical usability validation with real-world application in public educational contexts. Most existing research focuses on business or private education sectors, often overlooking the specific constraints and requirements of public institutions (Demkina & Demkin, 2023).

This study proposes the design, implementation, and evaluation of a web-based inventory management system, adaptable to multiple devices and empirically validated within a Peruvian public university. The study aims to answer the following research question:

What is the level of functionality, compatibility, and user experience of the developed inventory management system, according to the perception of administrative users involved in inventory processes?. By addressing this question, the research seeks to provide evidence on the impact of accessible, user-centered technological solutions in institutional digital transformation, thus contributing to closing the technological gap in the Latin American public education sector.

2. Literature Review

Efficient inventory management in educational institutions has evolved through the adoption of digital technologies, particularly in addressing challenges related to accuracy, traceability, and scalability in resource-constrained environments. Several studies have reported that inventory record errors can result in financial losses, stockouts, and operational management limitations (Abiodun & Justina, 2022; Amirrudin et al., 2023; Ramos-Miller & Pacheco, 2023). This issue is especially critical in public universities, where resource optimization directly impacts the quality of services provided (Anjani & Nizar, 2021; Odasco & Saong, 2023). In response, web and mobile systems have been proposed to automate inventory control. These systems typically include features such as asset registration, search, alerts, graphical visualization, and automated reporting (Agboola et al., 2022; Gardella et al., 2024; Tanaman et al., 2023). However, mareone of the main limitations identified is the lack of cross-platform compatibility, which restricts access across various devices and operating systems (Pawar et al., 2024; Segun-Falade et al., 2024).

In this context, cross-platform software development has gained relevance by enabling the creation of adaptable solutions for diverse technological environments using frameworks such as Flutter, React Native, and tools based on hybrid web architecture (Blanco & Lucrédio, 2021; Fatkhulin et al., 2023; Panda, 2025). These approaches promote portability, deployment efficiency, and reduced development costs essential aspects for public academic institutions (Ganesh, 2025; Tamarab & Ivana, 2025).

Agile software development, particularly through the SCRUM methodology, has been consolidated as an effective strategy for iterative and collaborative implementation of technology projects. SCRUM is based on work cycles known as sprints, in which the team delivers functional increments of the product while incorporating continuous user feedback (Abdullah et al., 2023; Ciancarini et al., 2024; Ekechi et al., 2024; Kiramy et al., 2023). This methodology has been successfully adopted in digital public sector projects, though it requires adjustments to organizational contexts especially within universities (Guk & Mokhonko, 2025; Natalia, 2025; Rachman & Sushandoyo, 2021).

From the end-user perspective, usability is a critical dimension. According to the international standard ISO 9241-210:2019 Ergonomics of human-system interaction, Part 210: Human-centred design for interactive systems, usability is defined as the extent to which a system can be used by specific users to achieve specific goals with effectiveness, efficiency, and satisfaction (ISO, 2019).

Among the most widely used instruments to assess usability are the System Usability Scale (SUS) and the Computer System Usability Questionnaire (CSUQ), both extensively validated and recommended by recent studies in software engineering and education (Hajesmaeel-Gohari et al., 2022; Hariyanto et al., 2020). Human-Computer Interaction (HCI) theory provides an additional conceptual framework in which the user experience is examined in terms of efficiency, effectiveness, and perceived satisfaction (Guitton, 2021; Wang et al., 2022). Moreover, Nielsen's usability heuristics such as system status visibility, user control, consistency, and error prevention are widely applied to guide the design of intuitive and accessible interfaces (Sobodić et al., 2024; Vlachogianni & Tselios, 2022). Finally, although extensive literature exists on inventory systems and usability in mobile or educational applications, there remains a significant gap in integrating agile methodologies, cross-platform development, and formal usability evaluation within a single study applied to public universities. This research aims to address that gap through the design, implementation, and evaluation of a system developed using the SCRUM methodology, offering cross-platform compatibility and validated through internationally recognized instruments such as the CSUQ, adapted to the Peruvian institutional context.

