Journal of Applied Engineering and Technological Science
Vol 6(1) 2024: 138-154

SOFTWARE DESIGN FOR INVENTORY MANAGEMENT IMPROVEMENT IN A PERUVIAN NATIONAL UNIVERSITY

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Received: 01 September 2024, Revised: 14 November 2024, Accepted: 20 November 2024
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ABSTRACT
The purpose of this study was to design a software to optimize inventory management in the Office of Information Technology and Communications (OTIC) of the Faculty of Industrial Engineering and Systems of the Universidad Nacional del Callao, Peru. The research arose due to the lack of an efficient system that minimizes asset losses and reduces operational errors in the university context, where resource constraints demand sustainable and adaptable solutions. To address this problem, an agile methodological approach was used, implementing the Scrum methodology in the software design, as well as an architecture based on MVC (Model-View-Controller) with technologies such as MySQL, PHP and CodeIgniter. The evaluation of the system included usability surveys to users and an expert judgment, focused on three dimensions: Reliability, Usability and Design. The results of the study showed a high acceptance of the system in terms of ease of use and user satisfaction, highlighting the effectiveness of the modular design for future extensibility and performance improvements. This study provides theoretical value by highlighting the application of agile methodologies in educational environments and highlights the importance of a scalable design to improve inventory management in academic institutions. In practical terms, the implementation of this software offers an adaptable and scalable solution, with potential for replication in other universities, optimizing resource management and strengthening operational efficiency in the educational sector. The main contribution of the study lies in the combination of a flexible and low-cost design, aimed at meeting the specific needs of inventory management in educational environments with budgetary constraints.
Keywords: *Inventory Management, Scrum, Software Design, University, Usability.*

1. Introduction

In recent years, universities and other educational institutions have begun to adopt advanced technologies to improve resource management, especially inventory systems. Several recent studies indicate that technological tools such as the Internet of Things (IoT), Enterprise Resource Planning (ERP) software and Artificial Intelligence (AI)-based systems can significantly optimize asset control and tracking (Devi et al., 2023). These innovations enable universities to increase the accuracy of inventory management, reduce operating costs and improve the efficiency of administrative processes (Shinde et al., 2023; Aluguri et al., 2023). However, existing solutions have limitations of adaptability and scalability for specific environments such as academia, which necessitates research into customized and sustainable solutions for this sector (Ozkaya, 2020; Larutama et al., 2023).

The Faculty of Industrial Engineering and Systems of the Universidad Nacional del Callao (UNAC) exemplifies these challenges, facing problems of misplacement and underutilization of assets, caused by errors in records and the lack of a centralized tracking system. In 2022, up to 20 cases of misplaced assets were documented, resulting in additional costs and suboptimal decisions due to the lack of accurate data on the availability and location of resources (Purwanningrum et al., 2023; Martishin et al., 2023). The implementation of a modular system in this context is essential, as it allows for progressive scale-up without requiring significant restructuring of the technological infrastructure (Anand et al., 2021). These issues highlight the need for a more robust inventory management system that allows educational institutions to efficiently manage and optimize their assets (Ramos-Miller and Pacheco, 2023) (Singh et al., 2022).

This study proposes an innovative solution through the development and implementation of an inventory management system designed specifically for the needs of the university environment. Unlike previous approaches, the system designed in this study not only seeks to optimize inventory control accuracy, but is also designed to improve scalability and adaptability, facilitating efficient asset management in different operational contexts. By integrating advanced and adaptable technologies, the proposed system addresses the limitations identified in the literature and contributes to knowledge in the field of inventory management in educational institutions. Thus, a solution that optimizes the functionality and control of university resources is presented (Lumba & Waworuntu, 2021; Shah et al., 2021).

Through this research, we seek to provide a comprehensive approach to inventory management in universities. While previous studies have developed effective solutions in other sectors, these are not fully applicable in educational environments due to their limited flexibility and customization capabilities. This work, therefore, aims to contribute a system that addresses such limitations and demonstrates the benefits of a tool tailored to the specificities of the education sector (Daracan et al., 2020; Wang & Chen, 2022).

The objective of this research is to develop and implement an inventory management system that allows educational institutions to optimize the accuracy, adaptability and scalability of their resource management processes. With this system, we seek to contribute to a more efficient administration and improved decision making within the university environment, establishing a solid foundation for its replication in institutions facing similar challenges.

2. Literature Review

Inventory management in educational environments has been widely studied in the last decade, highlighting the importance of automation and traceability systems to optimize resources and reduce operating costs (Fortuna and Gaspar, 2022; Jayapal et al., 2023). In the context of public universities such as the Universidad Nacional del Callao, budget and technical resource constraints require technological solutions that are adaptable and sustainable. The following is a review of key studies that support the design of a system that meets these needs.

Larutama et al. (2023) and Shinde et al. (2023) highlight the benefits of implementing traceability systems to improve operational efficiency and reduce costs in universities in several countries. In both studies, significant improvements in internal efficiency were achieved through the use of advanced technologies for real-time asset control. While Larutama et al. (2023) applied a database-driven traceability system, Shinde et al. (2023) integrated IoT technologies, for greater visibility and accuracy in inventory control. However, the infrastructure and high costs of IoT present a challenge for universities such as UNAC, where funding and infrastructure are limited. As an alternative, a system based on relational databases will be implemented, which allows efficient traceability and adjusted to the capabilities of the institution (Alkelany, 2023; De Oliveira et al., 2022).

Martishin et al. (2023) show how relational database-based inventory systems in universities can optimize asset organization and provide rapid access to real-time information without requiring an advanced technological infrastructure. This approach is especially relevant in the context of the Universidad Nacional del Callao, where such a system could improve asset traceability and control without imposing significant resource demands. This study offers a viable alternative for institutions with similar characteristics and needs, aligned with local infrastructure and operational capabilities (Matuska et al., 2023; Ramos-Miller and Pacheco, 2023).

Cross-platform accessibility is another important feature in the efficiency of university inventory systems, especially in contexts where decentralized access is critical (Singh et al., 2022). They developed a mobile system that facilitates inventory consultation and management from handheld devices, promoting accessibility and usability for administrative staff. This type of approach is relevant for UNAC, where a system accessible from different devices will allow real-time inventory control and consultation, without relying on advanced technologies. The design of the university's initial solution will be oriented towards a mobile implementation, allowing the consultation and updating of inventories in an efficient and accessible manner for university staff (Hady & Kusumo, 2023; Singh et al., 2022).

