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A Mobile System with Usage Pattern Analysis to Optimize Storage Management

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***Abstract*— Limited storage on mobile devices and the lack of adequate technological systems for inventory management make it difficult for micro, small, and medium-sized enterprises (MSMEs). Approximately 30% of these companies do not use technology systems for inventory management, while only 20% have incorporated digital technologies into their operations. This research aims to develop a mobile system with usage pattern analysis to optimize storage management. The Scrum methodology was used, as it allows agile and flexible project management, facilitating the adaptation to changes and the continuous delivery of functionalities. The study was based on evaluations of criteria such as usability, design, functionality, and efficiency by 10 experts using the Likert scale. It showed that the implementation of this mobile application had a highly significant influence of 9.85% on efficiency improvement and a substantial influence of 10.18% on cost reduction. In addition, the mobile system was found to positively and significantly impact product distribution. These results support adopting this tool as an effective strategy to improve efficiency and customer satisfaction and increase the company's profitability and competitiveness. In conclusion, the development of this mobile system is presented as an innovative solution to face the challenges of mobile storage in MSMEs, contributing to optimizing their inventory management and improving their competitiveness in the market.**

***Keywords*—Cost reduction; warehousing management; efficiency improvement; product distribution.**

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I. INTRODUCTION

Presently, storage for companies is a serious management problem that has affected companies. According to the United Nations (UN) [1]. Micro, small, and medium-sized enterprises (MSMEs) represent a large part of the business fabric in Latin America; they account for approximately 99% of companies, underscoring their importance for local economies. In addition, these companies generate between 60% and 70% of formal employment, which is key in creating job opportunities and boosting national economies. From this perspective, micro-enterprises play a fundamental role in sustainable development and economic growth, being a key player in poverty reduction. Despite their importance, the UN has also pointed out that MSMEs in Latin America face significant challenges, such as limited access to financing and the need to adapt to digital transformation, factors that are key to their long-term growth and sustainability. These companies represent around 90% of all businesses worldwide and generate more than 50% of global employment, according to the World Bank [2], and in some countries, such as Mexico, this figure rises to 52%. However, the International Finance Corporation (IFC) [3] has pointed out that a global financing gap of approximately US$5.7 trillion prevents many of these companies from accessing the credit necessary for growth and expansion.

A key area where MSMEs face challenges is digitalization. According to a study by the Inter-American Development Bank (IDB) [4], Only 20% of MSMEs in Latin America have incorporated digital technologies into their operations. The COVID-19 pandemic accelerated this digital transition, but infrastructure and access to modern technologies remain significant obstacles to their competitiveness in the global marketplace.

In Latin America, SMEs have not yet reached the level of development and innovation required to be competitive in the market because approximately 30% do not use technological systems to effectively manage information, such as inventory systems [5]. This lack of implementation of technological systems makes them vulnerable and slows their growth, which translates into limited economic development for the region. Thus, in the following study [6], inventory is a crucial asset for microenterprises since it represents approximately

64.75% of their total assets. These companies allocate more than half of their financial resources to inventory investment. This underlines the importance of proper inventory turnover, consumption, and control management. Some developing countries are still implementing technologies in their management processes. A study by the "Instituto Nacional de Estadística e Informática" (INEI) [7], estimates that 42.0% of small and medium-sized enterprises (SMEs) in Peru do not use technological systems to manage their processes. In other words, around 82% of these companies only have systems covering the fiscal accounting area, while approximately 40% are limited to the sales area. In addition, about 19% of SMEs cover exclusively the logistics area, about 15% focus only on resource management, and about 10% deal only with information technology (IT) management. These percentages correspond to specific support areas. As for the financial sector, about 11% of SMEs only cover it, and only about 4% have integrated management systems in place.

This point highlights the relevance of computer systems in an organization for inventory control [8], which allows cost and time savings to be achieved. However, failing to update existing inventory control can result in incorrect product delivery to customers.

