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RESEARCH ARTICLE

Design of a mobile app for the learning of algorithms for university students

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Abstract: This research work is based on the realization of a prototype of a mobile app for the learning of algorithms for university students applying the methodology of design thinking because nowadays, this methodology is becoming more popular and used by many companies for its iterative processes in which we seek to understand the user and redefine problems in an attempt to identify strategies and solutions alternatives that might not be instantly apparent with an initial level of understanding. Using this methodology, we identified and designed what users needed, focusing on UI and UX with the info we recollected from the many interviews and forms we made. The results of this research were the complete prototype for the subsequent development of the mobile app on future projects and much feedback that we will consider from the final users to improve the app. Thanks to this app, many students can practice and learn about different algorithms and expand their minds to generate solutions to one problem.

Keywords: algorithms, design thinking, mobile learning, mobile app, mobile design

1 Introduction

Recently, there has been an increase in disapproved students or students who obtain low marks in the first university cycles in courses that involve logic or mathematics due to the difficulties they go through due to the lack of a suitable learning methodology and family, social or social problems (Anastasaki & Vassilakis, 2022); meaning not having an interest or having a good source of motivation in learning these courses (Akhtar, 2022).

According to research, some main drawbacks they face are the need for more motivation and the methodologies used (Zhou et al., 2018). These problems above are due to the traditional and obsolete methodologies with which the courses are taught, added to the difficulty they have in understanding the course since, despite technological advancement; most schools maintain their traditional way of teaching (Campos-Pajuelo et al., 2022). That is why when passing to the higher cycles, these problems or doubts persist and will bring them more inconveniences when trying to understand more advanced courses, generating frustration, stress, fatigue, and sometimes even changing careers or leaving university (Gözüm et al., 2022).

In addition, it should be noted that due to the pandemic, teaching is currently online through applications such as Zoom or Meet (Karakose & Malkoc, 2021; Kalogiannakis & Papadakis, 2022), the problem with this situation is that not many teachers have reasonable control over the attendance of students or their active participation during the class (Mohammed, 2022), it could be said that the lack of discipline and perseverance is one of the causes that contribute to the lack of motivation and disinterest of the students (Zhou et al., 2018).

Therefore, the following work aims to improve the teaching of algorithm learning by developing a prototype for learning algorithms for students of the first cycles of the Technological University of Peru (UTP). These types of applications, in other countries, are already having optimal results; if implemented in the algorithm courses of the first cycles, it would ensure that students learn without difficulty and in less time; in addition, the teachers would advance more quickly each class (Ladias et al., 2021; 2022). In addition, the application's design for teaching and learning the algorithm course will allow a tool that optimally complements the learning.

What is sought with the prototype is to have a representation or design of how the final application will be displayed; this will seek to promote the stimulus and disposition of the students towards the algorithms course in a pleasant, didactic, and interactive way through games while they learn while playing, as they are already being implemented in other countries, mainly obtaining the expected results and even exceeding expectations.

2 Literature review

This section presents the panorama of different research works on algorithm learning and how to make these more understandable for students—using not only different methodologies

but also explaining why different methods should be used after traditional teaching models based on the results they presented during their tests (Karakose et al., 2023).

In our country, there needs to be a significant improvement in the quality of teaching provided by national schools (Lazarinis et al., 2022). In some cases in private schools, this deficit is more noticeable in courses that need more reasoning and logic on the part of the students, such as mathematics or computing. We must remember that the logical thinking generated by mathematics is an essential basis for learning algorithms (Akour et al., 2021).

The main detail to consider about learning algorithms is that they are like a basis for learning computer science and programming because they teach logical thinking and follow a sequence of tasks or activities to achieve a goal or result (Louka, 2022; Papadakis, 2021). With the educational level that Peru manages, a large part of the student body has many learning difficulties (Papadakis, 2023). There are very few national schools that can provide good quality teaching. There are many other reasons students need to be more motivated or committed to their studies (Akour et al., 2021).

They indicate that programming learning and teaching currently face significant challenges; due to this is that their problems and their origins continue to be the subject of permanent research. Previous studies have shown that problems still need to be solved; among these are the low or no motivation of students to achieve (Papadakis et al., 2023) or achieve the objectives set and the scarcity of effective pedagogical models and methods that improve and facilitate learning (Oyelere et al., 2018).