3. Research Methods

This study employed a quantitative approach with a descriptive-explanatory design, aimed at analyzing the effects of implementing a cross-platform software system across three key dimensions: functionality, compatibility, and user experience in institutional inventory management.

The target population consisted of technical staff from the Office of Information and Communication Technologies (OTIC) at a Peruvian public university. The sample included all 15 active personnel responsible for managing the inventory system, selected through non-probabilistic census sampling due to their direct involvement in the system's initial implementation phase. Ethical research principles were upheld, including obtaining informed consent and ensuring anonymity and confidentiality in data handling, in accordance with best practices in institutional research.

3.1. Instruments

Two instruments were used for data collection:

a) **Structured survey:** A 13-item questionnaire with closed-ended questions addressing functionality and compatibility, administered via Google Forms. Responses were recorded using a 4-point Likert scale (1 = Very Good, 4 = Poor).
b) **Computer System Usability Questionnaire (CSUQ):** Adapted to the Spanish-speaking university environment, this instrument comprised 16 items grouped into four factors: system quality, information quality, interface quality, and overall satisfaction. A 7-point Likert scale was used (1 = Strongly agree, 7 = Strongly disagree), following Lewis's (2018) recommendations.

The CSUQ was validated by a panel of three experts in software engineering and educational technology. Reliability was assessed using Cronbach's Alpha coefficient, resulting in a value of 0.714, indicating acceptable internal consistency.

3.2. Procedures and Data Analysis

Data analysis was conducted using statistical and visual tools aimed at evaluating the functionality, compatibility, and user experience of the implemented system. The following procedures were applied:

a) **Descriptive statistics:** Frequencies, means, mode, and standard deviations were calculated to interpret the responses from the applied questionnaires.
b) **Data visualization:** Results were displayed using stacked bar charts (for functionality) and radar charts (for user experience), in order to facilitate visual interpretation of the findings.
c) **Conversion of CSUQ scores to SUS scale:** To express usability results on a standardized 0–100 scale, Equation 1 proposed by Lewis (2018) was applied.

$$SUS = 100 - (\bar{x} - 1)x25$$

Where $\bar{x}$ represents the global average of the CSUQ responses on a 1-to-7 scale.

$$CSUQ = 100 - \left(\frac{\sum_{n=1}^{16} P_n}{16} - 1\right)(\frac{100}{6})$$

Where P_n represents the score of each item in the questionnaire, and 16 corresponds to the total number of items.

3.3. Software Development

The software was developed using the agile SCRUM methodology, which allowed the process to be divided into four work sprints, facilitating incremental delivery and continuous user feedback (see Table 1). This methodology, based on the framework proposed by Schwaber and Sutherland (2020), defines specific roles, structured events, and artifacts that guide iterative development. The phases of the SCRUM process and their application in each sprint are outlined in Table 2.

Table 1 – Sprints in Software Implementation

Sprint	Objective	Task
Sprint 1	Design and Implementation of Login and User Management	Development of the login controller. Implementation of the role and permissions management system.
Sprint 2	Basic Inventory Management	Implement functionality to add, edit, and delete inventory records. Integrate with MySQL.
Sprint 3	Interface Optimization and Cross-Platform Compatibility	Design an adaptive user interface for mobile and desktop devices. Perform tests on browsers and operating systems.
Sprint 4	User Validation and Experience Improvement	Implement surveys to gather feedback. Make adjustments based on satisfaction survey results.

The development of the five SCRUM components is presented in Table 2, which allowed for the structured organization of activities within each sprint.

Table 2 – Phases of the Proposed Methodology

Phases	Description	Application in Sprints
1. Sprint Planning	Define the objectives and tasks to be performed in each sprint based on product feedback.	In Sprint 1, the implementation of the login and user management was planned, prioritizing system security.
2. Daily Scrum	Daily meetings to review progress and adjust the plan according to emerging challenges.	During Sprint 2, the daily meetings focused on solving issues with MySQL integration.
3. Sprint Work	Development of the tasks defined during sprint planning.	In Sprint 3, work was done on the user interface design and cross-platform compatibility testing.
4. Sprint Review	Review of the tasks defined during sprint planning.	In Sprint 4, usability improvements were reviewed based on user survey feedback.
5. Sprint Retrospective	Reflection on the sprint to identify improvements in processes or work organization.	After Sprint 4, opportunities were identified to improve the system's speed and cross-platform adaptation.