In addition, the use of agile methodologies, especially Scrum, has proven to be effective in the development of adaptive and scalable inventory systems in the educational environment. Aluguri et al. (2023) and Ozkaya (2020) show that the application of Scrum in educational software development allows fast and continuous iterations, optimizing the accuracy and efficiency of the inventory system. This approach is well suited to the needs of the Universidad Nacional del Callao, where the ability to adjust the system based on user feedback will allow continuous and progressive development, aligned with the demands of the academic community. The implementation of Scrum ensures that the system can evolve according to institutional and user changes, guaranteeing long-term adaptability and sustainability (Kisno et al., 2022; Dzaky and Kurniawan, 2023).

The Technology Acceptance Model (TAM) also plays an important role in the design of accessible and easy-to-adopt inventory systems. Nurharjadmo et al. (2022) demonstrated that a system designed under the TAM, which prioritizes ease of use and accessibility, significantly increases its acceptance among university users. For the Universidad Nacional del Callao, it is essential that the system be intuitive and accessible, facilitating its adoption and minimizing the need for advanced technical training. This approach ensures that the designed system is not only functional, but also achieves wide acceptance among end users, including administrative staff (Damayanti et al., 2022).

In conclusion, the literature review reflects a clear trend towards digitalization, multiplatform accessibility, agile methodologies and technology acceptance models in university inventory management. Unlike previous studies, the described proposal seeks to achieve a balance between efficiency and budgetary viability, ensuring the sustainability and adaptability of the system in an environment with limited resources. This approach provides a replicable and effective basis for inventory management in other universities with similar characteristics and operational challenges (Abiodun and Ikuomola, 2022; Lievchalermwong and Aunyawong, 2022).

Theoretical Bases:

The design of an inventory management system for the Universidad Nacional del Callao (UNAC) is based on various theoretical frameworks that allow understanding the structure, adoption and adaptation of such a system in the university context. The General Systems Theory, proposed by Von Bertalanffy, states that a system should be seen as a set of interrelated elements that work together towards a common goal (Martishin et al., 2023). This approach is essential at UNAC, where the inventory management system is viewed as a subsystem that interacts integrally with other administrative and academic areas. This facilitates effective communication and information sharing between departments, which optimizes control and resource availability (Budgen, 2020).

The Technology Acceptance Model (TAM), developed by Abusanna (2023), provides a valuable framework for forecasting users' willingness to adopt the inventory system based on perceived usefulness and ease of use (Kedarisetty & Kantheti, 2022). In the context of UNAC, this model is particularly relevant, as administrative and academic staff have varying levels of technological competence. Perceived usefulness is associated with the expectation that the system will significantly optimize efficiency in inventory management, while ease of use is related to the effort required to interact with the platform, a key factor in the adoption of technological systems at the university level (Al-Bashayreh et al., 2022).

The implementation of the system follows the agile Scrum methodology, which allows iterative and incremental development, facilitating continuous and flexible adaptation. Scrum is widely recommended in educational software projects due to its ability to integrate user feedback in each cycle, allowing adjustments that respond to specific needs (Azanha et al., 2017). In the case of UNAC, this methodology allows for an adaptable and scalable design that

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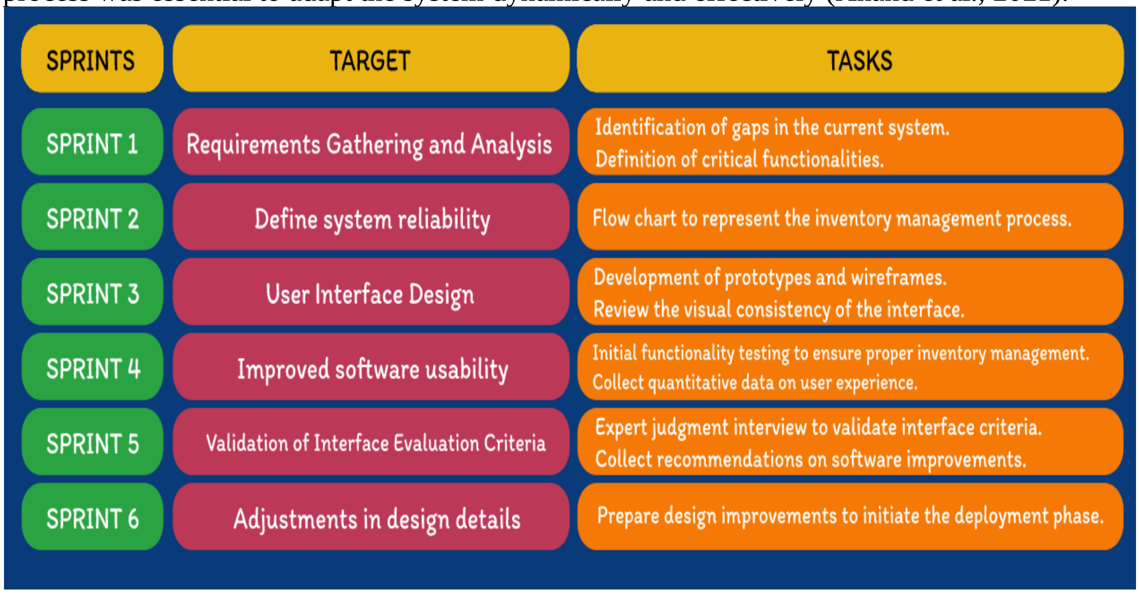
responds to the changing needs of university staff and processes, ensuring that the system remains aligned with the institution's objectives over time (Pasuksmit et al., 2023).

Finally, the use of relational databases is considered as an essential strategy for managing and organizing inventory data in real time. MySQL has been selected for its ability to handle high volumes of data and provide an organized structure, which ensures both asset traceability and data integrity at each stage of its lifetime (Dhondge et al., 2023). Relational databases have proven to be particularly effective in educational environments by providing rapid updating and reliable access to information; which is crucial for UNAC in its effort to improve inventory control and tracking across the university (Daracan et al., 2020).

Together, these theoretical frameworks provide a solid foundation tailored to the specific requirements of UNAC, guiding the design and development of the inventory management system towards a scalable, sustainable and user-centered solution. These foundations allow addressing the operational and administrative challenges of the university context, ensuring an efficient implementation and offering a management model that can be replicated in other educational institutions with similar characteristics and constraints.

3. Research Methods

The present study adopted a mixed approach, combining qualitative and quantitative methods to develop an effective solution by designing a customized inventory management software for the Office of Information Technology and Communications (OTIC) of the Faculty of Industrial Engineering and Systems of the Universidad Nacional del Callao. This approach allowed for a comprehensive understanding of the specific needs and challenges of the university context, ensuring that the resulting software would accurately and effectively match the user's requirements (Bontchev & Milanova, 2020). The development of the system was carried out following the agile Scrum methodology, structured in sprints that facilitated continuous adjustments based on feedback from users and experts (Zayat & Senvar, 2020). Figure 1 illustrates the cycle of sprints used, allowing iterative modifications and improvements to be made based on the specific needs of the inventory workers at UNAC. This iterative process was essential to adapt the system dynamically and effectively (Anand et al., 2021).



