

PAPER

Mobile Application with Artificial Intelligence Assistant to Improve the Logistical Process in Pharmaceutical Companies

Rosa Menéndez Mueras¹,
Esteban Julio Medina
Rafaile², José Luis Herrera
Salazar³(✉)

¹Facultad de Ingeniería,
Universidad Tecnológica del
Perú, Lima, Perú

²Facultad de ciencias,
Universidad Nacional
Santiago Antunez De
Mayolo, Huaraz, Perú

³Facultad de Ingeniería,
Ciencias y Administración,
Universidad Autónoma de
Ica, Ica, Perú

[luis.herrera@
autonomadeica.edu.pe](mailto:luis.herrera@autonomadeica.edu.pe)

ABSTRACT

According to the World Bank (WB), an estimated 60% of pharmaceutical companies in developing countries report significant problems in their supply chain, often resulting in delays and financial losses. The objective of this study is to develop a mobile application with an artificial intelligence assistant to improve the logistics process in a pharmaceutical company. In this sense, the Cascada methodology was used, together with various computer tools, to develop the prototype. Favorable results were obtained with respect to the criteria of functionality, usability, innovation and technology. Concluding that the application meets all the necessary conditions to mitigate the problem of the logistics process in pharmaceutical companies.

KEYWORDS

artificial intelligence, pharmaceuticals, logistics, inventory management

1 INTRODUCTION

Supply chain management in the pharmaceutical industry faces a number of challenges, especially in developing countries. According to the World Bank (WB), an estimated 60% of pharmaceutical companies in these countries report significant problems in their supply chain, usually resulting in delays and financial losses [1]. Moreover, the impact of the pandemic has exacerbated this situation. The World Health Organization's (WHO's) Department of Noncommunicable Diseases (NCDs), through its surveys of countries' capacity to manage NCD-related resources and services, revealed an increase in the unavailability of medicines from 15% in 2020 to 21% in 2021 [2]. In the face of these challenges, the WHO has highlighted the importance of efficient logistics to ensure the availability of pharmaceuticals in hard-to-reach regions, publishing guidelines on the management and distribution of medicines [3]. Equitable access to safe, effective, and quality medicines and health technologies is fundamental to achieving universal health, according to the Pan American Health

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Organization (PAHO) [4]. In line with this, the United Nations Industrial Development Organization (UNIDO) warns that poor inventory management hampers industrial development and recommends the implementation of technologies to improve efficiency [5]. This is why the WHO points out that artificial intelligence can be beneficial in pharmaceutical logistics, helping to avoid drug shortages, especially in settings with a shortage of specialists, by improving the efficient management and distribution of resources [6]. Because of this, research exploring the use of artificial intelligence and emerging technologies to improve the logistics process in pharmaceutical companies has been explored, such as the present study [7] conducted by the Peruvian Ministry of Health reported that of the 24 facilities visited, 66.7% of them had the National Essential Medicines Catalogue at the time of the intervention. Similarly, [8] mentions that the administrative area of the Public Prosecutor's Office of Puno developed a mobile application to improve the inventory of patrimonial assets, since it performs manual inventories which generate delays and high costs; the mobile application "Kusa-Yupaq," uses technologies such as Android Studio, Java, and a MySQL database with REST architecture; validated with ISO-9126 and evaluated through a T-Student test, the application showed a 23% reduction in inventory time and a 26.2% reduction in operating costs compared to the traditional method. In [9] focused on developing a prototype mobile application to improve inventory management in the pharmaceutical industry, addressing problems of inefficiency and negative consequences arising from poor inventory management; using RUP methodology and IT tools, the prototype was designed and evaluated through peer-reviewed surveys; the results were highly positive, with a 93% approval rating, confirming that the prototype meets the requirements of presentation, security, usability and functionality, indicating that the application is ready for the development phase. In addition, [10] developed an intelligent inventory and decision support system (DSS) called "Imbentaryo App" that uses a forecasting algorithm and SMS technology to improve supply management at the Supply Management Office (SMO) of Tanauan, Leyte, Philippines; developed with an agile model and web and mobile technologies, the app facilitates decision-making through predictive data analysis. Validated against ISO 25010, it received a rating of 4.32, considered extremely efficient. On the other hand, the Cebu government's Long-Term Care Medical Assistance Program faces problems in the manual delivery of medicines, such as lack of proof of receipt by beneficiaries, difficulties in inventory control and supply shortages; To address these challenges, the Aeon web and mobile application was developed, which collaborates with the program to effectively monitor supplies, issue predictive resupply notifications and use facial recognition and GPS to track deliveries; the study used the agile software development method and, according to a usability survey, 87% of respondents prefer the system over the manual process and would recommend it for the program [11], [12] offers a mobile application on Android that can provide an optimal route to visit a set of customers, using a genetic algorithm to resolve the problem and is implemented using the Google API.