Using technology and mobile applications in business processes has transformed how organizations manage their operations, improving efficiency, communication, and decision-making. Mobile applications allow employees to access critical business systems from anywhere, facilitating remote task management, project monitoring, and real-time collaboration. According to recent studies, more than 75% of companies have implemented some form of mobile technology to optimize their processes, with a particular focus on areas such as inventory management, sales, customer service, and data analysis [9]. In addition, enterprise mobility allows for greater flexibility and customization, adapting services and technology solutions to the specific needs of each company, resulting in increased productivity and better experience for both employees and customers [10].

Mobile devices tend to fill up quickly due to the storage of data, applications, and multimedia files, which affects their performance and user experience. Given this situation, the development of mobile systems that use usage pattern analysis to manage storage and improve device performance efficiently has been proposed.

Previous research [11], [12] has shown that implementing machine learning and data mining algorithms in mobile systems can provide adaptive solutions for storage optimization. In addition, studies such as [13] and [14] highlight that analyzing usage patterns improves storage management and allows for more accurate customization of recommendations to the user, making the system more efficient and user-friendly. On the other hand, the study [15] proposes a mobile application for small businesses in India that optimizes inventory, sales, and salary management through voice commands; it also offers attendance control functions, stock alerts, and data analysis to obtain information on profits and trends, fulfilling the objective of improving efficiency and reducing errors in daily management. Also, in [16] developed a lightweight mobile application for micro and small business (MSE) retailers, allowing them to record sales, purchases, and inventory on the phone and use business intelligence through dashboards. After testing the application, a survey of 40 owners showed that they perceived it as valuable and relevant and would be willing to adopt it, with positive results in usability and functionality.

Finally, the development of this type of technology is essential in a world where storage on mobile devices is an increasingly limited resource and where the demand for efficiency and agility in using such devices continues to increase. Therefore, this research seeks to explore and propose a mobile system that optimizes storage management through intelligent analysis of usage patterns.

II. Materials and Method

In this research, as shown in Table 1, the Scrum method was adopted [17], because of its ability to manage projects efficiently through short sprint cycles, allowing for continuous product delivery. This agile, lightweight, and self-organizing framework fosters collaboration between cross-functional teams, accelerating the implementation of ideas, such as analyzing usage patterns to optimize storage management. In a study [18], indicates that implementing Scrum improved organization, adaptability, and the ability to identify key factors. It also facilitated effective collaboration in agile teams, which increased the likelihood of project success.

TABLE I
Choice of Methodologies

Methodologies	Information	Comprehension	Adaptation	Flexibility	Points
RUP	4	3	3	4	14
SCRUM	4	5	5	5	18
XP	3	2	3	2	10
Mobile D	4	3	3	2	12
KANBAN	2	3	3	2	10

A. General Description of Methodology

The Scrum methodology is vital to agile software development, as its success depends on the maturity of the team, the right composition of its members, and adherence to key values and roles [19]This approach is divided into five key stages: initiation, planning and estimation, implementation, review and retrospective, and finally, launch. We will focus on the following four essential processes for this project.

1) Sprint Planning: During this process, we organize meetings to outline user stories, evaluate tasks, and build the sprint backlog. In addition, we allocate a time of seven hours throughout a month-long sprint [20]. During this process, the Scrum team chooses the elements of the product backlog that must be completed to achieve the sprint goal.

2) Sprint Development Work: In this process, the Sprint Backlog is implemented without making modifications that may impact the sprint objective. It ensures that the quality objectives are met and renegotiates the scope with the product owner and the development team as development progresses [21]. During this process, it is possible to anticipate the review and adjustment of progress against the schedule of activities and the established objective.

3) Sprint Review: During the sprint review, the Scrum Team shows the Product Owner the results of the current sprint to verify and validate their work. The Product Owner reviews the progress of the product against the established acceptance criteria, deciding to accept or reject the user stories that have been completed [21].

4) Sprint Retrospective: During this process, a 4-hour meeting is held within a monthly sprint and is part of the sprint retrospective. In this meeting, the Scrum team gathers to analyze and evaluate the previous sprint, focusing on the procedures, tools, interaction, and communication used, as well as other elements relevant to the project [22].