SPRINTS	TARGET	TASKS
SPRINT 1	Requirements Gathering and Analysis	Identification of gaps in the current system. Definition of critical functionalities.
SPRINT 2	Define system reliability	Flow chart to represent the inventory management process.
SPRINT 3	User Interface Design	Development of prototypes and wireframes. Review the visual consistency of the interface.
SPRINT 4	Improved software usability	Initial functionality testing to ensure proper inventory management. Collect quantitative data on user experience.
SPRINT 5	Validation of Interface Evaluation Criteria	Expert judgment interview to validate interface criteria. Collect recommendations on software improvements.
SPRINT 6	Adjustments in design details	Prepare design improvements to initiate the deployment phase.

Fig. 1. Sprints used in the Scrum Methodology

The software was designed under an MVC (Model-View-Controller) architecture, an approach that facilitates the separation of user interface, business logic and data management. Figure 2 illustrates this workflow, showing how each module operates independently, which optimizes the organization of the system and allows for future extensions without compromising the stability and performance of the software.

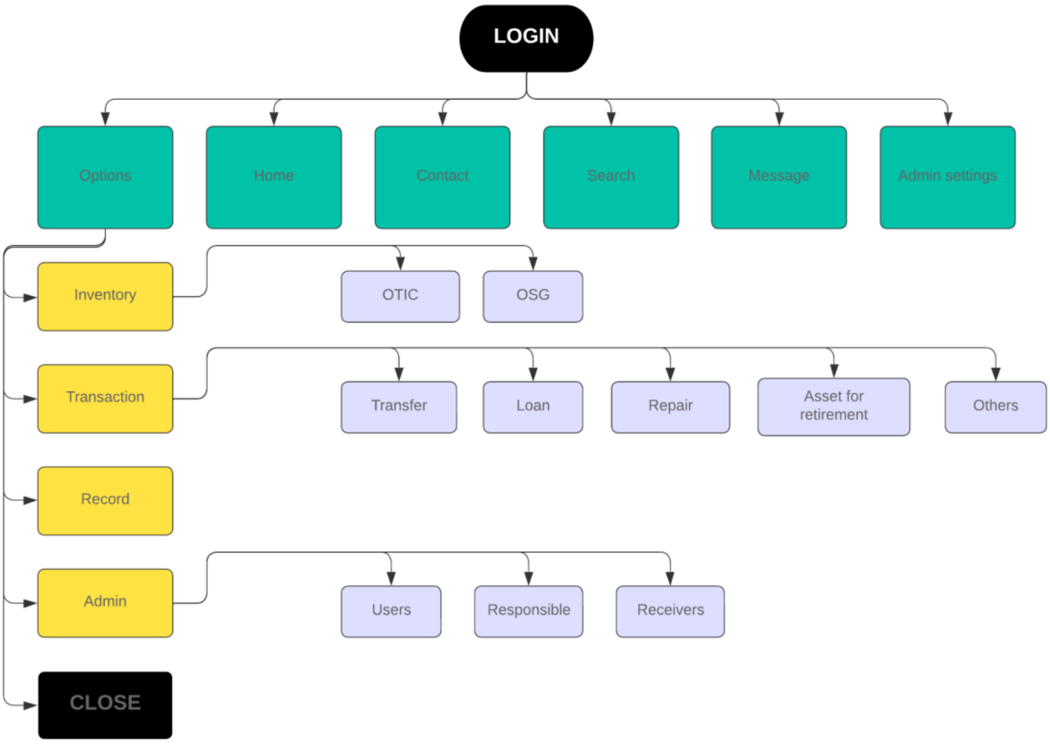


Fig. 2. MVC Architecture Flow Diagram

The interface design was prototyped using the Figma dynamic prototyping and design tool, which allowed users to visualize and evaluate the system at an early stage of its development. Interactive versions of the screens were generated using this tool, which ensured that the navigation and layout of information was intuitive and met user expectations.

In addition, to achieve a responsive interface, the jQuery and Bootstrap libraries were integrated, ensuring that the system adapts efficiently to different devices, providing a dynamic user experience. In addition, the CodeIgniter framework was used to strengthen the organization of the code and optimize both the performance and security of the system.

The main functionalities of the system, designed to facilitate the inventory management process, are shown in the following figures:

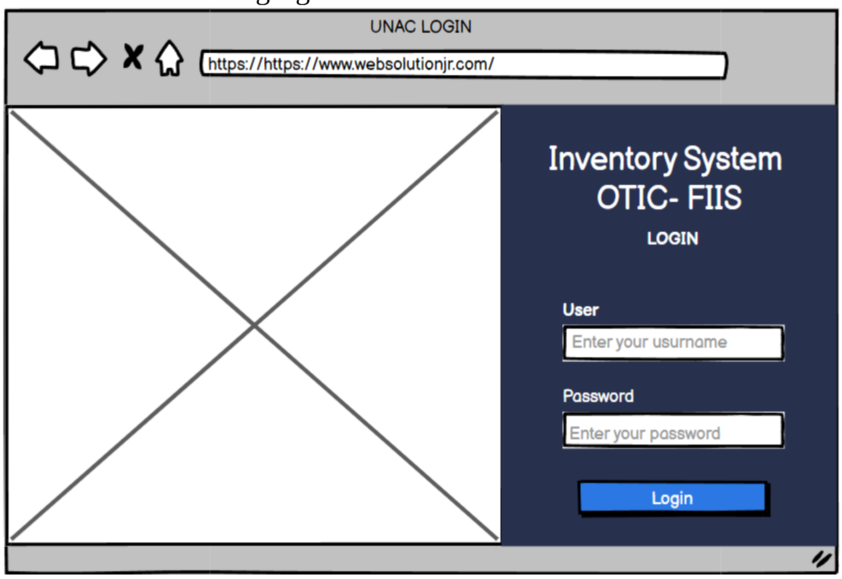


Fig. 3. User login

Figure 3 shows the “Login” interface, where users can access their account using their credentials. By pressing the Login button, the functionality of the inventory management software will be enabled.

