Mobile Application: A Proposal for the Inventory Management of Pharmaceutical Industry Companies

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***Abstract*—In recent years, the development of mobile applications has been evolving and becoming more and more frequent. This event is positive, since it plays an important role in facing and mitigating the multiple adversities that appear in the different existing sectors, such as business. On the other hand, it was detected that a little known problem that many companies in the pharmaceutical industry experience is poor inventory management, which causes countless consequences, generally of a negative nature. For this reason, in this work it was decided to make a mobile application prototype to face this problem. In this regard, the RUP methodology was used, along with various computer tools, in order to elaborate the prototype. Besides, as a data collection technique, surveys were made, which were subjected to expert judgment, in order to qualify the prototype. Likewise, very satisfactory results were obtained, concluding that the mobile application prototype that was developed complies with all the necessary conditions to mitigate the inventory management problems of pharmaceutical industry companies.**

***Keywords*—Inventory management; mobile application; pharmaceutical industry; prototype; RUP methodology**

I. Introduction

In the context of the pandemic that we had to live through, no sector was spared from Covid-19. The health sector was also hit hard by said pandemic [1],[2].Currently, having good inventory control is very important for any company, regardless of its types and items. This action seeks to ensure that the elements that are needed, such as raw materials [3], supplies and spare parts, are available in a timely manner, in optimal conditions and in their respective locations.

It is necessary to keep in mind that in a review of studies it was mentioned that the organization's inventory management involves decisions that include financing, promotion, supply and acquisition management. All of them have high risks and have a direct impact on the financial framework [4]. Besides, proper inventory management ensures availability and minimizes investment when materials are needed.

In the case of the pharmaceutical industry, inventory management is also essential, both from a financial and operational perspective. Efficient inventory management reduces procurement and transportation costs. Likewise [5], it maintains an effective stock of products to meet the demands of customers and prescribers.

It cannot be denied that efficient inventory management is crucial for the future of any business, as it becomes a key factor for profitability thanks to its multiple benefits. Among them we have, for example, that it will allow the company to have a timely control of all its products [6], as well as knowing at the end of the period a reliable state of the economic situation.

On the other hand, efficient inventory management will also avoid causing problems that threaten the safety and health of patients. This is because the system will allow the proper management of products, thus preventing patients from acquiring expired, falsified [7], deficient and/or damaged medicines.

In this context, inventory management systems are very convenient. Implementing, consolidating and effectively applying an inventory control system helps in the progress of any business, as well as improves the efficiency of its activities [8]. If companies and organizations use an inventory system, they will obtain many benefits, since the correct inventory management will improve their decision making.

Based on everything mentioned above, it is justified that this work is very important, since it aims to contribute to all companies in the pharmaceutical industry that choose to implement the proposed mobile application. In the same way, the objective of the research is to design a mobile application prototype, using the Figma tool. This in order to improve inventory management in companies belonging to the pharmaceutical industry so that they achieve many benefits, such as the reduction of losses due to expiration dates and the improvement of customer service.

To all this, it is also worth mentioning the content of the next chapters that make up this work. In Section II, works related to the topic are shown together with an analysis; in Section III, the methodology used is indicated together with the tools that helped in the elaboration of the application prototype; in Section IV, the development of the work is detailed; in Section V, the results obtained are presented; in Section VI, the results obtained are explained and compared with prior knowledge on the topic; and finally, in Section VII, conclusions are drawn and ideas for future work are provided.

II. Literature Review

As it was well emphasized before, in the present work it was decided to address the issue of designing a mobile

application prototype to improve inventory management in companies belonging to the pharmaceutical industry, since it was evidenced that it is a common problem today. For this reason, it was decided to search for scientific productions that are useful and related to the topic, in order to collect information on their observations, results, conclusions and other relevant aspects and learn from them.

In the first instance, in a work carried out by the authors [9], it was proposed to design and implement a pharmacy management system with a stock alert system, in order to improve accuracy and improve safety and efficiency in the pharmaceutical store. About it, in its conclusions it is indicated that the developed software allows new prescriptions and refills to be processed more quickly and easily; at the same time, this makes the work of pharmacists automated, allowing them to have more time to advise clients and thus prevent them from making medication errors.

On the other hand, in a work carried out by the author [10], it was proposed to design a mobile application for inventory management in a minimart. In the process, Waterfall was the methodology used, with the stages of analysis, design, coding and implementation. Besides, in its conclusions it is indicated that among the many benefits of this application is that it allows the management of articles to be easier.

From another approach, in a work carried out by the authors [11], it was proposed to develop a system to accurately manage consumable goods in storage. In the process, Systems Development Life Cycle (SDLC) was the methodology used. Likewise, the mobile application was developed using the Android system. Besides, in its conclusions it is indicated that this system has proven capable of reducing inventory access time by 80% and accurately tracking inventory compared to manual stock counting.

Meanwhile, in a work carried out by the authors [12], it was proposed to develop an information system for the hotel industry, in order to facilitate the control of data and inventory, orders and acquisitions and guarantee the follow-up of the cleaning process and consumption of materials as a whole. In the process, Design Science Research (DSR) was the methodology used. Besides, in its conclusions it is indicated this system has multiple benefits, among which it is mentioned that it allows data control and analysis to be carried out very easily.