3.4. Architecture and Technologies

The implementation was carried out using a Model-View-Controller (MVC) architecture. PHP was used for backend development, and MySQL was chosen as the relational database management system due to its efficiency in handling large volumes of data (Tamarab & Ivana, 2025). The user interface was developed using HTML and CSS, optimized for both mobile and desktop devices.

The overall system functionality is illustrated in the functional flow diagram shown in Figure 1.

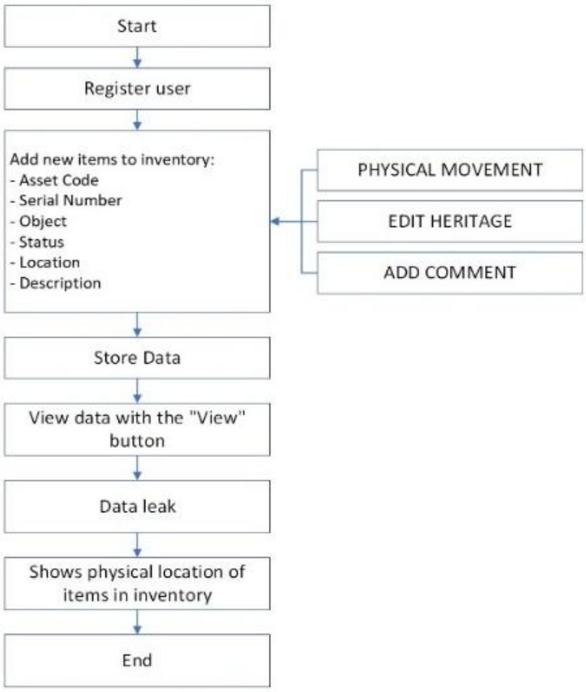


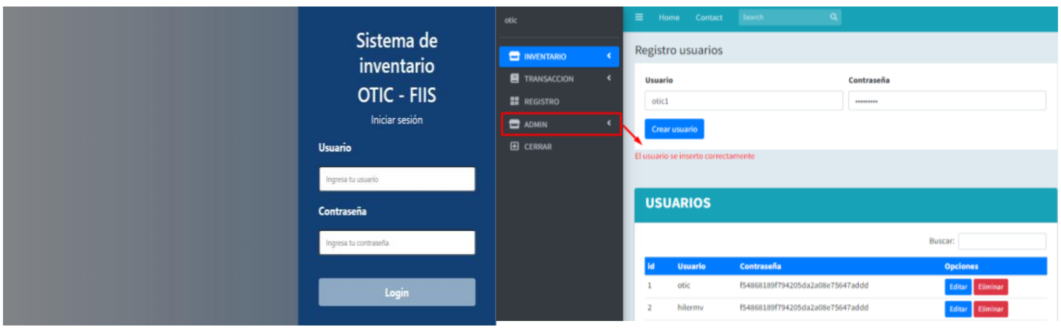
Fig. 1. Flowchart

3.5. User Interface and Functional Modules

The system was designed using a modular architecture and a user-centered interface, following usability principles and human-computer interaction standards (ISO 9241-210; Nielsen). The components were organized into four functional modules, represented in Figures 2 through 5, visually integrating key functionalities without duplicating interfaces.

3.5.1. Access and User Management Module

Figure 2 displays the core interfaces of the access and user management module. In (a), the login screen is shown, where users enter their personal credentials to access the platform. In (b), the user administration section is presented, allowing for the creation, editing, and deletion of accounts, as well as role assignment. These features ensure centralized and secure control over system permissions.