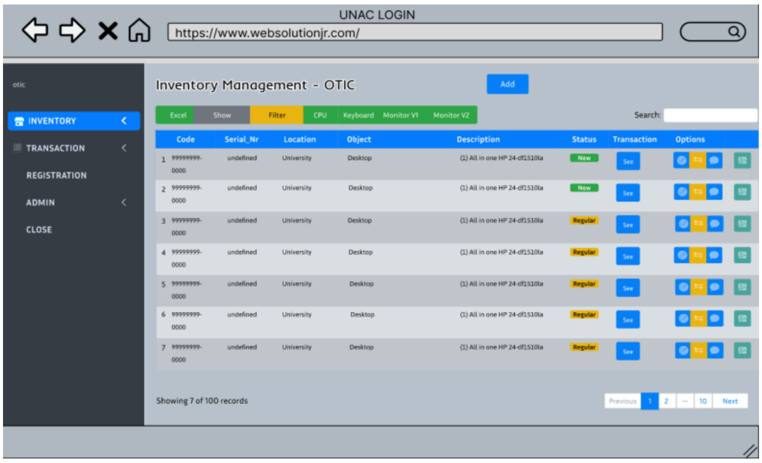


Fig. 4. Menu Interface (Inventory)

Also, Figure 4 shows the various options derived from the "Main Menu Interface (Inventory)". This interface presents the main characteristics of the product, such as Code, Serial No., Location, Object, Description, Status, Transaction and Options. This option promotes the order and simplicity of the design, showing the information in an organized and clear way.

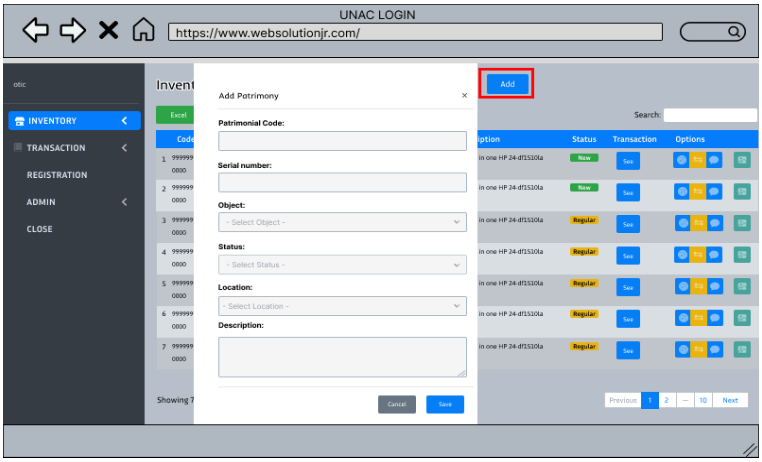


Fig. 5. Add Object

Figure 5 shows the "Add Object" option, which presents a pop-up message that allows you to enter the details of the new item. In this section, new items can be added to the inventory by specifying details such as Name, Quantity, Description, among others.

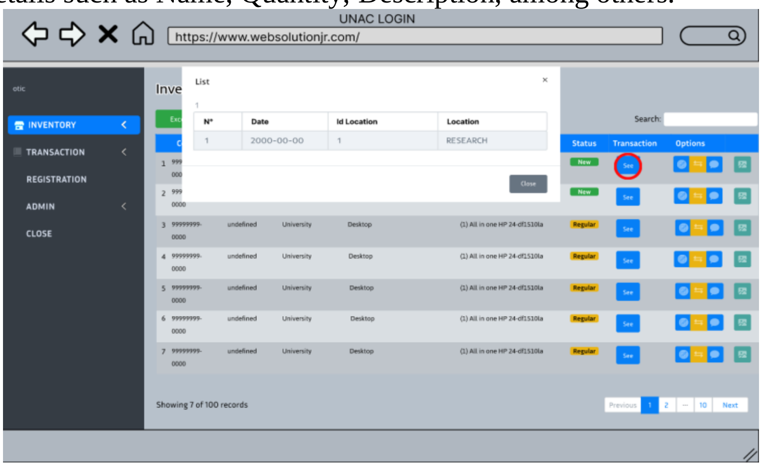


Fig. 6. Inventory Location

Figure 6 shows the "Transaction" option, which presents a pop-up message with the Inventory Location. This section shows a list of characteristics, such as Date, Location ID and Location, which promotes easy access to the physical location of the inventory items.

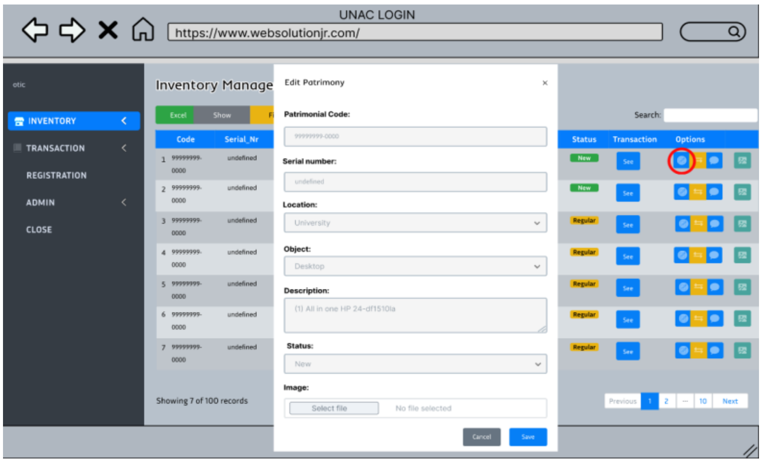


Fig. 7. Edit Inventory

Figure 7 shows the first response of the "Options" button, which presents a pop-up message with the "Edit Heritage" section. This section allows changes to be made to the details of any item such as Heritage Code, Serial Number, Location, Object, Description, Condition and Image. This offers the possibility to correct errors in the information initially provided.

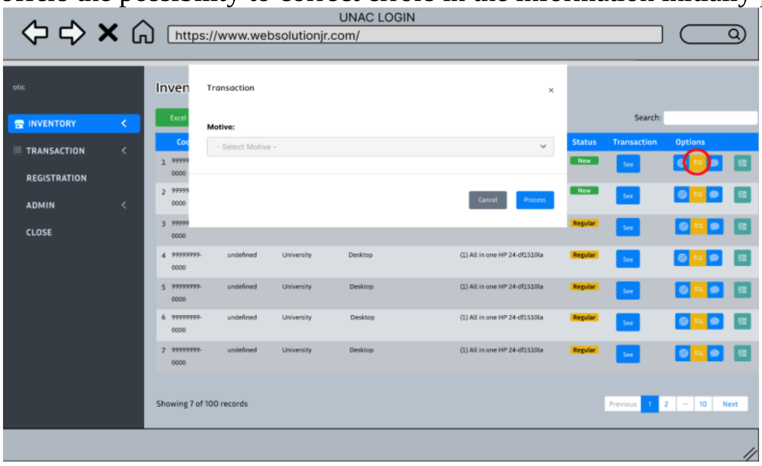


Fig. 8. Inventory Shifting

Figure 8 shows the second response of the "Options" button, which presents a pop-up message with the "Movement" section. This section allows you to manage the physical movements of inventory between locations within the same organization, facilitating the transfer and recording of movements, with specifications of location, origin and destination, to ensure proper order.