From another perspective, in a work carried out by the authors [13], it was proposed to develop a mobile application for inventory management with sales prediction. In the process, regression analysis, typical of data mining, was used. Likewise, the mobile application was developed using the Android system. Besides, in its conclusions it is indicated that this application helps companies achieve greater social empowerment and development.

Similar to the previous one, in a work carried out by the authors [14], it was proposed to develop an inventory management system using the Rule of Association, in order to ensure that stores properly maintain their records and update your items in stock. In the process, the association rule, typical of data mining, was used. Likewise, AngularJS was used for the implementation of the system; PHP (Hypertext Preprocessor) for the backend of system development and database management; HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) for system interface design; and NoSQL as the database engine. Besides, in its conclusions it is indicated that this system was very useful, since it allowed creating transactions, updating items in stock, keeping records, generating reports for decision-making and making stores more effective.

Taking into account the previous works investigated, it can be seen that there is a limitation in the use of software development methodologies, since they only appear in some articles. In addition, it is also evident that there is a limitation in the exploration of different platforms that exist to develop mobile applications.

III. Methodology

Poor performance and unreliability of applications are common factors that drastically affect their acceptance. In this regard, measures must be taken in terms of quality. For this reason, in the development of this work, it was decided to use a software development methodology, together with various computer tools, in order to develop the prototype of the inventory management mobile application for pharmaceutical industry companies.

A. The RUP Methodology

RUP (Rational Unified Process) is a software development methodology that is object-oriented. It is responsible for establishing the bases, templates and examples for each of the aspects and phases of software development. Furthermore, it combines aspects of the development process (such as defined phases [15], techniques and practices) with other development components (such as documents, models and manuals) within a unified framework.

This methodology is one of the most widespread and well-known among software development companies. It is based on the Unified Modeling Language (UML) and is characterized by being iterative and incremental, focused on architecture and guided by use cases [16]. Likewise, the goal of this methodology is to develop high-quality software, capable of meeting the needs of customers, within the costs and schedules planned for the project [17].

Having mentioned all of the above, the scheme of the RUP methodology can be seen in Fig. 1.

B. Phases of the RUP Methodology

The RUP methodology consists of four development phases, within which several iterations are carried out in order to satisfy defined criteria before embarking on another phase. In other words, if we want to advance to the second phase of the RUP methodology, we first have to meet all the criteria established in its first phase.

1) Inception Phase: This first phase is very short and focuses on achieving the feasibility of the project. To do this, it is necessary to establish the scope, identify current and future risks, propose an overview of the software architecture and develop the plan for phases and subsequent iterations with customers or stakeholders.