The objective of this study is to develop the design of a mobile application with artificial intelligence assistant to optimize the logistics process in pharmaceutical companies, providing the logistics manager with better control to ensure an efficient supply to customers.

2 METHODOLOGY

The waterfall methodology was used for the development of this work; it is an approach to project management that follows a sequential and linear process, where

each phase must be completed before moving on to the next; it is structured and is based on the fact that each stage depends on the previous one [13]. Among its advantages are its simplicity and clarity, making it easy to understand and apply; its linear structure and the definition of deadlines and deliverables from the outset allow for more predictable and efficient planning and resource allocation [14].

2.1 Phases of the cascade methodology

The cascade methodology considered in this study follows five distinct phases. Once a phase is completed, it is considered final, meaning that it is not possible to go back, and the only way to repeat any stage would be to restart the process from the beginning. This approach was chosen to ensure an effective outcome and to achieve the stated objectives, as shown in Figure 1.

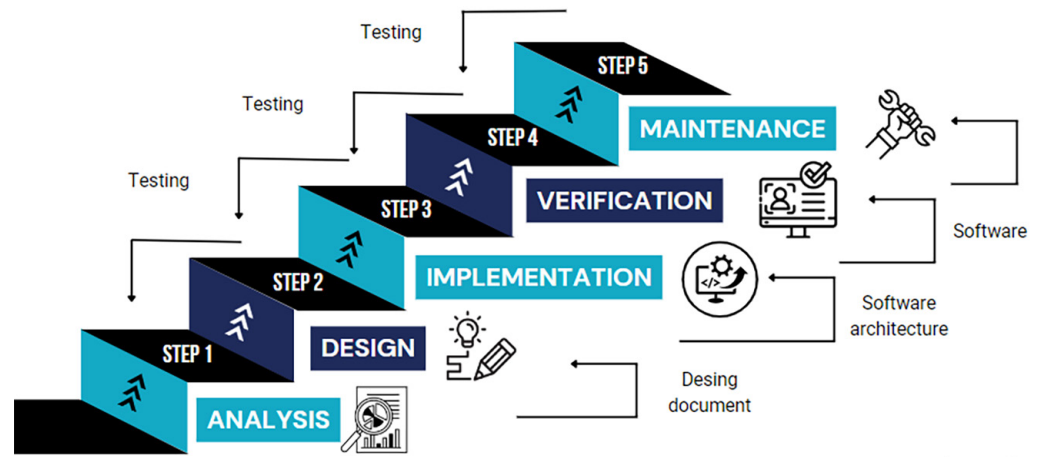


Fig. 1. Phases of the methodology

The definition of each phase is as follows [15]:

- a) **Analysis:** The first phase begins with the compilation and analysis of the requirements of the system or software to be developed, the client’s needs are identified and the project objectives are established.
- b) **Design:** The complete architecture of the system is defined and, in general, the components that will make up the final product or service are described; in addition, the project plan is established, including a detailed design of the product.
- c) **Implementation:** In this stage, the construction of the system is carried out, following the design previously defined during the previous phase.
- d) **Verification:** At the end of the previous phase, the product should be almost complete, marking the beginning of the testing phase, which can be stressful due to the possibility of having to restart the process in case of significant problems.
- e) **Maintenance:** This is carried out after delivery of the product and may vary according to the type and agreements with the customer.

2.2 Methodology development

The development of the waterfall methodology follows a linear and sequential progression through several phases. Each phase is dependent on the successful

completion of the previous phase. While this structure provides clarity and organization, it is important to be aware of the challenges that arise when adapting to changing requirements. Therefore, careful planning and consideration are crucial to applying this methodology effectively.