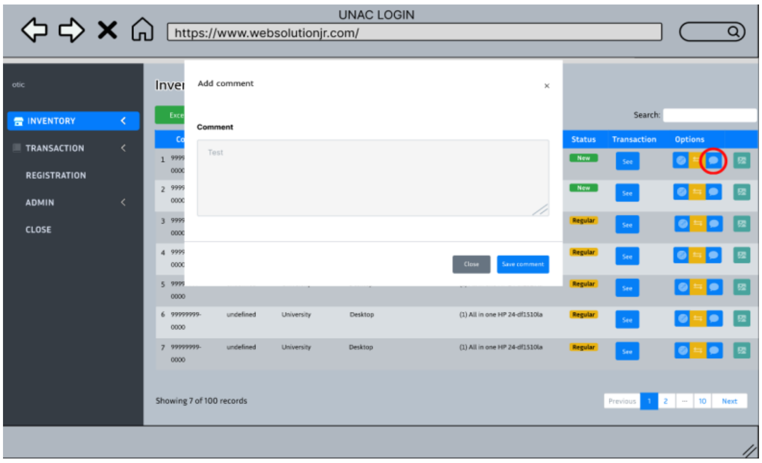


Fig. 9. Add comment

Figure 9 shows the third response of the "Options" button, which presents a pop-up message with the "Add Comment" section. This section allows notes or comments to be added to each inventory entry to facilitate tracking and further documentation of each object.

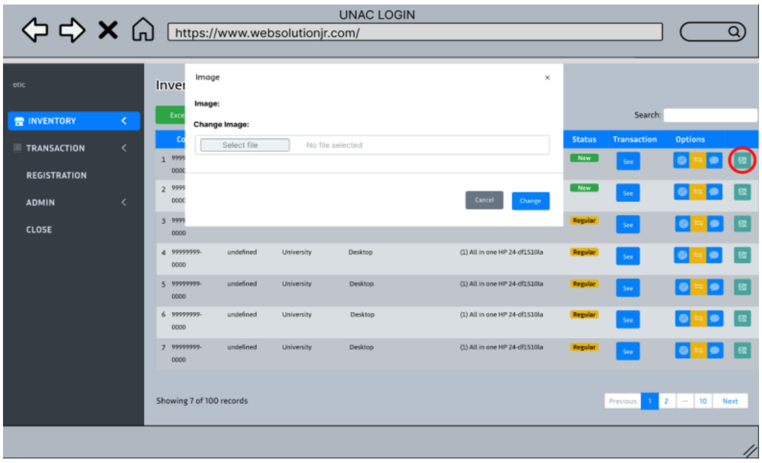


Fig. 10. Upload Inventory Image

Figure 10 shows the fourth response of the “Options” button, which presents a pop-up message with the “Image” section. This section allows attaching representative images of the inventory items, facilitating quick visual identification of each item and, therefore, ease of identification.

The usability evaluation was carried out by means of surveys distributed through Google Forms, designed on a Likert scale and organized in three dimensions: general satisfaction, ease of use and interface accessibility. The sample consisted of the 10 workers responsible for inventory at UNAC, who are the only ones with authorized access to register, modify and monitor inventory data in the system. It is important to note that this approach introduces a sampling bias by focusing exclusively on this group of users, which limits the representativeness of the results (Lumba & Waworuntu, 2021). This bias arises because only workers assigned to the inventory have permissions to modify and update assets, while other groups, such as students and employees, only have viewing access. Therefore, the findings obtained are representative and reliable within the context of these users, but not necessarily generalizable to other groups or environments (Shinde et al., 2023).

On the other hand, to ensure the reliability of the system, a thorough review of each function was carried out through worker testing. This ensures that, under similar conditions, the system will operate consistently and without errors (Kedarisetty & Kantheti, 2022). The MVC architecture and the use of CodeIgniter contributed to the reliability of the system by structuring data access in a modular and controlled manner. In addition, reliability is addressed in terms of accuracy and veracity of the data that the system records and displays, ensuring that it accurately reflects the operations performed in the inventory (Larutama et al., 2023).

As for the qualitative data analysis, expert interviews were conducted, the results of which were organized and coded using ATLAS.ti. The analysis focused on key aspects such as system reliability, security and adaptability, providing detailed insight into areas for improvement, especially in terms of visual design and process optimization (Azanha et al., 2017).

Regarding ethical considerations, the required standards were met in each phase of data collection and analysis. All participants were informed about the purpose of the research and the voluntary nature of their participation. The confidentiality of their responses was guaranteed, and the data collected were managed anonymously and securely. UNAC employees were assured that their responses would be used exclusively for the development and improvement of the inventory system, encouraging their willingness to provide honest feedback. In addition, participating experts were informed about the purpose of their input and all necessary consents were obtained, complying with established research ethics protocols (Daracan et al., 2020).

4. Results and Discussions

4.1. Results

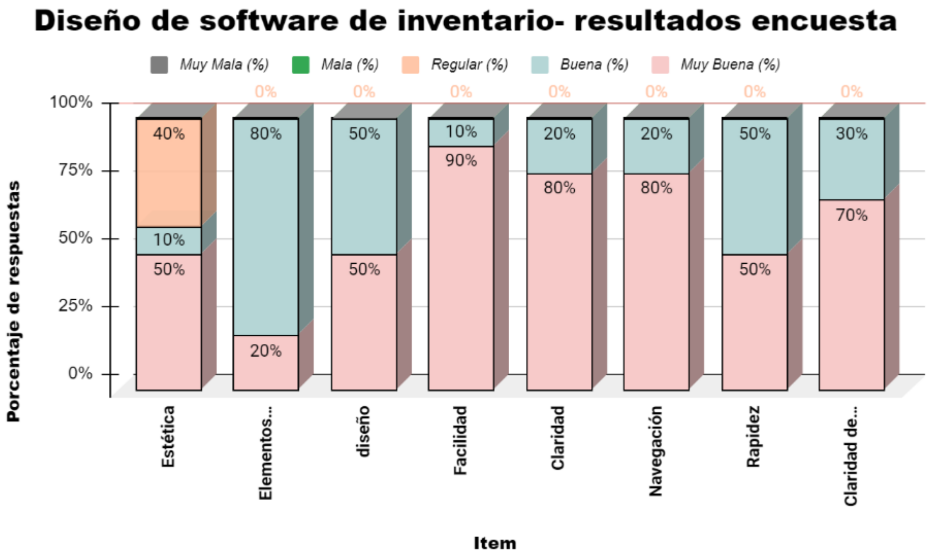
The data obtained through the surveys and expert judgment provide essential information on the usability, design and satisfaction of the software. The results are presented below, divided into three categories: Design, Usability and Satisfaction of the proposed prototype. In the first instance, an instrument was developed consisting of surveys applied to employees of the Universidad Nacional del Callao, the questions are shown in Table 1 below.