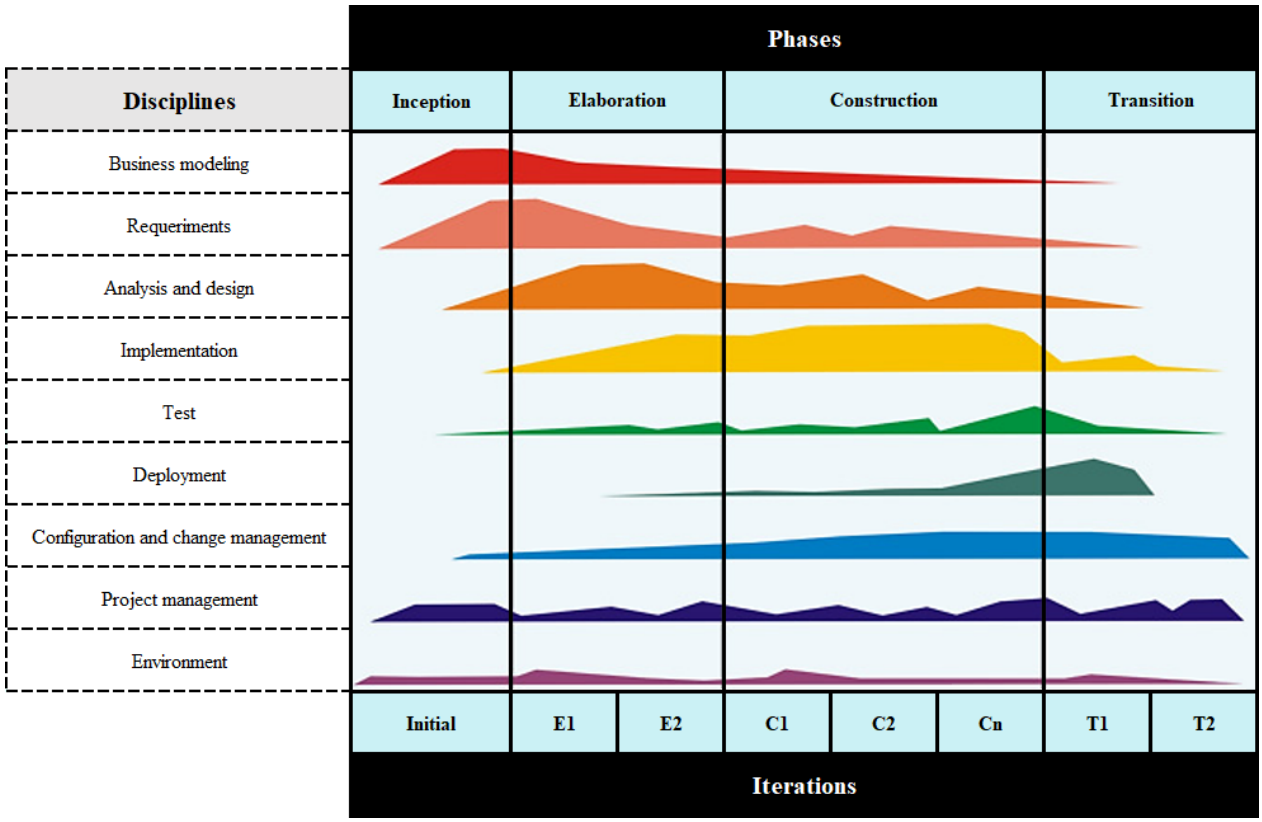


Fig. 1. Scheme of the RUP Methodology

2) Elaboration Phase: This second phase seeks to have a well-established base before moving on to the next. For this, it is necessary to select and elaborate the use cases [18], define the base architecture of the software, specify the selected use cases, develop the first analysis of the problem domain and design the preliminary solution.

3) Construction Phase: This third phase focuses on achieving the functionality of the software. For this, it is necessary to verify the pending requirements, manage the changes in relation to the evaluations made by the users and carry out the improvements.

4) Transition Phase: This fourth phase is the one that closes the project and seeks to ensure the availability of the software for end users. For this, it is necessary to carry out the final tests, adjust the errors and defects found, train users on the use of the software and provide the necessary technical support [18].

C. Elements of the RUP Methodology

A case apart from the four phases presented above, the RUP methodology is governed by four elements that work together and help to obtain the final result of the project.

1) Roles: It refers to the functions performed by each of the individuals or entities involved in the project. In this regard, it is worth mentioning that an involved party can play several roles, as well as the same role can be represented by several parties. In this sense, some roles [19], for example, could be that of a technical documenter, a software architect and a quality assurance.

2) Activities: It refers to the tasks that must be carried out by each of the individuals or entities involved in the project. In this regard, it is worth mentioning that each activity is assigned to a specific role. In this sense, some activities, for example, could be the elaboration of the use case diagram, the capture of software requirements and the performance of tests.

3) Artifacts: It refers to the products (in intermediate or final state) that originate during the various activities of the project and that are used to obtain the final result. In this regard, it is worth mentioning that the products capture information about the work carried out and transmit it. In this sense, some artifacts, for example, could be a document (such as the software architecture document), a model (such as the use case model) and an element belonging to a model (such as a class) [19].

4) Workflows: It refers to the sequence of activities that produce observable results of the project. In this regard, it is worth mentioning that all the roles, activities and artifacts that have been previously defined are integrated into the workflows. In this sense, some workflows [19], for example, could be a sequence diagram, a collaboration diagram and an activity diagram.

Having mentioned all of the above, the elements of the RUP methodology can be visualized in Fig. 2.

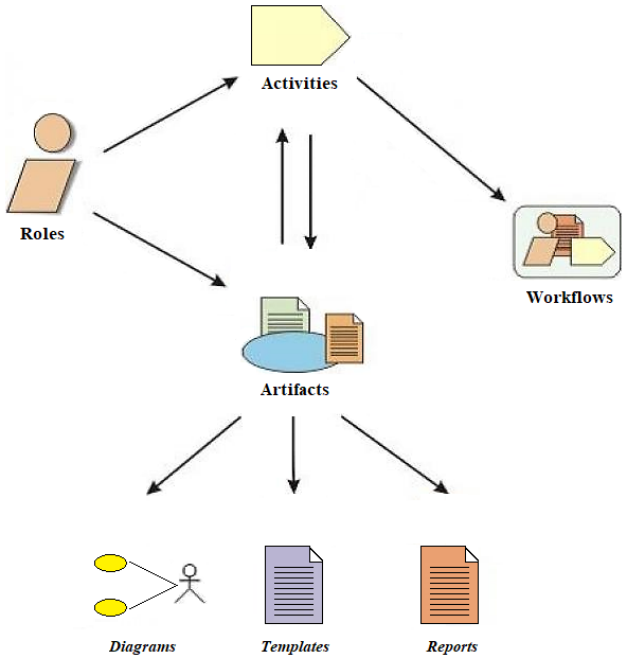


Fig. 2. Elements of the RUP Methodology

D. Technological Tools

1) Figma: It is used to create prototypes, through a development environment, which has an intuitive and easy-to-use interface. Figma allows designing user interfaces with excellent features in terms of design, prototype, collaboration, etc. In addition [20], it allows you to work collaboratively during the creation process and export the result in various formats such as PDF, PNG and JPG.

2) StarUML: It is an open source software modeling application based on UML standards [21]. It is flexible and easy to use.

3) Google Forms: It is a web-based application used to create forms for data collection purposes. Among its many benefits [22], its ease of handling when adding questions and answers stands out, as well as its ability to export the results in spreadsheets and statistical graphs.

IV. Study Case

During the development of the project, the activities of the phases of the RUP methodology that are most related to the development of the prototype of the mobile application for inventory management in a pharmaceutical industry company will be followed.

Based on the above, only the most necessary points of each of the phases of the RUP methodology were selected in order to achieve the final result that is the elaboration of the proposed prototype.