- a) Analysis:** In this first phase, information is collected through interviews to address the problems identified. Subsequently, all the information gathered is analyzed. The team proposes ideas to reach a consensus and establishes the necessary requirements to improve the logistics process in pharmaceutical companies. In addition, it seeks to optimize bottlenecks to increase the efficiency and fluidity of processes.
- b) Design:** In this phase, the design of the mobile application is carried out with the aim of improving the company's logistics process. Using the analysis and the compiled requirements, the team begins to develop the application, allowing the company to have better inventory control, access to accurate reports on the stock of medicines, and communication with the Chabot, which provides recommendations in case of detecting any delay in the process. In addition, based on the analysis, the architecture of the application will be designed, which will define how it will be structured and how its different components will interact. This design is crucial, as it will lay the foundations for the effective implementation of the system. It is important to note that the design of the application prototype will be carried out in the implementation phase, where the interfaces will be created and the necessary functionalities will be integrated.

Figure 2 shows the architecture of the mobile application, which is designed to provide a seamless experience on iOS and Android devices, connecting through a robust backend that links to a MySQL database to efficiently store and manage all logistics information. This backend also integrates with the WhatsApp Business API, allowing real-time notifications and updates to be sent to users, improving communication and speed of response. In addition, Amazon Web Services is used to ensure scalability and data availability, while Dialogflow facilitates the creation of a conversational assistant that can interact with users in an intuitive way. Finally, the application connects to ChatGPT, allowing it to offer intelligent and personalized support, optimizing the user experience by providing accurate and relevant responses in real time.

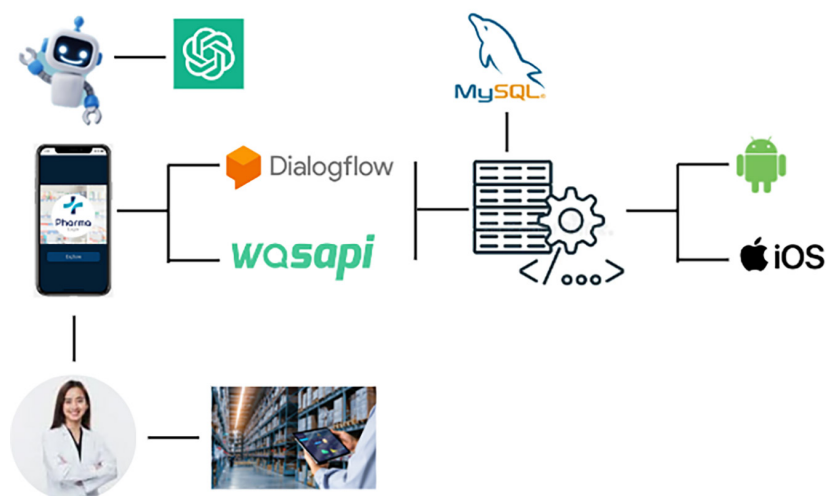


Fig. 2. Project architecture

Software

- **Chatgpt:** It is designed to chat, answer questions, correct mistakes and say no to incorrect requests; such as InstructGPT, it follows instructions and provides detailed answers [16].
 - **Mysql:** It is a solution offering advanced features, management tools and technical support, designed to ensure high levels of MySQL scalability, security, reliability and uptime [17].
 - **Wasapi:** It is an advanced tool for large companies, approved by Meta. Wasapi empowers it with artificial intelligence, automations, and integrations [18].
 - **Dialogflow:** It is a tool that helps you make applications talk naturally to people using their words, on phones, websites, devices, and voice-activated systems [19].
- c) **Implementación:** Focuses on carrying out the implementation and ensuring that it meets the requirements previously defined in the initial phases, such as requirements specification and design [20].

During this stage, prototypes of the application were developed. Figure 3 presents the initial interfaces, which include the login screen, login, and the main menu. In Figure 3a, the login screen is shown with the company logo; in Figure 3b, the login interface is shown; and in Figure 3c, the main menu of the application is presented along with the chatbot notification, in case the user wants to log in.