Table 1 – Instrument.

Design
How would you rate the overall aesthetics of the software?
How would you rate the organization of the interface elements according to the current design?
How would you evaluate consistency in the use of colors, typography and style of the design?
Usability
How would you rate the ease of performing tasks on the prototype?
How would you rate the clarity of the steps required to complete the tasks?
How would you rate the ease of navigating between the prototype's screens and menus?
Satisfaction
How would you rate the speed with which you were able to complete the tasks on the prototype?
How satisfied are you with the clarity of the instructions provided for using the software?

Table 1 shows the items of the instrument of a survey conducted with 10 employees of the Universidad Nacional del Callao. This survey is composed of 8 questions, organized in three dimensions: Design, Usability and Satisfaction. Each of these dimensions evaluates different key aspects of the clarity and effectiveness of the software prototype interface.

The results will serve to determine the validity and reliability of the Interface Criteria selected in this research, which are related measurable aspects as shown in Graphic 1.



Graphic 1: Quantitative Analysis of Inventory Software
Source: Own elaboration

Graphic 1, presents the results of a survey of 10 employees of the Universidad Nacional del Callao on the design of the inventory management software. The survey evaluated categories such as aesthetics, organization of elements, ease of use, clarity of navigation, speed and clarity of instructions. These dimensions allow us to identify both the strengths and areas for improvement of the software.

In terms of Aesthetics, 40% of the participants rated this aspect as “Fair”, while 10% rated it as “Good” and 50% rated it as “Very Good”. These results suggest that, although the visual design is acceptable, there is a perception of room for improvement in terms of attractiveness and functionality. The organization of the elements was well rated, with 80% rating it as “Good” and 20% as “Very Good”, indicating an arrangement of components that facilitates interaction with the system.

The overall design of the software was rated uniformly, with 50% of responses as “Very Good” and the other 50% as “Good”, underlining its relevance to the user experience. As for the ease of performing tasks, 90% of the participants rated it as “Very Good” and 10% as “Good”, indicating that users find the system efficient and easy to operate.

Clarity in the steps required to complete tasks was also positive, with 80% rating it as “Very Good” and 20% as “Good”, suggesting that the system structure and instructions are clear and well understood. Navigation between screens received 80% “Very Good” and 20% “Good” responses, reflecting a smooth user experience and seamless interaction. Regarding System Speed, 50% rated this aspect as “Very Good” and 50% as “Good”. While the system is fast, this result suggests that performance improvements could be implemented. Finally, the clarity of the instructions was well received, with 70% responding “Very Good” and 30% “Good”, indicating that most users easily understand the system guides.

The overall mean of the survey scores was 67.5, reflecting a positive assessment of the software overall, although with opportunities for improvement, particularly in aesthetics. The standard deviation of 6.61 suggests moderate variability in responses, especially in aesthetics and clarity of steps, while an autocorrelation of 1.0 indicates consistency among the items evaluated, all related to Design, Usability and Satisfaction of the software. In summary, the software was well received in terms of design and functionality, with ease of use and navigation standing out as particularly valued aspects. These observations strengthen the basis for future improvements, especially in visual design and system performance, to further optimize the user experience.

Secondly, interviews and Expert Judgment were conducted with eight specialists in the field of inventory software. The analysis was elaborated using the ATLAS.ti tool, and focused on three key dimensions: **Design**, **Reliability** and **Usability**.

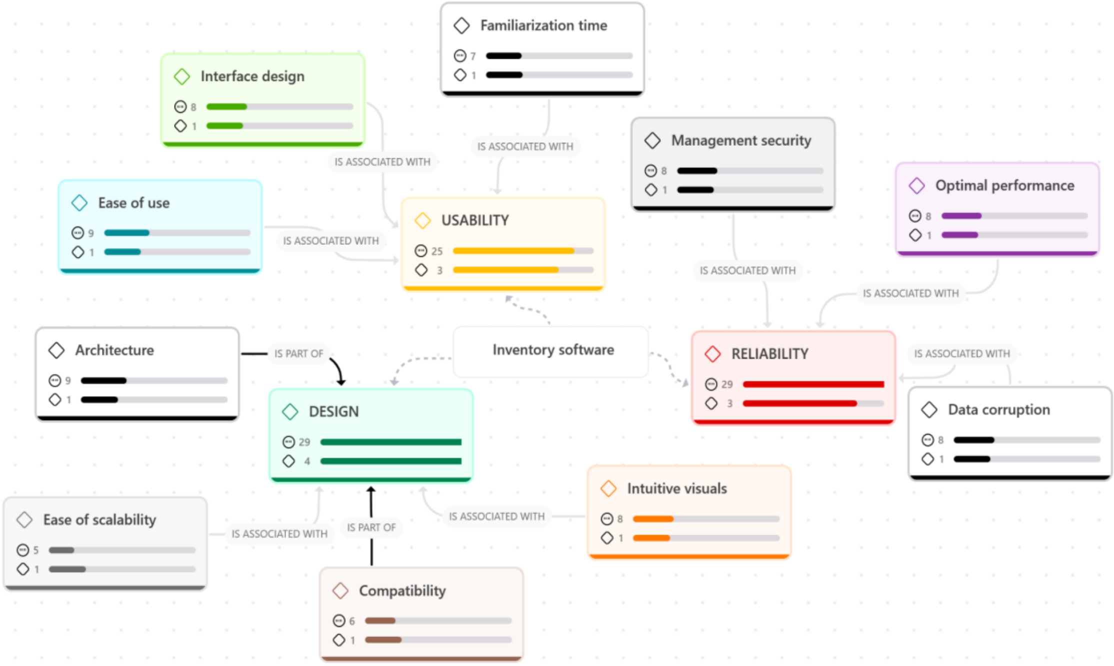


Fig. 11. Dimensional Analysis

Figure 11 shows a qualitative analysis performed with the ATLAS.ti tool, where three central aspects were addressed: Design, Reliability and Usability, all fundamental to evaluate the inventory management system. The first code, Design, highlights the importance of implementing an architecture that efficiently connects the data and the system interface, facilitating both scalability and multiplatform compatibility. This design structure has been documented as an effective approach in academic systems, where flexibility and interoperability are essential for technological adaptation (Budgen, 2020; Benson-Emenike et al., 2023; Faludi et al., 2023). The inclusion of microservices also allows new functionality to be added in a modular fashion without compromising system stability, a practice that has proven effective in educational environments by facilitating progressive upgrades (Anand et al., 2021).