Scrum is characterized by cross-functional, well-organized, and skilled teams that work in short, focused sprints to complete their tasks effectively. Mobile applications stand out for their impressive performance capacity and constant availability. For this reason, this model combines the real-time processing power of the mobile device with the massive storage and analytics power of the cloud backend, using predictive and machine learning models to analyze usage patterns. In this way, storage management is optimized in a personalized and proactive way, improving user experience and system efficiency, as illustrated by the architecture presented in Fig. 1

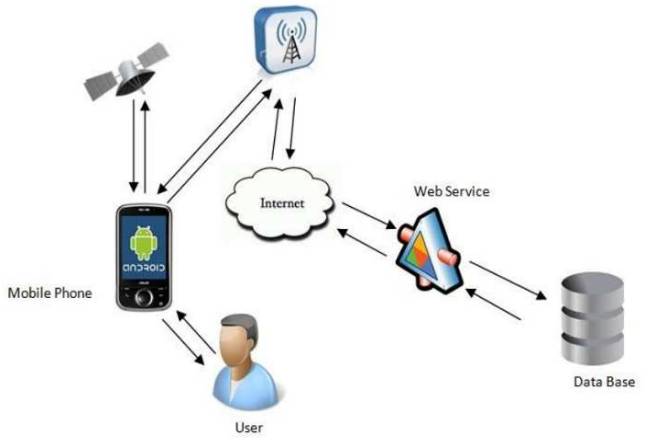


Fig. 1 Example of an image with acceptable resolution

B. Development Tools

1) Java: This programming language provides large-scale security and satisfaction to meet the hardware and software requirements of mobile devices [23], [24]. Using this language, hacker-proof applications are created. Java and Android Studio make it easy to develop object-oriented programs that are also reusable.

2) Android Studio: Android Studio's integrated development environment is based on IntelliJ IDEA. It also provides several tools that improve efficiency during the application development process. Android Studio has the advantage of enabling real-time execution of the application, as well as offering simple and fast compilation [25]. In addition, it helps to distribute, reuse, and structure the code efficiently.

3) SQLite: It is a lightweight, independent, and open-source database manager, specialized in simple and persistent data storage, which makes it a fundamental tool for the creation of mobile applications [26]. It also offers several advantages by being integrated with Android Studio, as Android has several packages that improve performance by leveraging resources through compatibility. This facilitates structured data entry and simplifies the development process. Its main advantage lies in its ease of learning, making it the perfect choice for those without experience in database management.

4) Mockit: The project management tool was created by Wondershare. Its asset-packed libraries and integrated user interface templates allow you to efficiently create the prototype that best reflects the user's ideas [27].

C. Case Study

1) Initial stage: A survey was conducted as part of the initial phase of this research study to gather the requirements for developing the mobile application. As a result, an analysis was carried out and transformed into user stories, also known as UH, followed by a specific number. Seven user stories were defined for the development of the mobile application, as detailed in Table 2.

TABLE II
USERS' HISTORY

User History (UH)	Description
User History 1	**UH1**: As a company user, I want to be able to log in so that the user can enter the main menu and interact with the application.
User History 2	**UH2:** As a company user, I want to register a user to manage information records better.
User History 3	**UH3:** As a company user, I want to be able to update my data to better manage my information records.
User History 4	**UH4:** As a company user, I want to be able to register a product and select the expiration date and type of product so that it can be entered.
User History 5	**UH5:** As a company user, I want to view the summary of my product registration and the date and time it was registered.
User History 6	**UH6:** As a company user, I want to view the summary of my user registration and the date and time I registered.
User History 7	**UH7:** As a company user, I want to visualize a summary of the usage patterns and the date on which they were performed.

2) Planning stage: In the second step of the mobile application development, a detailed analysis of each user story was performed, dividing the tasks into two key aspects: estimations and prioritization, as described in Table 3. The project is composed of seven stories organized in 3 working sprints. Within the agile Scrum methodology framework, the Sprint was carefully evaluated, considering the possibility that the execution speed may fluctuate.