A. Phase 1: Inception

1) Scope of the Project: In this part, the scope of the project is established, which is related to its purpose. In other words, considering the purpose of this project, the need arose to raise some specific points, thus shaping the scope of the project. About it, the points that constitute the scope of the project are the following:

- Allow users to login.
- Register, modify and delete users.
- Register, modify, delete and query users.
- Register, modify, delete and consult providers.
- Register, modify, delete and consult products.
- Record sales.
- Generate sales reports.

2) Risks Associated with the Project: In this part, the risks associated with the project are identified to take them into account during the development of each of the activities because, as in any project, there are always situations that could occur and have a positive or negative impact on the final result. In this case, such uncertain events or conditions could be detrimental to scope and quality. About it, the risks associated with the project that were identified are the following:

- Inadequate choice of the technological tools to be used in the elaboration of the prototype.
- Ambiguous list of functional and non-functional requirements.
- Ambiguous definition of the roles of those involved in the project.
- Inaccurate rendering of Unified Modeling Language diagrams.
- Poor design of the prototype product of errors and details not considered.

3) Overview of Software Architecture: In this part, an overview of the mobile application architecture is proposed, which was done in order to provide a solid base to start modeling the system prototype. About it, the proposed architecture for this mobile application is presented in Fig. 3.

B. Phase 2: Elaboration

1) Software Requirements: In this part, the functional requirements and non-functional requirements of the system are defined. The functional requirements focus on the functionality of the system, since they are all those specific functions that the mobile application has. On the other hand, the non-functional requirements focus on the quality of the system, since they are all those specific attributes that the mobile application has. In this regard, these requirements are presented in Table I and Table II.

2) Business Use Cases: In this part, the business actors are established and the business use case diagram is designed. About it, these diagrams can be observed in Fig. 4 and Fig. 5.

3) Business Activities: In this part, the business activity diagram is elaborated. About it, this diagram can be observed in Fig. 6.

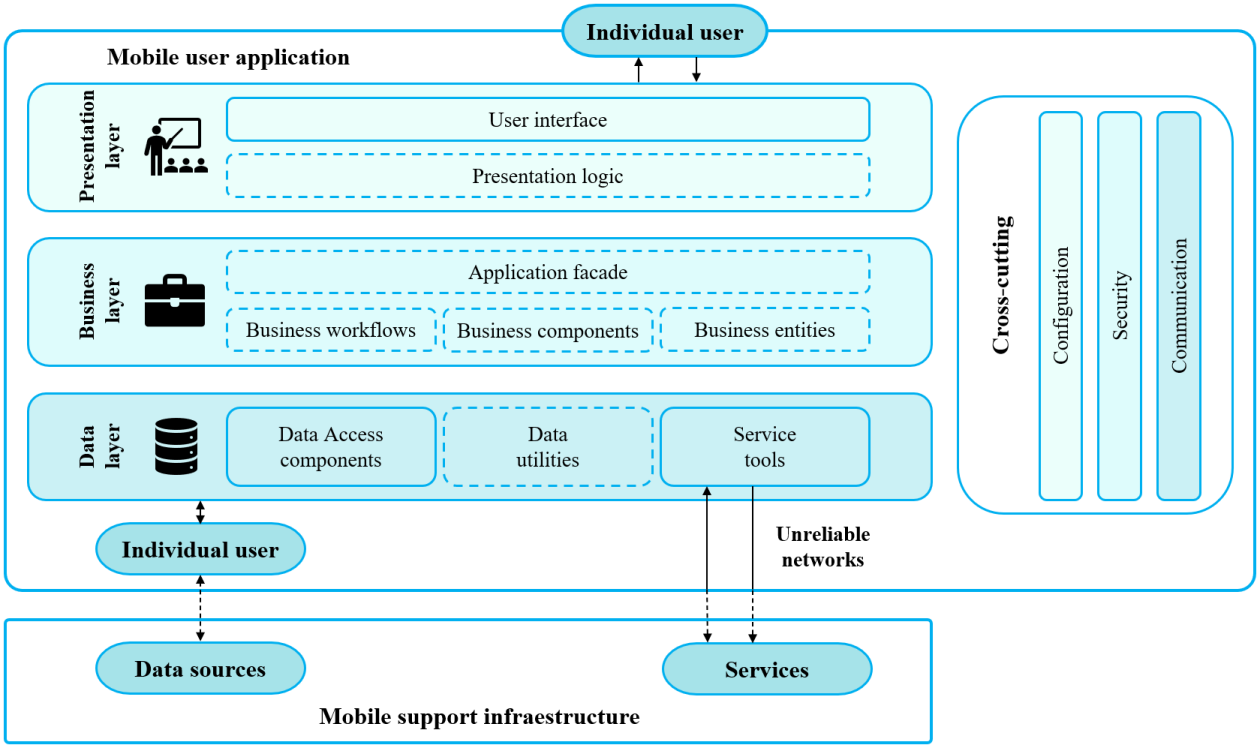


Fig. 3. Architecture of the Proposed Mobile Application

TABLE I. CAPTURE OF FUNCTIONAL REQUIREMENTS

Code	Description
FR01	The system will allow to validate the access of the users according to the entered data.
FR02	The system will allow to display a successful or failed login message
FR03	The system will allow to modify the login data of the users.
FR04	The system will allow to delete users.
FR05	The system will allow to register new users.
FR06	The system will allow to consult products.
FR07	The system will allow to modify of products data.
FR08	The system will allow to delete products.
FR09	The system will allow to register new products
FR10	The system will allow to consult providers.
FR11	The system will allow to modify of providers data.
FR12	The system will allow to delete providers.
FR13	The system will allow to register new providers
FR14	The system will allow to register the sale of products in real time.
FR15	The system will allow to generate sales reports.