Likewise tells us that computing in general and educational computing has reached high levels of sophistication. However, it is separate from the educational success expected of this technological boast (Arpaci, 2019). Clear examples can be seen in algorithm animations, where the expected success has yet to be achieved despite its wide range of systems and maturity. Among the main reasons for this relative failure is the incredible workload that the construction of animations means (for teachers typically). However, it also has to do with the fact that using it only sometimes guarantees greater efficiency in student learning.

Furthermore (Wai et al., 2016) tells us that students among the most challenging courses consider programming language courses at university to learn. For this reason, some other authors mention that programming and algorithms are abstract and complex courses based on concepts and processes that are challenging to teach and are less to learn (Papadakis et al., 2021). From what we could see, many authors confirm the difficulty of teaching and learning algorithms and programming languages, not only due to causes based on students but also because of traditional teaching methods on courses or subjects that are not like the courses presented one or two decades ago, since these are increasingly inefficient and difficult to apply, knowledge, like many other things, is always constantly advancing. With it, there should also be advances in teaching methods and models (Tkachuk et al., 2021).

Regarding new methodologies or ways of teaching mentions gamification based on a methodological structure of the Werbarch and Hunter model recognized as DMC (Dynamics, Mechanics, and Components), which is Among the best known in the design of gamification strategies and aims to allow learning to be more motivating and enjoyable for students, this model could be a good start to try in the first years of student learning through primary (Luckin & Cukurova, 2019). Meanwhile, please talk about the development of E-learning through mobile applications since this would bring good ideas and benefits to motivate students in the learning process on various topics to choose from, such as its Pecahanku application for teaching fractions, making teaching more active, fun, and memorable for primary level students.

The term M-Learning where he defines as a distance learning model using educational technology through mobile devices that allows students and teachers to use these devices to reinforce teaching and learning. This author also tells us about the application he developed for teaching programming languages, in this case, Java, to university students. He indicates that this model requires establishing good educational content to raise student learning (Buenaño-Fernández et al., 2019). The same M-learning model will increase students' motivation and interest in learning. In addition, he was also based on the concept of gamification since it can increase the sense of competition in the student, which will increase their motivation to excel in learning due to the need to achieve social recognition from their peers.

Based on what has been presented above, traditional teaching models will only sometimes be the most efficient since it will depend a lot on the topics or courses to be taught and on the students who need greater motivation or incentives to learn. In contrast, these "new "Models or teaching methods these authors showed us have mostly had good results in studies or tests carried out during their investigations.

Thanks to the gamified teaching model, positive aspects were obtained in increasing students' motivation with self-learning. Regarding the performance shown by the students, a considerable increase could be noted (Ruan et al., 2019); it could be concluded that the students used to

dedicate more time to the course related to this teaching model compared to the other courses and even provided ideas to implement to increase their learning such as It could be to increase the hours of practice in the laboratories where this new teaching model was applied.

Mobile applications significantly impacted students and their learning because they showed greater interest in fractions using the mobile application. Teachers could use this tool to reinforce their teaching, and students could have fun and enjoy learning. Some students even stated that using this mobile application increased their ease of learning. After having designed and developed the mobile application for learning algorithms and programming languages, the students obtained good results during the advance of the first two phases of the application, Although during the last phase, only 57\% of the students were able to solve the problem, this because the students had a lack of motivation to complete this learning phase (Shorfuzzaman et al., 2019). Therefore, it was decided that in the future, the application would have to be redesigned where new elements should be added and the quality of the teaching materials should be refined.

According to Leinonen, Design Thinking methodology is an innovative method to solve problems with three critical aspects: desirability, economic and technical feasibility. Likewise, it is characterized by a methodology in which people create solutions (co-creation). This methodology focuses on understanding human needs for a productive, feasible, and desirable solution.

This methodology is organized into a group of active and precise phases (Kildea et al., 2019); these phases mix the finding with the ideation and prototyping. Nevertheless, first, an advanced evaluation of the scope of the difficulty must be carried out; this will investigate the results; in them, and the ideas of the subjects involved must be considered (Sano et al., 2018). For this reason, the context of the people from whom you will design and propose results must be understood as much as possible.