TABLE III
PRODUCT BACKLOG

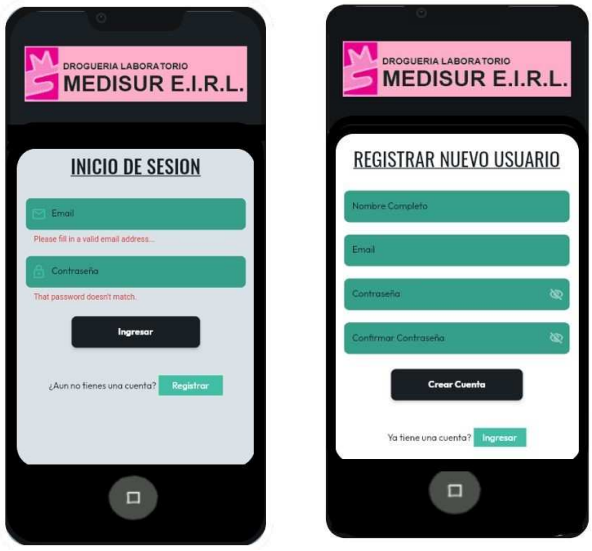
N° Sprint	Functional Requirements (FR)	History	Time Estimated	Estimated Points	Priority
Sprint 1	**FR01**: The application must have a log in so that the user can enter the main menu.	H1	2	20	1
	FR02: The application must be able to record the user's data.	H2	2	20	1
	FR03: The application must be able to update the user's data.	H3	3	30	1
Sprint 2	**FR04:** The application must be able to register a product and show the product data and the type of product the company has.	H4	3	40	2
Sprint 3	**FR05:** The application must be able to show a summary of the product registration, as well as the date and time of registration.	H5	4	50	3
	FR06: The application must be able to show a summary of the user's registration, as well as the date and time of registration.	H6	4	50	4
	FR07: The application must be able to show a summary of the usage patterns and the date on which they were performed.	H7	4	50	4

3) Implementation: The Scrum methodology, through sprints, improves agile project management by setting fixed deadlines and specific objectives for each phase; this encourages continuous learning and greater efficiency, avoiding time wasted in the early stages [28]In this phase of the scrum methodology, the sprint's planning and execution were carried out through the development and analysis of user stories, which yielded various results. During planning, stories were prioritized and estimated to execute tasks and develop prototypes of the application based on them.

In the first sprint, we addressed user stories 1, 2, and 3 of the Product Backlog. Table 4 details these stories, including their estimated duration and acceptance criteria. This sprint addresses the following options: login, new user registration, and update user data. Fig. 2 shows the prototypes of the application that allows login so that the user can enter the main menu (Fig. 2 (a)) and register user data, as shown in Fig. 2 (b).

TABLE IV
SPRINT BACKLOG - SPRINT 1

	Description
User History 1	As a company user, I want to be able to log in so that the user can enter the main menu and interact with the application.
Estimated time	2 days
Acceptance criteria	The user and password must be validated. Only registered users with their respective credentials can enter the system.
User History 2	As a user of the company, I want to be able to register a user to manage information records better.
Estimated time	2 days
Acceptance criteria	It must be validated that the username does not exist at the time of registration and that the fields are not empty.
User History 3	As a company user, I want to be able to update my data to better manage my information records.
Estimated time	3 days
Acceptance criteria	Validate that the username does not exist during registration. Then, select the respective buttons to perform their corresponding functions.



(a) (b)

Fig. 2 Sprint backlog 1: Access login and registration

In the second sprint, we addressed user story 4 of the Product Backlog. Table 5 details these stories, including their estimated duration and acceptance criteria. The application allows one to register a product to show the product data and the type of product the company has.