TABLE II. CAPTURE OF NON-FUNCTIONAL REQUIREMENTS

Code	Description
NFR01	System learning time per user not exceeding 4 hours.
NFR02	Simple installation.
NFR03	Simple configuration.
NFR04	Disponibilidad de acceso 24/7 a todo el sistema.
NFR05	Safe and easy access.
NFR06	User authentication with a number of attempts not exceeding 3.
NFR07	Quick and easy navigation.
NFR08	Friendly and modern graphic interface.
NFR09	Ability to make changes and fixes.
NFR10	Ability to incorporate new functionalities.
NFR11	Compatibility with Android Studio and MySQL.
NFR12	Estándar de resolución 1440 x 2560: 560dpi.

4) System Use Cases: In this part, the system actors are established and the system use case diagram is designed. About it, these diagrams can be observed in Fig. 7 and Fig. 8.

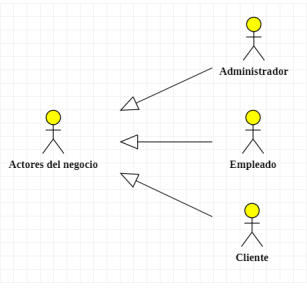


Fig. 4. Business Actors Diagram.

C. Phase 3: Construction

In this phase, the prototype of the mobile inventory management application is presented, which was developed with the Figma tool. This this application has two functionalities, these being the logistics area for employees and the sales area for customers. It is worth mentioning that the sales area was added as an added factor. Later, the most relevant interfaces of the application are shown.

In Fig. 9, it can be observed the charging interface, which appears when running the mobile application.

In Fig. 10, it can be observed the interface that appears after waiting for the application to load. This interface welcomes the

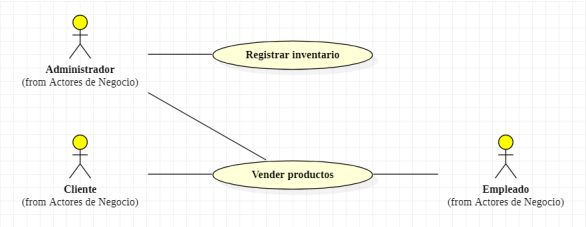


Fig. 5. Business Use Cases.

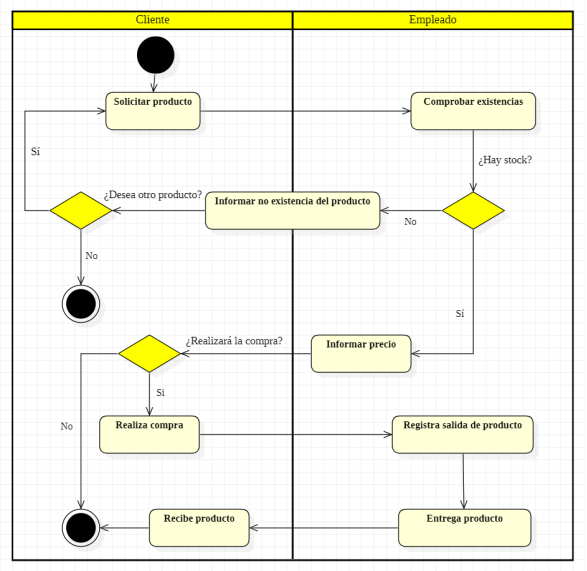


Fig. 6. Business Activity Diagram.

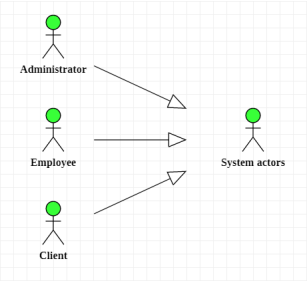


Fig. 7. System Actors Diagram.

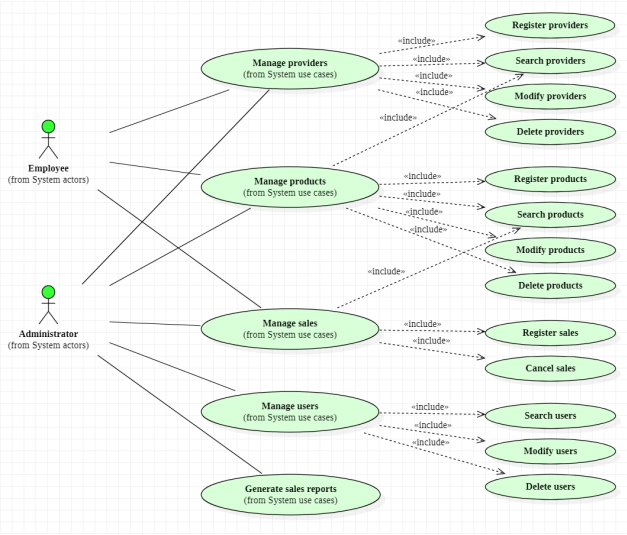


Fig. 8. System Use Cases.

user to the logistics area and asks him to enter his access data to enter. On the other hand, further down there is an option that directs the user to the entry interface to the sales area. The choice of which area to enter will depend on whether the user is an employee or a customer.