In conclusion, different research works that used different methodologies and tools were analyzed to increase the student's motivation to learn different topics. Each obtained largely positive results from their research collected through analysis, comparisons, opinions, questionnaires and interviews. As seen in the paragraphs before, the increase in motivation and desire for self-learning shown by students using different learning models after the traditional ones is one of the main objectives of our research work. However, we were able to notice in previous research that the increase is not constant due to various causes, in some cases due to fatigue, lack of originality, and even boredom, so we deduce that applying this type of methodology is quite convenient as long as you can choose for constantly monitoring it and redesigning the points that are not of much interest to the students, points that we will take into account when carrying out this research work.

3 Methodology

Design thinking is a tool in which teamwork is developed, each member contributing ideas, and their point of view, thus obtaining feedback (Altman et al., 2018). Among its most essential characteristics (Petousi & Sifaki, 2020), it stands out that it is fully user-oriented, allowing solutions to be generated based on detected problems and generating value for people (Dobrigkeit et al., 2019).

3.1 Emphasize

It is the basis of the tool, where you have to observe, investigate, listen, and get involved in the study's problems, establishing a relationship with the client and her needs. This stage's objective is to identify the relevant needs or requirements of the user. Some tools or techniques to apply at this stage include interviews, focus groups, and observation.

3.2 Define

In this stage, the information acquired in the previous phase is observed and exposed, obtaining the result of the problem to later look for possible practical solutions to the problem proposed by the client; only the most essential thing should be considered to develop an innovative result towards the needs or requirements of the user (Pande & Bharathi, 2020). One of the most common techniques in this stage is Clustering, which consists of placing all the information obtained from the previous stage in its posts. Then they proceed to group these according to their content. Furthermore, finally, synthesize these group contents in a sentence.

3.3 Ideate

In this phase, the options for the exposed problem will be raised; for this reason, it is the most important; it seeks to encourage originality, innovation, critical thinking, and creativity. It

generated ideas and proposals in a pleasant and creative environment (Braun & Clarke, 2021). It is about obtaining the most significant number of possible ideas that provide a solution to the problem posed. This can be done through brainstorming or another tool or technique that encourages defining new ideas.

3.4 Prototype

What was proposed in the previous phase will be physically projected, and the most viable and coherent proposals will be chosen, originating a concrete proposal. It is necessary to develop schemes, models, and representations of projects (Micheli et al., 2019). At this stage, we will show the user the progress we have or plan to make so that they can provide us with Feedback and confirm if what we are designing meets their needs or requirements. The objective of this stage is to fail quickly and cheaply, waiting for the client to tell us if the solution path we are taking is the right one.

3.5 Test

What was proposed in the previous phase will be physically projected, and the most viable and coherent proposals will be chosen, originating a concrete proposal. It is necessary to develop schemes, models, and representations of projects (McGann et al., 2018). At this stage, we will show the user the progress we have or plan to make so that they can provide us with Feedback and confirm if what we are designing meets their needs or requirements. The objective of this stage is to fail quickly and cheaply, waiting for the client to tell us if the solution path we are taking is the right one.

4 Results and discussion

4.1 Emphatize

In order to complete the proposed project, the first step we have to take is to put ourselves in the place of our target audience, in this case, university engineering students from the first cycles of the UTP. It will seek to deepen the way of thinking and acting of users to be able to understand their environment very well and to be able to correctly and clearly define their needs (Tsoukala, 2021).

In this case, we collected information through interviews with university students to determine if they had any basic idea of algorithms and if they would use a teaching application. In addition, to know and understand the problems and difficulties that arise in students and their situation, collecting this situation is essential for our research and realizing this work. For the interviews, we used the Google Forms tool, where questions were asked to the users regarding their opinion about the proposed design and about new contributions that could be implemented in the application.

After implementing the first small survey, we used templates that helped us organize some ideas obtained to make changes and apply improvements to the design being made.

Environment Map: The environment map will help us understand the environment in which the target user moves and how the brand (project) is in the market (see Figure 1).