TABLE V
SPRINT BACKLOG - SPRINT 2

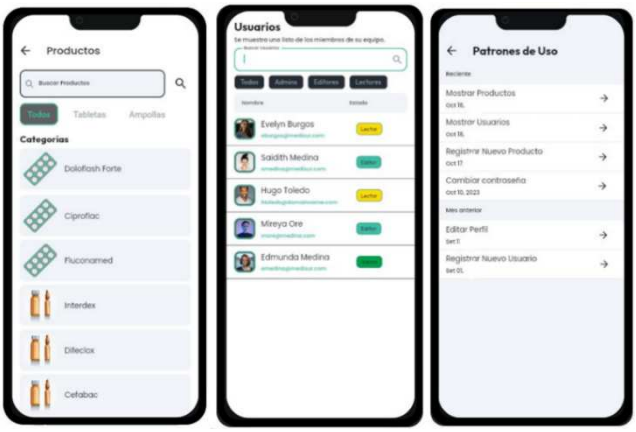
	Description
User History 4	As a company user, I want to be able to register a product and select the expiration date and type of product so that it can be entered.
Estimated time	3 days
Acceptance criteria	It must be validated that the product name does not exist when making a record. The expiration date of each product must be selected, and the type of product the user wants to enter must be selected.

In the third sprint, we addressed user stories 5, 6, and 7 of the Product Backlog. Table 6 details these stories, including their estimated duration and acceptance criteria. The application allows the display of a summary of the product backlog and filtering it by category; the design prototype is shown in Fig. 3 (a). The application can also display a

summary of the user record, as shown in Fig. 3 (b), and finally, the application can display a summary of the usage patterns, in addition to the date on which it was performed, as shown in Fig. 3 (c).

TABLE VI
SPRINT BACKLOG - SPRINT 3

	Description
User History 5	As a company user, I want to be able to view the summary of my product registration, as well as the date and time it was registered.
Estimated time	4 days
Acceptance criteria	It must be validated that the product name exists when viewing the record. A window with all the data of the registered product should be displayed.
User History 6	As a user of the company, I want to be able to view the summary of my user registration, as well as the date and time I registered.
Estimated time	4 days
Acceptance criteria	It must be validated that the user's name exists when viewing the record. A window with all the data of the registered user should be displayed.
User History 7	As a user of the company, I want to be able to visualize the summary of the usage patterns, as well as the date on which it was performed.
Estimated time	4 days



(a) (b) (c)

Fig. 3 Sprint backlog 3: Prototypes of (a) Product Listing, (b) User Listing, and (c) Usage Patterns

III. RESULTS AND DISCUSSION

This part presents the results obtained after 10 experts evaluated the design quality level. During the validation, different aspects, such as usability, design, functionality, and efficiency, were evaluated through a series of questions based on a Likert scale. Experts in the field validated the system. Table 7 shows the questions used according to the evaluation criteria and the result obtained by calculating the mean and standard deviation (T.D.). It also shows that the total mean is 4.61, close to 5 (maximum score), so the final quality level is "Very good."

TABLE VII
EXPERT VALIDATION

Criteria	Questions	Media	D.E	Quality
Usability	Is the application fast?	4.4	0.52	Good
	Is the application intuitive, designed for users without application knowledge?	5	0.00	Very Good
	Is the application divided into sections for better user understanding?	5	0.00	Very Good
	Does the application have a user-friendly interface?	4.6	0.52	Very Good
Design	Are the elements in the interface clearly laid out and do they provide a good user experience?	4.9	0.32	Very Good
	Are visual elements such as icons, buttons and graphics consistent and attractive?	4.9	0.32	Very Good
	Does the design of the application follow a visual identity consistent with the purpose of the application?	4.8	0.42	Very Good
Functionality	Would the application help you to improve the maintenance management process?	4.4	0.70	Good
	How satisfied are you with the variety of options available in this application?	4.8	0.42	Very Good
	Does the application allow the company's workers to register and assign work orders quickly and easily?	4.5	0.53	Very Good
Efficiency	Does the application allow the generation of automatic and accurate maintenance reports, optimizing the failure and cost analysis processes?	4.7	0.48	Very Good
	Is the feedback from the reports immediate?	4.2	0.63	Good
	Does it show accurate results?	3.9	0.32	Good
Total average and final quality level		**4.61 = 5**		**Very Good**

The quality of the prototype was evaluated considering the average of the criteria analyzed. Fig. 4 shows that each of the criteria: usability, design, functionality, and efficiency, has an average score of 4.75, 4.86, 4.56, and 4.26, respectively. According to the results obtained, it is confirmed that the quality of the mobile application is adequate. The average score is 4.61. In addition, the total average score must be higher than 4 for the mobile application to be functional.