In Fig. 11, it can be observed the interface that appears after entering the access data. It shows the data of the employee who entered the system and gives the option to enter any of the windows you want.

In Fig. 12, it can be observed the interface that shows the providers part. It allows the user to contact them and register new ones.

In Fig. 13, two interfaces can be observed. The first interface allows you to register a new product. To do this, it will ask the user to enter their code and available stock. Also, it will ask the user to enter a comment about the product they are registering, as well as its expiration date. On the other hand, the second interface shows the list of products that are available.

In Fig. 14, it can be observed the interface that allows you to make sales reports, according to the date range that is entered. This interface shows the products sold, along with their respective units and prices. Also, it allows you to export the information.

In Fig. 15, it can be observed the interface that welcomes the user to the sales area. This interface shows the current products and offers. Also, it allows to search for products in the search engine.

In Fig. 16, it can be observed the interface showing the products part. In this interface the user can select any product he wants to buy.

In Fig. 17, it can be observed the payment interface, which allows you to make sales, asking if the payment method will be in cash or by card and if you want a bill or invoice. Also, this interface has the option to include an address for the delivery of the product.

D. Phase 4: Transition

It is important to validate that the elaborated prototype meets the necessary requirements of the end users and is free of errors and defects; otherwise, solutions will have to be found for the identified observations. For this reason, a validation of the prototype was carried out through expert judgment. Likewise, it is worth mentioning that the survey was prepared in Google Forms and contained fourteen (14) questions. About it, all this information can be observed in Table III.

On the other hand, it was sought that each expert, under their own criteria, qualify the proposed model. To do this, the survey responses were designed to be answered according to the Likert scale. Likewise, scores and percentages were

Fig. 9. Load Interface.

Fig. 11. Logistics Area Interface.

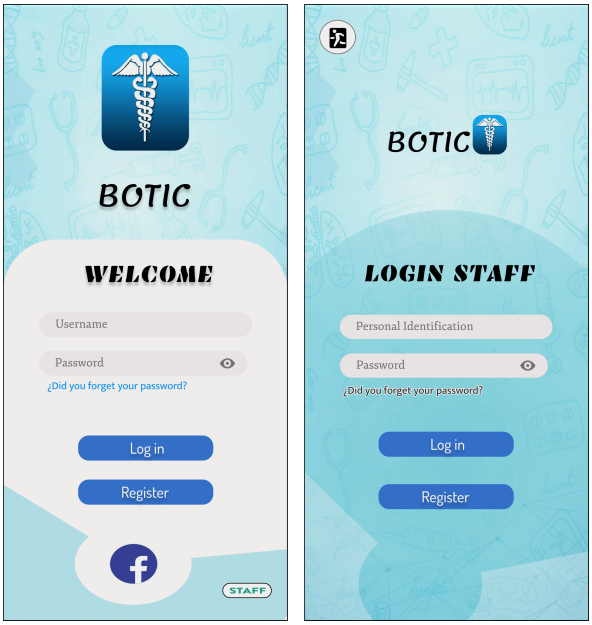
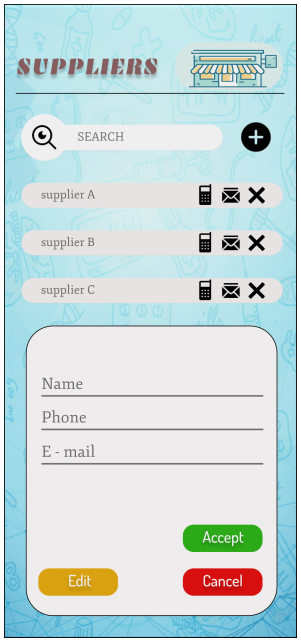


Fig. 10. Interfaces de inicio de sesión.



(a) N°5

Fig. 12. Provider Management Interface.

assigned. About it, all these data can be observed in Table IV.

V. Results

A. About the Case Study

In the inception phase, the scope of the project was established, focusing particularly on the operability of the system. Likewise, the risks associated with the project were identified, within which the prototype was tried to be free of errors and details not previously contemplated. Besides, an overview of the software architecture was proposed that served as a guide for the modeling of the system.

In the elaboration phase, the functional and non-functional requirements were captured. Likewise, five (5) UML diagrams were elaborated, these being the business actors, the business use cases, the business activities, the system actors and the system use cases.

In the construction phase, the prototype of the mobile

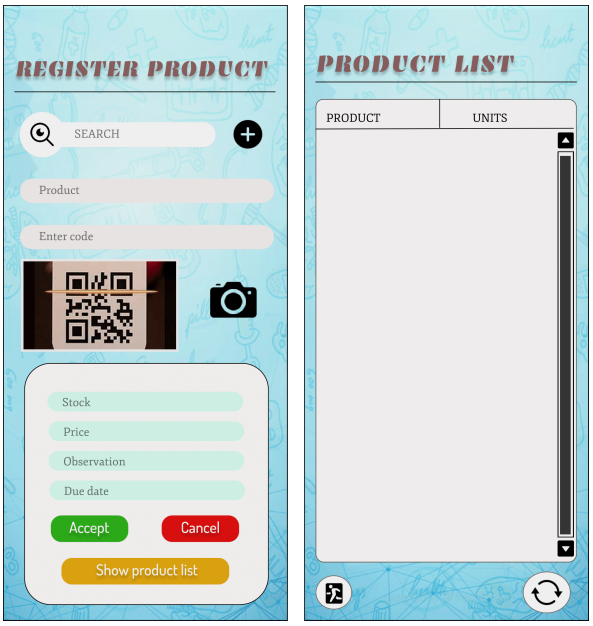


Fig. 13. Product Management Interfaces.