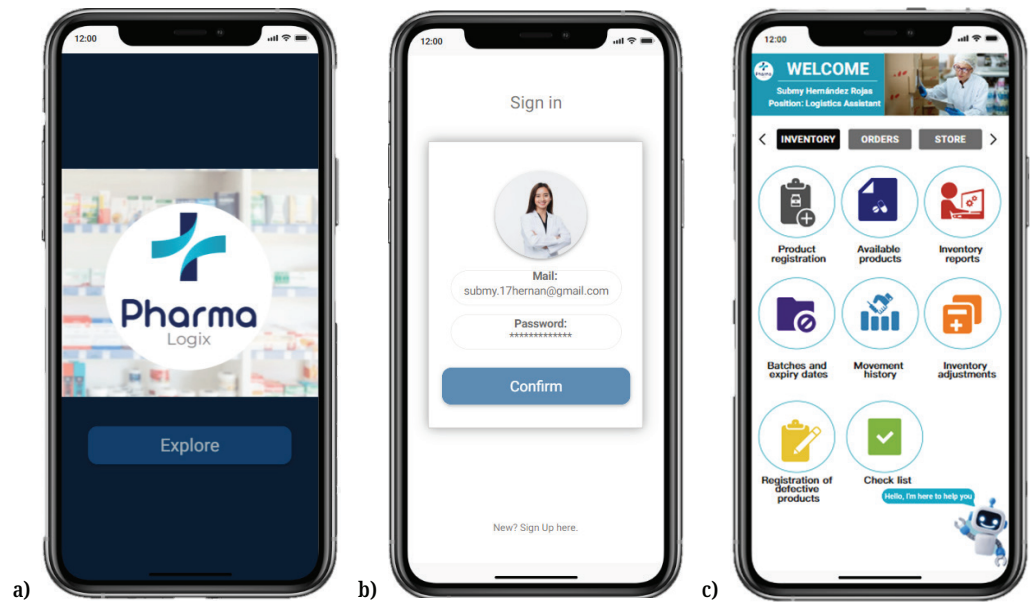


Fig. 3. Initial interfaces: (a) Login screen, (b) Login, (c) Main menu

Figure 4 shows the interfaces related to the pharmaceutical company’s stock of medicines. By entering any category, the available stock and detailed information for each medicine can be displayed. In Figure 4a, the different categories of medicines offered by the company are presented. Figure 4b shows the stock of medicines according to the category selected by the user, and Figure 4c presents the description and dosage of the corresponding medicines.

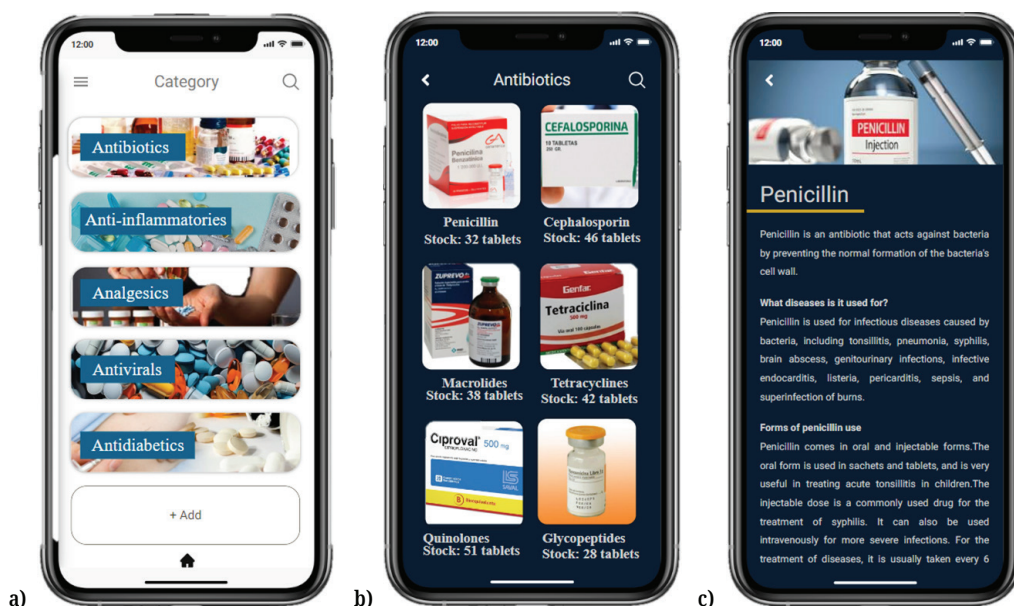


Fig. 4. Medicines management: (a) Categories of medicines, (b) Stock of medicines, (c) Description of doses

Figure 5 presents the user interaction interfaces with the Chatbot called PharmaBot. This chatbot responds with statistical graphs, images, and has access to location. In Figure 5a, it can be seen that PharmaBot provides recommendations to improve transport routes, a fundamental aspect to optimize the logistical process in the sale of medicines. Figure 5b shows that the Chatbot provides the current stock of medicines, and Figure 5c shows how the Chatbot provides real-time data from international organizations, such as disease trends, so that the logistics assistant can improve his or her process in an informed way.