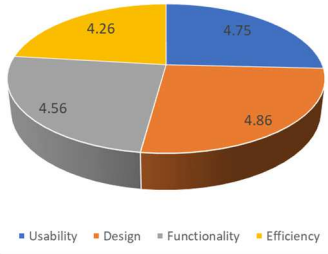


Fig. 4 Summary of criteria evaluation

Fig. 5 shows that 75% of the respondents considered the application's usability to be "Very Good," while 25% rated it as "Good." No expert rated it as "Very Bad," "Bad," or "Regular."

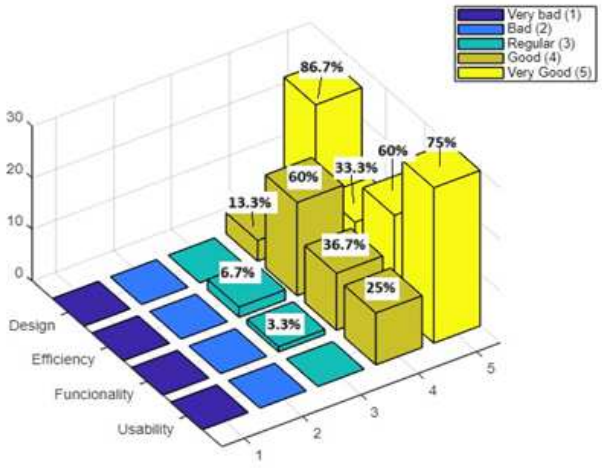


Fig. 5 Criteria evaluation analysis

The design of the present research was developed using the scrum methodology. The evaluation was carried out by considering the criteria of Functionality, Design, Usability, and Efficiency. An average score of 4.87 for design and 4.75 for usability was obtained out of 5. This represents 86.7% and 75%, respectively, and is considered by the experts to be "Very Good." It was concluded that the mobile application improved the storage management process. On the other hand, the validation of the application through expert evaluation, it was found that all the attributes were accepted in an average of 81% [29]. Functionality was the aspect with the lowest score, while coherence and integration obtained the highest score, reaching 83%. Regarding the use of mobile applications, experts rate their usability, presentation, functionality, and security as "Very high" according to 70%, 80%, 90%, and 80% of respondents, respectively [30]. Relevant conclusions include the fact that the probabilistic inventory model helped to save 2.4% on start-up management.

IV. Conclusion

The results show that the mobile application with usage pattern analysis has a highly significant influence of 10.18% in improving the company's cost reduction. The presence of the mobile application with usage pattern analysis has proven to significantly impact cost reduction since the differences observed between the results before and after its implementation are statistically significant. This contributed to an increase in the company's cost reduction. These findings support the importance and effectiveness of the mobile application with usage pattern analysis as a strategic tool to optimize operating costs and improve the organization's financial performance.

On the other hand, this study's findings conclusively demonstrate that mobile applications with usage pattern analysis significantly influence 9.85% of company efficiency improvements. These findings support the importance and effectiveness of mobile applications with usage pattern analysis as a strategic tool to optimize operational performance and promote efficiency in the organization.

Based on the results obtained, it has been determined that implementing the mobile application with usage pattern analysis significantly improves product distribution in the company. Implementing the mobile application with usage pattern analysis significantly and positively impacts the company's product distribution. This supports the adoption of this tool as an effective strategy to improve efficiency and customer satisfaction in the distribution process, which in turn can lead to increased profitability and competition.

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