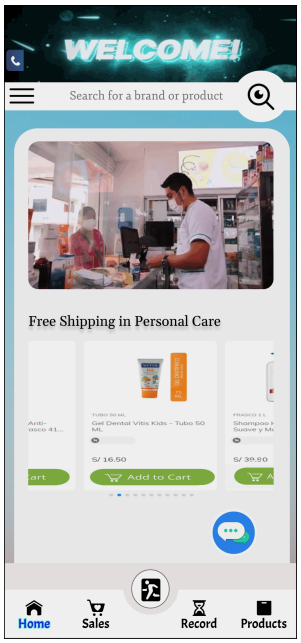


Fig. 15. Sales Area Interface.

Fig. 14. Sales Report Interface.

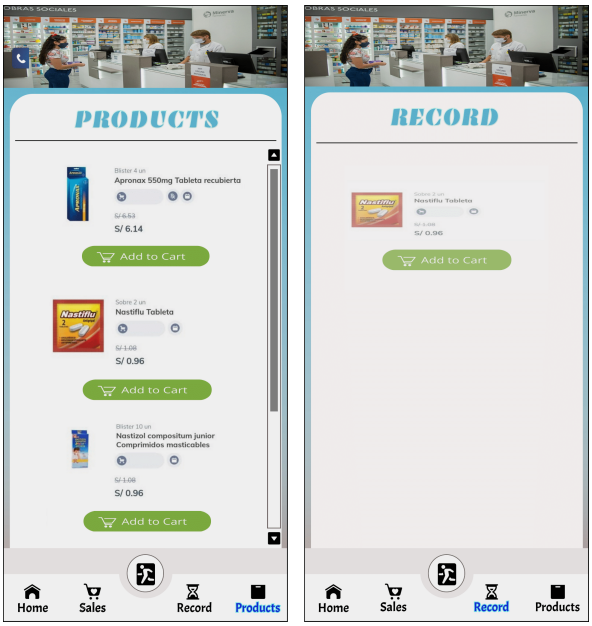


Fig. 16. Product Selection Interfaces.

inventory management application for the pharmaceutical industry was developed. About it, it is worth mentioning that the prototype consists of a wide variety of graphical interfaces, which allow users, products, suppliers and sales to be managed.

Finally, in the transition phase, surveys were carried out with the purpose of validating that the prototype is in optimal conditions and meets the needs of the user.

B. About the Survey

The survey model was elaborated with the Google Forms computer tool, which was very beneficial for the management of the data obtained.

Favorable results were obtained with respect to each of the survey criteria. About it, 96% of the total answers indicate that the respondents totally agree with the presentation of the application. Also, 92% of the total answers indicate that the respondents totally agree with the security, usability and functionality of the application. In short, all this shows that the application is optimal in terms of presentation, security, usability and functionality. For more details, all these data can be observed in Fig. 18.

Finally, it is necessary to mention that the survey

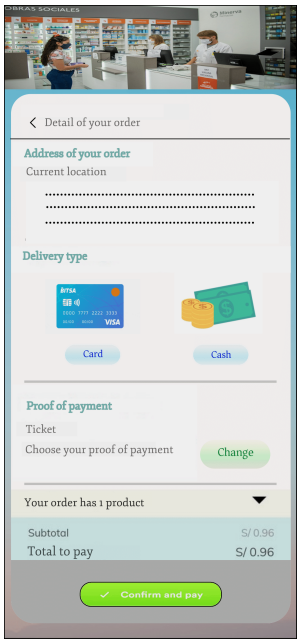


Fig. 17. Payment Method Interface.

TABLE III. SURVEY QUESTIONS

Criteria		Questions
Presentation	Q01	The interface of the application is modern.
	Q02	The interface of the application is friendly.
	Q03	The colors of the application stand out and contrast with each other.
	Q04	The graphics of the application pop and are timely.
	Q05	The windows of the application are well arranged.
	Q06	Indicate how much you agree with the presentation of the application.
Security	Q07	The access to the application is only for registered users.
	Q08	Indicate how much you agree with the security of the application.
Usability	Q09	The access to the application is easy.
	Q10	The navigation in the application is fast.
	Q11	Indicate how much you agree with the usability of the application.
Functionality	Q12	The application meets the needs of the user.
	Q13	The application will help improve inventory management.
	Q14	Indicate how much you agree with the functionality of the application.

application returned 93% in the final percentage. About it, all these data can be observed in Table V.