The second code, Reliability, highlights the need for robust security measures, such as automatic logout in case of inactivity, which reinforces access control and data integrity protection. Also, implementing a caching system to optimize performance and creating automatic backups are essential strategies to prevent data corruption, according to recent studies in academic environments that prioritize efficient and secure information management (Martishin et al., 2023; Hassan et al., 2022). In addition, cross-platform compatibility, mentioned as an integral part of the design, ensures that the system works optimally on different devices and browsers, aligning with modern practices in educational inventory management (Vinokur et al., 2023).

The last code, Usability, emphasizes the importance of an intuitive and accessible interface, a crucial aspect to facilitate the use of the system, especially for users with limited technical experience. The clear and minimalist organization of information contributes to a quick familiarization process, which is critical in educational systems where user variability is high. This design strategy is recommended in educational management studies to improve user interaction and satisfaction (Al-Bashayreh et al., 2022; Damayanti et al., 2022; Shah et al., 2021).

Taken together, this qualitative analysis, backed by expert feedback, establishes a solid foundation for refining the key elements of Design, Reliability and Usability in the inventory management system, ensuring that the system not only meets current operational requirements, but is also scalable, secure and easy for users to adopt.

Table 2 - Expert Judgment Results.

	E1	E2	E3	E4	E5	E6	E7	E8	AVERAGE
USABILITY	85	85	90	90	95	80	85	80	86
DESIGN	90	85	70	90	65	85	70	90	81
SATISFACTION	90	90	95	90	95	90	95	95	92

Table 2 shows the scores given by systems engineers and design technicians, using a Likert scale ranging from “Poor” (0-20) to “Excellent” (85-100). In the Usability factor, the average was 86, placing it in the “Excellent” category. This result reflects that the software was perceived as highly functional and easy to use. However, certain evaluators, such as E6 and E8 (with scores of 80), suggest that, despite the high usability, there are still areas that could benefit from additional adjustments to optimize user interaction.

Regarding Design, ratings ranged from 65 to 90, with an average of 81, which places this aspect in the “Very Good” category. While the design meets the experts' expectations to a large extent, there are still areas for improvement that could enhance the user experience and facilitate more intuitive navigation.

In terms of Satisfaction, ratings were consistently high, ranging from 90 to 95, with an average of 92, placing it at “Excellent”. These results indicate strong compliance with the software by the testers, highlighting its ability to meet operational needs and provide a positive and rewarding user experience. The consistency in the high ratings reinforces that the software is not only functional and efficient, but also intuitive and satisfying.

In conclusion, both Usability and Satisfaction were evaluated as “Excellent”, highlighting the ease of use and acceptance of the system among experts. On the other hand, the Design was rated as “Very Good”, reflecting a solid and effective structure, with room for improvement to optimize visual consistency and functionality. Finally, the following table presents the processing times of key tasks in the software, evaluated to measure the operational efficiency of the system.

Finally, it was considered to represent in the following table, the most representative tasks of the key software functions to evaluate the processing time per task.

Table 3 - Average times in seconds - Tasks performed.

Person	Add Object to Inventory	Search Object in Inventory	Export Inventory to PDF/Excel	Edit Inventory Information	Inventory Shifting	Inventory Location	Inventory Count
P1	2	3	4	3	4	3	4
P2	4	2	3	3	3	2	4
P3	2	2	4	2	4	3	4
P4	3	3	4	3	4	3	4
P5	2	3	4	3	4	3	4
P6	2	2	4	3	3	2	5
P7	3	2	4	3	3	3	4
P8	2	3	3	2	4	3	5

P9	3	3	4	3	5	3	5
P10	2	2	4	2	4	3	4

Table 3 presents a detailed analysis of the time required to perform key tasks within the prototype inventory management software, as evaluated by 10 participants. Representative tasks, such as “Add Object to Inventory”, “Edit Inventory Information” and “Inventory Location” were selected because of their importance in the daily workflow.

For the “Add Object to Inventory” task, times ranged from 2 to 4 seconds, with an average of 2.5 seconds, indicating reasonable efficiency considering the amount of data to be entered. In the case of “Edit Inventory Information”, the times ranged from 2 to 3 seconds, with an average of 2.7 seconds. This time reflects adequate performance, as it allows real-time updates without significant delays. As for “Inventory Location”, response times remained between 2 and 3 seconds, with an average of 2.8 seconds, demonstrating that users can quickly visualize the location of objects, suggesting an optimal loading time for this type of queries. These results show that the prototype facilitates users' interaction with the system by allowing them to complete fundamental tasks quickly and efficiently. However, opportunities for improvement remain in processes such as information editing, which could further optimize the user experience and operational efficiency of the system.

4.2. Discussion

Inventory management in educational environments has been a topic of growing interest in the last decade, with multiple studies highlighting the importance of implementing automation and traceability systems that optimize the use of resources and reduce operating costs.

In public universities such as the Universidad Nacional del Callao (UNAC), budget and technical resource constraints require technological solutions that are both adaptable and sustainable (Fortuna and Gaspar, 2022; Alkelany, 2023). According to Dasaklis et al. (2022) and Matuska et al. (2023), traceability systems have proven effective in improving operational efficiency and reducing costs at universities. These studies point out that the implementation of advanced technologies for real-time asset control has resulted in significant improvements in internal efficiency (Ghashim and Arshad, 2023). While Dasaklis et al. (2022) describes a traditional traceability system, Matuska et al. (2023) used Internet of Things (IoT) technologies, which enabled greater visibility and accuracy in inventory control. However, the infrastructure and high costs associated with IoT represent a challenge for institutions such as UNAC, which must operate with limited funding and infrastructure. To overcome these barriers, a relational database-based system will be implemented, which offers efficient traceability tailored to the institution's capabilities (Anand et al., 2021; Ozkaya & Fidandan, 2020; Singh et al., 2022).