Fig. 5. Conversation with the chatbot: (a) Access to location, (b) Sending statistical data, (c) Sending of images

d) Verification: To evaluate the system, 10 experts from various universities in Peru and 15 people involved in pharmaceutical companies, all from Lima, Peru,

with roles ranging from assistants to logistics supervisors, participated. The evaluation was carried out by means of questionnaires based on a Likert scale. The evaluation criteria are presented in Tables 1 and 2, corresponding to experts and users, respectively.

Table 1. Expert assessment criteria

Criteria	Aspects
Innovation	Are the features of the application innovative compared to existing solutions on the market?
	Does the proposed application meet the needs of the pharmaceutical sector?
	Are the solutions offered by the application original?
Functionality	Is the functionality of the application easy to use and understandable?
	Does the chatbot in the application provide real-time responses?
	Does the application allow for an efficient management of the medicine inventory?
Technology	Is the technology used to develop the application adequate for its functionality?
	Does the application adequately integrate artificial intelligence?
	Is the security of the data in the application confidential?

Table 2. Evaluation criteria by users

Criteria	Aspects
Usability	Is the registration process and access to the application simple and straightforward?
	Is the feedback provided by the application clear and timely?
	Can I perform the tasks I need to do without encountering significant obstacles?
Design	Is the interface of the application visually attractive and modern?
	Is the presentation of data in graphs and tables clear and understandable?
	Is the use of colors and typography appropriate and does it not cause confusion?
Accessibility	Can I access the application from different devices without problems?
	Are the application’s instructions and messages accessible and understandable to all users?
	Are accessibility features well implemented in the application?

3 RESULTS

3.1 Validation by expert judgment

An evaluation was carried out by 10 experts using the Likert scale to validate the application. The criteria evaluated included innovation, functionality, and technology. The results are presented in Table 3, which shows the means and standard deviations for each of these criteria. The overall mean obtained was 4.21, equivalent to 84.2% on the Likert scale. This result indicates that the quality of the application is considered very good, reflecting the effectiveness and potential of the proposed solution in the context of pharmaceutical logistics.

Table 3. Validation by expert judgment

Criteria	Aspects	Average	S.D	Quality
Innovation	Are the features of the application innovative compared to existing solutions on the market?	4.30	0.82	Very high
	Does the proposed application meet the needs of the pharmaceutical sector?	4.00	0.82	Very high
	Are the solutions offered by the application original?	4.40	0.70	Very high
Functionality	Is the functionality of the application easy to use and understandable?	4.40	0.52	Very high
	Does the chatbot present in the application provide real-time answers?	4.30	0.48	Very high
	Does the application allow an efficient management of the drug inventory?	4.20	0.92	Very high
Technology	Is the technology used to develop the application adequate for its functionality?	4.50	0.71	Very high
	Does the application adequately integrate artificial intelligence?	3.90	0.32	Very high
	Is the security of the data in the application confidential?	3.90	0.57	Very high
Total		4.21	0.65	Very high

Figure 6 shows the results of the validation carried out by the experts. It is concluded that the innovation of the application received 80% approval, classified between very good and good. On the other hand, the functionality obtained 90% approval in the very good and good categories, while the technology received 86% in these same classifications.