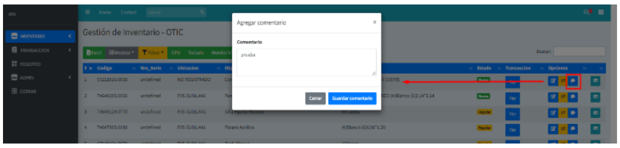


(a) (b)

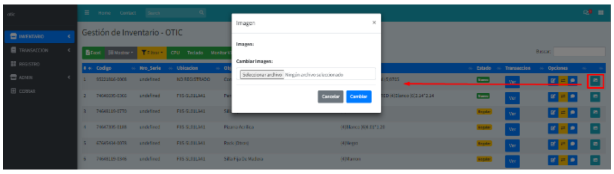
Fig. 2. User login (a) and user management with role-based access control (b).

3.5.2. Inventory Module

Figure 3 presents two specific functionalities of the inventory module. In (a), the interface for adding comments to asset records is shown, which facilitates contextual documentation and change tracking. In (b), the image upload feature associated with each asset is displayed, enabling direct visual identification and enhanced traceability. Both interfaces strengthen operational management and continuous inventory updating through an intuitive and adaptable platform.



(a)

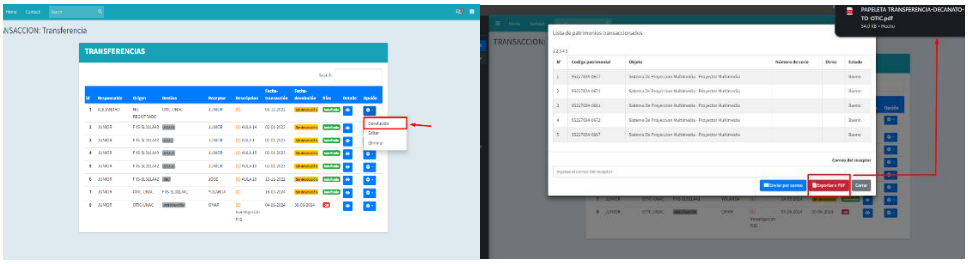


(b)

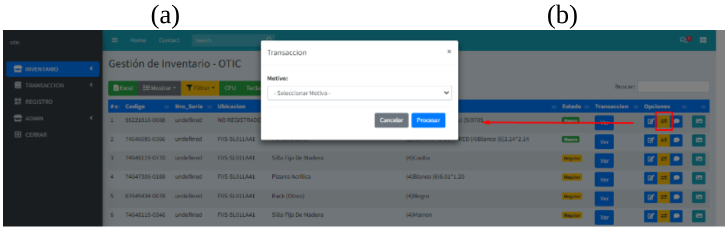
Fig. 3. Commenting interface for asset records (a) and image upload functionality for inventory items (b).

3.5.3. Transactions and Documentation Module

Figure 4 displays the functionalities related to asset return logging and transaction documentation. In (a), the main list of transfers is shown, including options to process asset returns. In (b), the system's ability to generate PDF reports is illustrated, supporting each transaction and facilitating formal documentation. Finally, in (c), a pop-up form is presented to select the reason for the return, which enhances traceability and transparency in institutional asset management.



(a) (b)

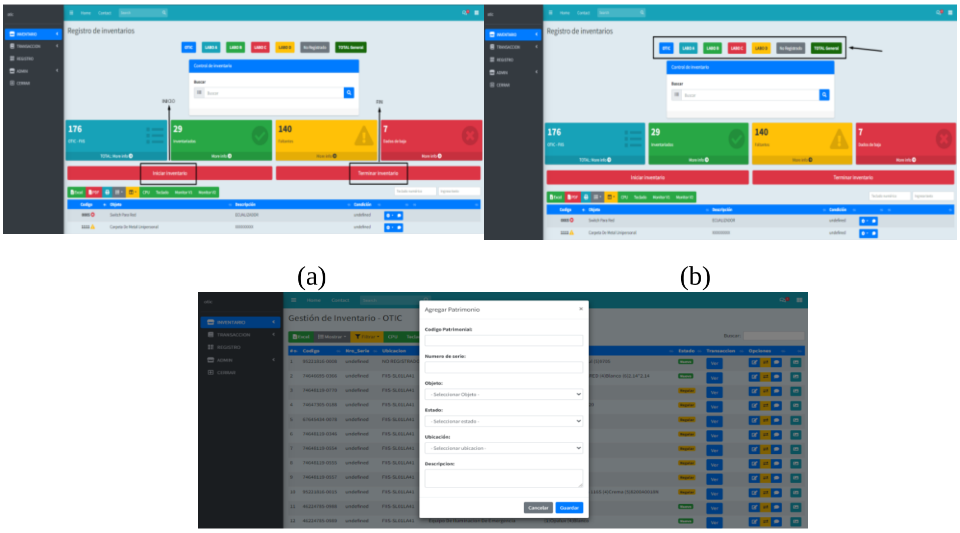


(c)