System design and accessibility are key factors for the efficiency of inventory systems in the university environment. Dhondge et al. (2023) developed a mobile system that allows inventory consultation and management from handheld devices, promoting accessibility and usability for administrative staff. This approach is particularly suitable for UNAC, as the ability to access the system from multiple devices will facilitate real-time control and consultation, without requiring additional investments in infrastructure. Multi-platform accessibility is essential in environments with decentralized locations, allowing to effectively respond to the need for consultation from various points of the institution (Herdiansah, 2021; Jayapal et al., 2023).

In terms of system architecture, Mesutoglu et al. (2022) and other studies highlight the relevance of a modular structure as a key to continuous growth in academic environments (Jayapal et al., 2023). Vinokur et al. (2023) discussed how management systems in these environments can be expanded by adding additional modules as needed, thus promoting long-term sustainability and adaptability. This modular structure allows the UNAC system to adapt to program expansion and increased number of assets, preparing it for future institutional growth. Abiodun and Ikuomola, (2022) also support this approach, suggesting that system adaptability is essential for efficient implementation and to maximize cost-effectiveness in terms of operability.

The implementation of agile methodologies, especially Scrum, has been widely recommended in the development of educational systems due to its ability to manage rapid iterations and constant adjustments. Also, the application of Scrum in educational software projects allows for continuous precision and efficiency, facilitating the integration of feedback and promoting incremental and adaptive development. In the case of UNAC, the Scrum methodology is well suited to the needs of the inventory management system, as it allows the system to evolve based on the changes and demands of the academic and administrative community (Zayat & Senvar, 2020; Anand et al., 2021). This ensures that the system remains up to date and is able to respond effectively to the changing requirements of the institution.

The Technology Acceptance Model (TAM) developed by Abusanna (2023) is an important basis in the design of accessible and easy-to-adopt inventory systems. Al-Mamary and Al-Shammari (2023) demonstrated that ease of use and accessibility are determining factors in the acceptance of new technologies among university users, a crucial aspect in institutions such as UNAC. Prioritizing these elements in system design ensures rapid adoption and reduces the need for advanced technical training. Furthermore, the focus on an intuitive and accessible interface has been supported by Herdiansah, (2021), who highlight that an optimized user experience improves adoption efficiency and daily use of the system. According to Damayanti et al., (2022), these aspects are key in contexts of high user turnover, such as academia, where variability in the level of technical competence can affect the effectiveness of the system (Dzaky and Kurniawan, 2023).

The use of relational databases, such as MySQL, has been identified as an efficient solution for handling large volumes of data in inventory systems. Benson-Emenike et al. (2023) emphasize the importance of using well-structured databases that allow traceability and constant updating of data in real time. At UNAC, the use of MySQL as the basis of the inventory management system enables efficient asset management and provides a reliable platform for resource control. This is complemented by studies suggesting that data accuracy and security are essential in inventory systems where constant updating of information is required (Devi et al., 2023; Larutama et al., 2023; Kisno et al., 2022).

In conclusion, the literature review reflects a clear trend towards digitization, multiplatform accessibility, the use of agile methodologies and the application of the Technology Acceptance Model in inventory management within educational environments. Unlike previous studies, the proposal of this study seeks to balance operational efficiency with budgetary viability, ensuring that the system is sustainable and adaptable in the long term in a context of limited resources. This strategy establishes an effective and replicable basis for inventory management in universities facing similar operational and budgetary challenges, and aligns with recommended best practices and design principles for the education sector (Lievchalermwong and Aunyawong, 2022).

5. Conclusion

The development of inventory management software for the Universidad Nacional del Callao has comprehensively addressed the challenges related to asset management in educational environments. This research has focused on conceptualizing and designing a robust, flexible and scalable tool that optimizes inventory tracking and control processes, ensuring its accessibility and real-time functionality. Although the software remains in the development phase, the methodological and technical decisions implemented in its design have been decisive in guaranteeing its viability and adaptability in the future.

One of the main contributions of this project has been the incorporation of modern technologies such as MySQL, PHP and JavaScript, which ensure a multiplatform and centralized design. These technologies enable the future implementation of a system where administrative staff and system users can access remotely and simultaneously from different devices. This flexibility is critical in the university context, where access from multiple locations is essential for efficient asset management. In addition, the system's ability to manage large volumes of data in real time ensures informed and accurate decision making, reducing the inherent error margins of manual inventory systems.

Another key aspect has been the use of the agile Scrum methodology during the development phase, a choice supported by studies that recommend its application in educational systems due to its ability to adapt to continuous changes (Kisno et al., 2022). The iterative nature of this methodology has allowed constant adjustments to the system design based on feedback from the experts and users involved. Although the software has not yet been implemented, this iterative process has ensured that the final design is adaptable, functional and aligned with the needs of the university environment. This flexibility has not only allowed optimizing the interface and logic of the system, but also ensures that, in future implementation phases, the tool will be efficiently integrated into the university's technological ecosystem.

In addition, the scalable design of the software ensures that it is not only limited to inventory management. The proposed architecture, based on the MVC (Model-View-Controller) model, allows the system to be integrated with other administrative areas of the university in the future, such as physical asset control or academic registration systems. This expansion will improve operational efficiency and coordination between departments. The use of prototypes on platforms such as Figma has facilitated the visualization of the flow to experts and users prior to system implementation. Expert judgments in usability, satisfaction and design have been key to aligning the software functionalities with end-user expectations, ensuring both technical and user experience efficiency.

The decisions made regarding the security and reliability of the system also deserve to be highlighted. The design has considered the implementation of protocols to protect sensitive data and prevent unauthorized access. Although not yet implemented, its modular architecture allows future security functionalities to be added, such as data encryption, automatic backups and activity audits. In terms of performance, techniques such as data caching and optimized queries are planned, which will allow the system to operate in an agile and efficient manner, even with a high volume of data and simultaneous users in a university environment.

This study has some limitations, such as the difficulty in finding specific studies on inventory management in universities, which limits the comparative scope of the research. In addition, the sample of users and experts was limiting in terms of the generalizability of the results. For future work, it is recommended to apply mixed methods that combine more robust qualitative and quantitative analyses, in order to obtain a more complete view of the impact of the system and facilitate comparison with other institutional contexts.

In summary, this inventory management software has the potential to improve inventory management not only in educational institutions, but in any organization with similar needs. As development and future implementation progresses, feedback will continue to improve the system, solidifying its position as a key tool in the optimization of university management.

Finally, the design of this software represents a solid and robust solution for inventory management at the Universidad Nacional del Callao. Its flexibility, scalability, accessibility and robustness make it a key piece for the future optimization of asset management, ensuring that the university is better equipped to manage its resources efficiently, securely and adapted to its growing needs.

Acknowledgement

The authors thank the Universidad Nacional del Callao for its support and availability to collect data for this research.

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