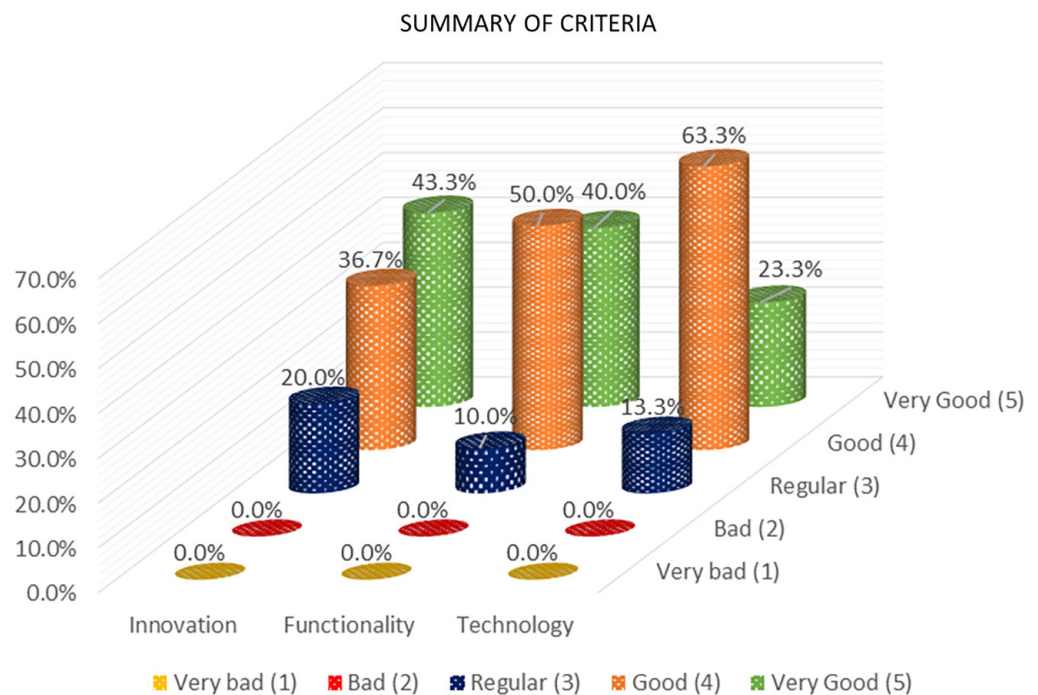


Fig. 6. Expert judgment results

3.2 Validation by users

The validation was performed by 20 users, including supervisors and logistics assistants from various pharmaceutical companies. The criteria of functionality,

usability, and accessibility were evaluated using the Likert scale. The results obtained are presented in Table 4. The overall mean score was 4.23, equivalent to 84.26%, which indicates that the mobile application has been very well received by users, reflecting a very good quality.

Table 4. Validation by users

Criteria	Aspects	Average	S.D	Quality
Usability	Is the registration process and access to the application simple and straightforward?	4.20	0.89	Very high
	Is the feedback provided by the application clear and timely?	4.20	0.95	Very high
	Can I perform the tasks I need to perform without encountering significant obstacles?	4.40	0.82	Very high
Design	Is the application interface visually attractive and modern?	4.20	1.01	Very high
	Is the presentation of data in graphs and tables clear and understandable?	4.10	1.02	Very high
	Is the use of colors and typography appropriate and does it not cause confusion?	4.30	0.86	Very high
Accessibility	Can I access the application from different devices without problems?	4.30	0.80	Very high
	Are the application's instructions and messages accessible and understandable to all users?	4.25	0.97	Very high
	How easy is it for you to access the application from different devices (smartphones, tablets, etc.)?	4.15	0.88	Very high
Total		4.23	0.91	Very high

Figure 7 shows the detailed results of the users as a percentage. It can be concluded that more than 50% of the users consider the application to be Very Good in relation to the established criteria. In particular, accessibility received 51.7%, design reached 56.7%, and usability obtained 55%.