Fig. 4. Transaction logging and report generation. (a) Transfer view. (b) PDF export. (c) Return form.

3.5.4. Counting and Search Module

Figure 5 illustrates key system functions related to inventory control. In (a), the main panel is shown with visual indicators and access to physical inventory registration, enabling identification of the start and end dates of the process. In (b), the location-based filtering option is displayed, which facilitates inventory organization by specific areas. Finally, in (c), the asset registration and editing form is presented, allowing the institutional database to be continuously updated. These integrated interfaces optimize both the chronological and geographical management of inventory in a visual and efficient manner.



(a) (b)

(c)

Fig. 5. Main dashboard with inventory timeline indicators (a), location filter (b), and asset registration/editing form (c).

4. Results

The results of this study are presented in three analytical blocks that allow for understanding the impact of the developed system from different perspectives: (i) system functionality, (ii) cross-platform compatibility, and (iii) user experience. This structure integrates both technical evidence and user perception, in line with methodological recommendations for usability and software quality assessment.

4.1 System Functionality

The evaluation of key functionalities was conducted through a questionnaire consisting of seven items, administered to users responsible for inventory management. Each item assessed a specific function using a four-level Likert scale: Very Good (1), Good (2), Fair (3), and Poor (4). The items applied are listed in Table 3.

Table 3 – Instrument items used to evaluate system functionality

ID	Question
Q1	Evaluate the login function.
Q2	Evaluate the inventory menu interface.
Q3	Evaluate the inventory location function.
Q4	Evaluate the inventory editing function.
Q5	Evaluate the movement registration function.
Q6	Evaluate the comments function.
Q7	Evaluate the image upload function in the inventory module.

Figure 6 summarizes the results obtained. Overall, a high level of satisfaction was observed, with the functions “Location,” “Movement,” and “Add Comment” receiving 80% “Very Good” ratings, and no functionality receiving evaluations in the “Poor” category.

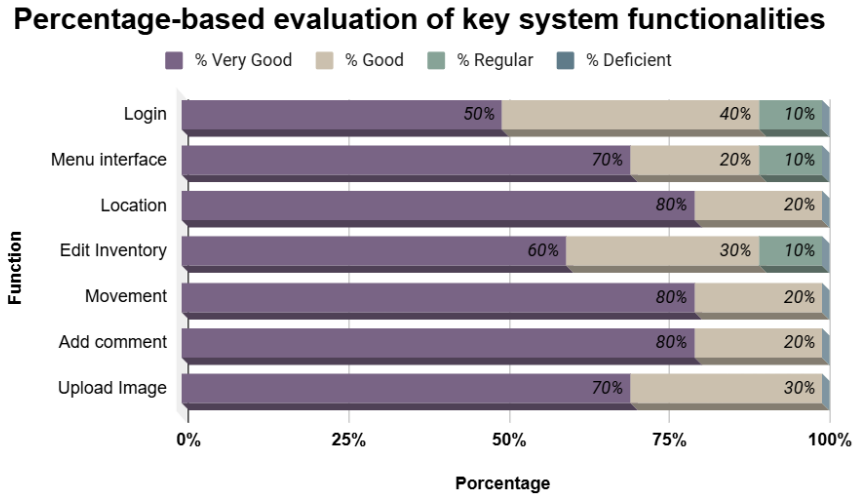


Fig. 6. Evaluation of key system functionalities

The average score obtained from the CSUQ questionnaire was 6.65. Applying Equation 1, as described in the methodology section, this value was converted to an equivalent SUS score of 93.75, representing an optimal level of usability according to the criteria established by Lewis (2018).