C. About the Methodology

As is well known, RUP is a methodology that focuses on planning and organizing a set of activities to turn user needs into software. The practices of this methodology are very common in large software projects; however, it is unknown what is the position of RUP compared to other software development methodologies. For this reason, a table was created to compare RUP with other software development

TABLE IV. ASSIGNMENT OF SCORES AND PERCENTAGES

Values	Scores	Percentages
Strongly disagree	1	20
Disagree	2	40
Neither agree nor disagree	3	60
Agree	4	80
Strongly agree	5	100

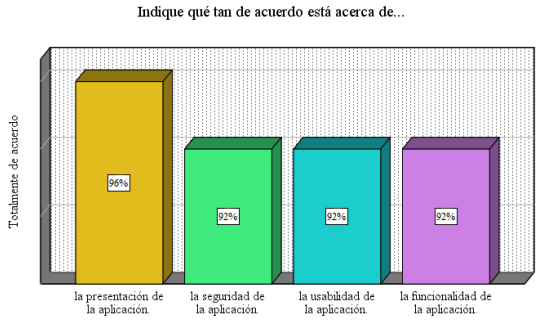


Fig. 18. Chart of Tables about the Opinion of the Respondents.

methodologies, in order to answer this question. About it, all this information can be observed in Table VI.

VI. DISCUSSIONS

During the literature review, works related to the development of mobile applications for inventory management were collected and analyzed. About it, it is worth mentioning that the works carried out by the authors [13] and [14] were very interesting. In both, data mining techniques were used in the methodological part and great results were obtained, demonstrating that there are other ways to develop software.

On the other hand, the literature review also allowed to compare the RUP methodology against other traditional software development methodologies, these being Waterfall and Incremental. Likewise, this comparison also involved some agile methodologies, these being Scrum, Kanban and Extreme Programming (XP). In this regard, it was identified that RUP is a very good methodology.

Now, regarding the surveys, it is worth mentioning that it is important that their application has yielded a high percentage of acceptance. This means that the prototype of the system is in optimal conditions and can be developed, since there is certainty that users will be highly satisfied with the application.

VII. CONCLUSIONS AND FUTURE WORKS

The prototype of the mobile inventory management application for the pharmaceutical industry developed meets the conditions of the users, given that the survey submitted to expert judgment was accepted by 93%. It was validated that the prototype has excellent presentation, security, usability and functionality. Therefore, it is concluded that there is certainty that the application will obtain great satisfaction from users and, therefore, can enter the development stage.

On the other hand, with respect to the case study, it is concluded that it was a good decision to use the RUP

TABLE V. SURVEY RESULTS

Questions	Experts										Percentages
	E01	E02	E03	E04	E05	E06	E07	E08	E09	E10	
Q01	5	5	4	5	4	5	5	5	4	5	94%
Q02	5	5	4	5	4	5	4	5	4	5	92%
Q03	5	5	4	5	4	5	4	5	4	5	92%
Q04	5	5	5	4	4	5	5	5	5	5	96%
Q05	5	5	5	4	5	4	5	5	4	5	94%
Q06	5	5	5	4	5	4	5	5	5	5	96%
Q07	5	5	4	5	5	4	4	5	4	5	92%
Q08	5	5	4	5	5	4	4	5	5	4	92%
Q09	5	5	4	5	4	5	5	5	5	5	96%
Q10	5	5	5	4	5	4	5	4	4	5	92%
Q11	5	5	5	4	4	5	4	4	5	5	92%
Q12	5	5	5	4	5	4	4	4	5	5	92%
Q13	5	5	4	5	4	5	4	4	5	5	92%
Q14	5	5	5	4	5	4	5	4	4	5	92%
Percentages	100%	100%	90%	90%	90%	90%	90%	93%	90%	99%	93%

TABLE VI. COMPARISON OF METHODOLOGIES OF SOFTWARE DEVELOPMENT

Criteria	Traditional methodologies			Agile methodologies		
	RUP	Waterfall	Incremental	Scrum	Kanban	XP
Proposals	It employs a set of activities necessary to transform user requirements into a system.	It linearly orders the different stages that must follow when developing the software.	It applies linear sequences in a staggered fashion as time progresses on the calendar.	It regularly applies a set of good practices to work collaboratively, as a team.	It applies a signaling system in which production tasks are displayed on demand by means of a series of cards.	It employs a set of techniques that provide agility, control, efficiency and flexibility in the development and management of the project.
Advantages	It allows early mitigation of high risks. It can be adapted and extended to meet the needs of any organization.	It provides the necessary tools to have clarity in the objectives from the beginning of the project. The costs and workload can be estimated at the beginning of the project.	It allows customers the opportunity to change requirements as components are added. It reduces the initial development time.	It allows to easily identify the objectives of each stage and the possible setbacks that may appear along the way. It manages the project in simpler and more manageable blocks, thus reducing the margins of error.	It allows variations in activities, thus ensuring that the product has the desired characteristics. It does not produce more than necessary, thus reducing waste.	It allows to save a lot of time and money. It has a very low error rate.
Disadvantages	The costs of the necessary team of professionals may not be covered on small projects. It may be unsuitable for use in small projects due to its high complexity.	It is difficult to go back and make changes. It delays tests until after completion.	It requires a lot of planning, both administrative and technical. It requires clear goals to know the status of the project.	It requires an exhaustive definition of the tasks and their deadlines. It requires that those who use it have a high qualification or training [23].	It is difficult to deliver on time on large projects. It is not implemented well in very long productive cycles.	It is difficult to keep track of what has been done. The commissions are very high in case of failure.

methodology, because it allowed the prototypes to be carried out in a systematic, orderly and coherent manner.

Finally, for future software development work, it is advisable to use other methodologies and other techniques related to data mining and technological trends.

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