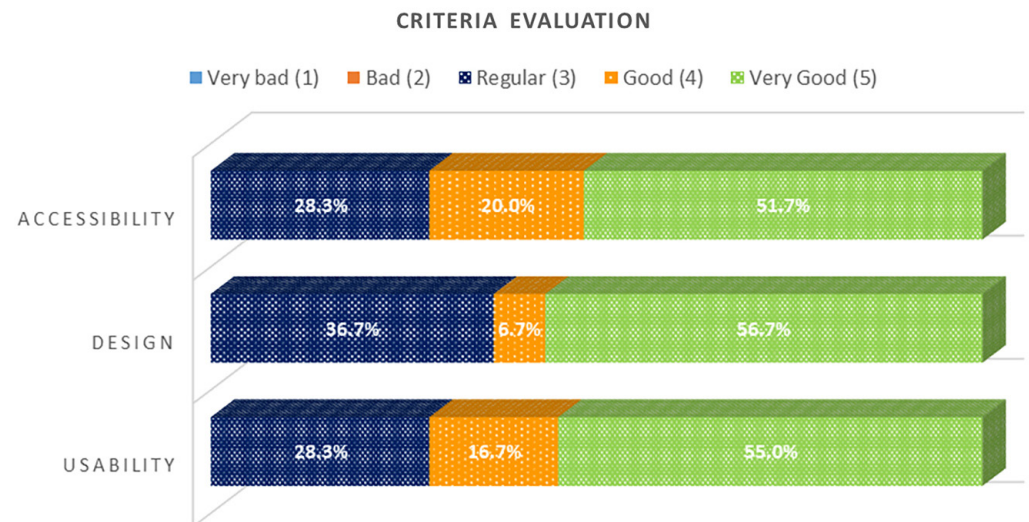


Fig. 7. Evaluation of criteria by users

4 DISCUSSION

The mobile application with an artificial intelligence assistant, designed to optimize the logistics process in the pharmaceutical industry, was developed using the waterfall methodology. This structured and sequential approach allows a clear

follow-up of each phase of the project. In contrast, research [9] applied the RUP methodology to create a mobile application to improve inventory management in pharmaceutical companies, achieving a positive result of 93% in the evaluation surveys. On the other hand, the study [10] used an agile development model, implementing web and mobile technologies in an inventory and decision support system (DSS), achieving a 4.32 rating. Likewise, [8] developed a mobile application that optimized the inventory of patrimonial goods, achieving a 23% reduction in inventory time and a 26.2% reduction in operating costs. The most innovative aspect of the mobile application in this study is its real-time chatbot, which provides recommendations to logistics personnel, facilitating favorable decision-making for the company. This integration of artificial intelligence not only improves efficiency but also enables a more agile and informed response to logistical challenges.

5 CONCLUSION

The mobile application prototype with an artificial intelligence assistant to improve the logistics process in pharmaceutical industries meets the conditions for the user, as it will allow them to avoid shortages and thus be able to adequately meet the needs of their customers, as reflected in the results. According to the experts' evaluation, the mobile application was optimally designed, meeting all the established criteria. The results of the survey of both experts and users indicate a high degree of satisfaction with the application, highlighting aspects such as innovation, technology, functionality, usability, accessibility and design. In addition, the development of the application followed the phases of the Cascade methodology, which allows a structured approach in the design process. The application also has a chatbot that facilitates logistics management, improving interaction and access to relevant information. For future work, it is recommended to incorporate machine learning algorithms to foresee demand patterns and adjust stock in real time, avoiding stock-outs. It would also be useful to enhance the chatbot with more advanced natural language processing to solve complex queries and add integrations with ERP (Enterprise Resource Planning) systems for more detailed tracking of inventories and purchase orders.

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7 AUTHORS

Rosa Menéndez Mueras is a Systems Engineer, doctoral candidate in administration, university professor, and author of university texts. Winner of third place in the fourth national university text competition organized by anr. Professor, researcher and teacher at the Universidad mayor de San Marcos and the Universidad Tecnológica del Peru. She can be contacted at c18678@utp.edu.pe.

Esteban Julio Medina Rafaile is a Systems Engineer from the César Vallejo University, has a solid academic background that includes a Master's degree in Higher Education Sciences (completed) and a Master's degree in Systems Engineering and Computer Science with a major in Information Technology Management in progress, as well as doctoral studies in Education Administration. He has work experience in the private sector as a systems analyst in companies such as Trading Motor's César's Maquinaria and systems consultant at the Accounting Firm "MESS", as well as in the public sector, where he has worked as a systems analyst in the Regional Government of Ancash and formulator of technical files in several municipalities. In addition, he has held roles as a teacher in various educational institutions, including SENATI, the Universidad San Pedro and UNASAM, with a focus on systems engineering and information technologies. He can be contacted at emedinar@unasam.edu.pe.

José Luis Herrera Salazar is a Professional in Systems Engineering with experience in planning, analysis, design and programming of computer systems and databases. Developer of equipment maintenance management systems, attendance control systems, warehouse control systems, production systems, academic systems. analysis, design and database administrator, management of human potential. strategic planning of business and social programs, strategic planning and objectives control using balanced scorecard and logical framework methodology. He can be contacted at luis.herrera@autonmadeica.edu.pe.