To complement the response percentages shown in Figure 6, descriptive statistics were calculated for each item in the functionality questionnaire. Table 4 presents the mean, standard deviation, and mode for each item, allowing for an assessment of consistency and variability in user ratings. These results reinforce the overall interpretation of user satisfaction and support the use of quantitative measures in the functional analysis of the system.

Table 4 - Descriptive statistics of the evaluated system functionalities

Item	Summary Description	Mean	Standard Deviation	Mode	Item
P1	Overall system functionality	1.73	0.47	2	P1
P2	Intuitiveness and ease of use	1.18	0.40	1	P2
P3	Navigation experience	1.55	0.52	2	P3
P4	Ease of learning the software	1.27	0.47	1	P4
P5	Quick understanding of key tasks	1.55	0.52	2	P5
P6	Efficiency in adapting to software use	1.27	0.47	1	P6

4.2 Compatibility

The system's technical compatibility was verified through functional tests on various operating systems, browsers, and devices. All tests were successful across the evaluated environments, validating the system’s flexibility to operate in diverse usage contexts.

Table 5 – Software Compatibility Tests

Platform	Browser / Device	Result
Windows	Chrome, Edge, Firefox, Brave	Compatible in all cases
Linux	Chrome, Edge, Firefox, Brave	Compatible in all cases
Mobile devices	Android (smartphone, tablet)	Full and stable functionality
Desktop	Chrome, Edge, Firefox	Full and stable functionality

The results show that the system maintains stable and consistent behavior, with no loading errors or visual/functionality issues. This reinforces its versatility and feasibility for large-scale institutional adoption.

4.3 System Usability

To analyze users' perception of system usability, the CSUQ was administered with 16 items across four dimensions: system quality, information quality, interface quality, and overall satisfaction. Responses were collected using a 7-point Likert scale, where 1 means "Strongly agree" and 7 means "Strongly disagree." The global average score of 6.65 was converted to a SUS (System Usability Scale) score of 93.75, categorized as "Best imaginable", according to the model proposed by Lewis (2018). Figure 7 illustrates the SUS scale interpretation used to classify the result.

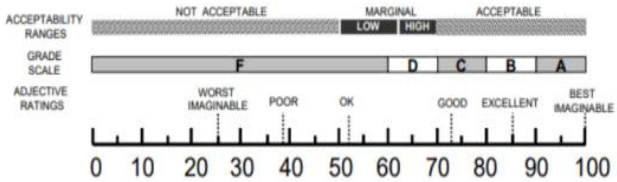


Fig. 7. SUS interpretation scale according to Lewis (2018)

Additionally, all four CSUQ dimensions showed consistently high satisfaction levels among users: system quality (1.60), information quality (1.53), interface quality (1.47), and overall satisfaction (1.40). Table 6 presents the average scores per CSUQ dimension.

Table 6 - Average scores per CSUQ dimension

Dimension	Items	Average (1–7)
System Quality	1–6	1.60
Information Quality	7–12	1.53
Interface Quality	13–15	1.47
Overall Satisfaction	16	1.40

5. Discussions

The findings of this research reveal substantial improvements in inventory management through the implementation of the proposed system, developed under agile principles. System functionality was positively evaluated by users, who particularly highlighted the efficiency of movement registration, intuitive navigation, and comment integration. These results align with those reported by (Mishra et al., 2022; Rafida et al., 2022), who emphasize that even low-complexity digital solutions can yield meaningful impacts when aligned with real workflow requirements.

The average SUS score of 93.75 places the system in the highest satisfaction tier ("Best imaginable"), validating its usability under international standards. According to ISO 9241-210, usability encompasses not only effectiveness and efficiency, but also user satisfaction, which was captured in this study through the CSUQ. This outcome is also consistent with Nielsen's (1995) usability heuristics, particularly regarding system status visibility, consistency, and interface flexibility. The cross-platform design demonstrated high compatibility with browsers such as Chrome, Firefox, and Edge, as well as with both mobile and desktop devices, without visual or functional errors. This technical performance supports the findings of (Al Saeed et al., 2020; Indrawan & Sawitri, 2023), who advocate for flexible architectures like React, Flutter, or CodeIgniter in institutional digitalization contexts. It also reinforces the perspective of (Makelana et al., 2022) , who emphasize the importance of developing accessible and functional digital solutions tailored to the needs of small and medium-sized organizations.

Regarding the CSUQ dimensions, all scored above 6.5 out of 7, with particularly high ratings in overall satisfaction, graphical interface, and content quality. These results validate the principles of user-centered design, widely promoted in the human-computer interaction (HCI) literature, as noted by (Juan & Xiaoli, 2021; Stankov & Gretzel, 2020) in their analyses of emotional design and user experience. Despite the positive results, some features such as inventory editing, received slightly lower satisfaction ratings, suggesting the need for iterative improvement. This approach aligns with (Tellez-Risco et al., 2022), who highlight the importance of continuous feedback cycles in educational environments. It is recommended to incorporate future sprints specifically aimed at optimizing critical functions, supported by longitudinal usability testing (Aditi Kulkarni, et al., 2022).

Furthermore, although the sample size was small (n = 15), the results provide a strong foundation for future implementations in other public universities in Peru, particularly those facing similar logistical challenges. This potential for scalability is addressed (Makelana et al., 2022), who argue that well-designed solutions can be transferred across multiple contexts when developed using modular principles and open technologies.

Ultimately, this experience demonstrates that the combined application of agile methodologies, cross-platform architecture, and standardized usability evaluation is a valid and replicable strategy for improving administrative processes in public higher education institutions. As suggested (Demkina & Demkin, 2023; Gamidullaeva et al., 2023; Wahyuni & Hamzah, 2024), user-centered design should not be exclusive to the private sector, but rather an integral component of public sector modernization efforts. Unlike previous studies, this research uniquely integrates SCRUM-based development, empirical usability validation, and cross-platform deployment within a public university context, an area previously underexplored in the literature. This contribution not only addresses technical and usability challenges identified in prior work but also provides a replicable model tailored to the constraints and needs of Latin American public institutions.

6. Conclusions

The results of this study allow us to conclude that the inventory management system developed using agile methodologies not only met the functional and technical requirements of the university environment but also achieved high levels of user acceptance and usability. The SUS score of 93.75 and CSUQ dimension ratings above 6.5 reflect a positive user experience in terms of efficiency, ease of use, and interface design.

From a technical standpoint, the system demonstrated excellent cross-platform compatibility, operating without errors across different browsers and operating systems. This underscores the importance of adopting modular architectures and adaptive web technologies in the development of institutional solutions.

It is recommended that future iterations of the system include adjustments to specific functions, such as inventory editing which showed room for improvement. Additionally, implementing continuous evaluation cycles through longitudinal testing is suggested to maintain high satisfaction levels over time.

Finally, this study demonstrates that such solutions can be replicated in other public institutions, provided they are tailored to local needs through user-centered approaches and empirical validation. Future development may also consider integration with asset depreciation modules, budget planning tools, or more complex warehouse management systems.

7. Study Limitations

This study presents several limitations that should be considered when interpreting the results. First, the sample size was relatively small (n = 15), consisting solely of active staff members from the OTIC office during the system's initial implementation phase. This constraint limits the generalizability of the findings to broader institutional contexts. Second, no control or comparison group was included to benchmark the system’s performance against previous practices or alternative inventory platforms.

Additionally, the evaluation was conducted as a one-time assessment during the implementation phase, without longitudinal testing to capture usage trends, adoption curves, or long-term sustainability. Furthermore, the institutional setting—a Peruvian public university—may present specific organizational and technological characteristics that do not necessarily reflect conditions in other institutions with different structures, cultures, or resource levels.

These limitations open valuable avenues for future research, including larger sample sizes, multicenter validations, and mixed-method approaches. Such strategies would enable a more comprehensive understanding of the effectiveness, adaptability, and impact of digital inventory solutions in diverse educational and administrative environments. Addressing these aspects could strengthen the evidence base for scalable technology adoption in the public sector.

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