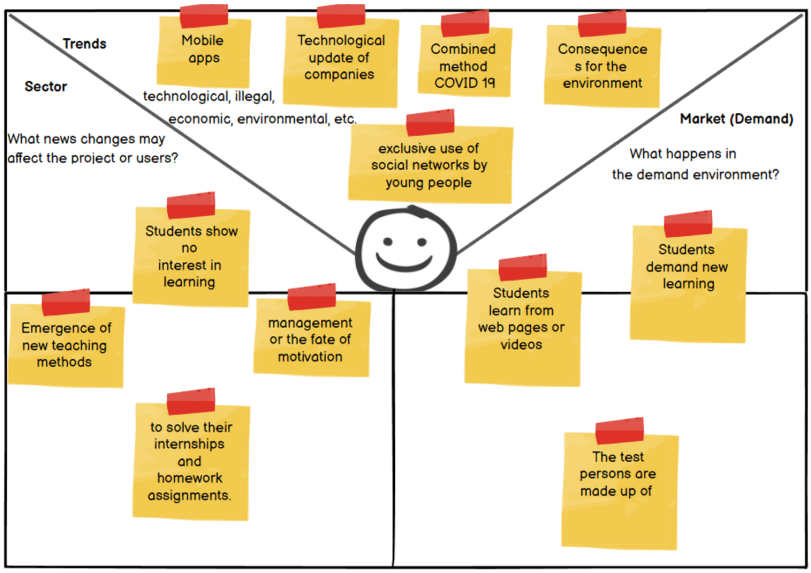

Figure 1 Environment map

Empathy Map: This aims to help us gather information from the user, their environment and their way of thinking and acting (see Figure 2).

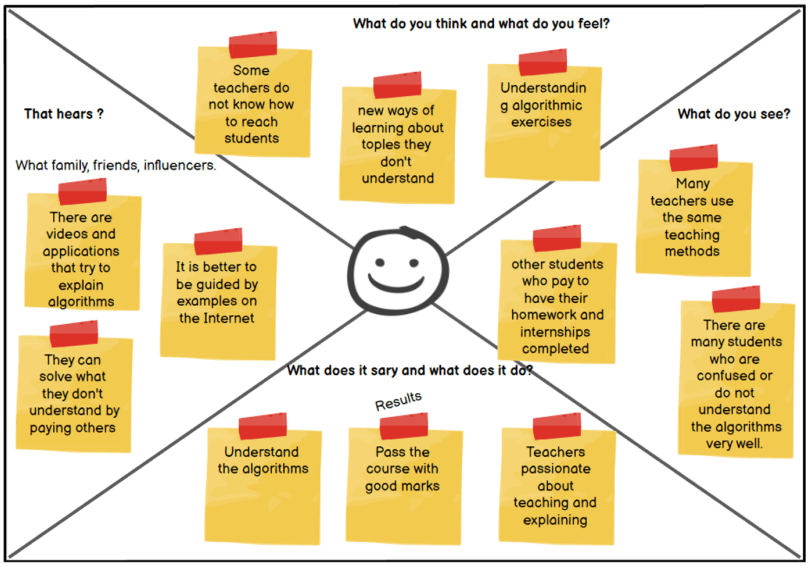

Figure 2 Emphaty map

From the survey, it was possible to deduce that, at present less than half of the students have basic knowledge of algorithms. This creates difficulties in understanding the classes, causing poor performance, poor grades, and even retaking the course. The survey also showed that many students believe that implementing these mobile applications would help improve their academic performance and facilitate learning.

4.2 Define

In this phase, we will seek to identify a starting point based on the information and data obtained from the previous phase based on interviews and to be able to propose the best solution to meet that need. As we know, the user's need is to learn and have access to different examples and exercises on algorithms. Golden Circle: This is a tool that has the task of helping us define the vision and purpose of the project to be carried out clearly and concisely (see Figure 3).

Figure 3 Golden circle

Elevator Pitch: Basically, its objective is to present a speech or exhibition about a product, service, or undertaking that will be the solution to a problem and persuade the audience or target audience (which may be investors, clients, superiors, etc.) in a short time between 45 seconds to 2 minutes, the length of an elevator ride (see Figure 4).

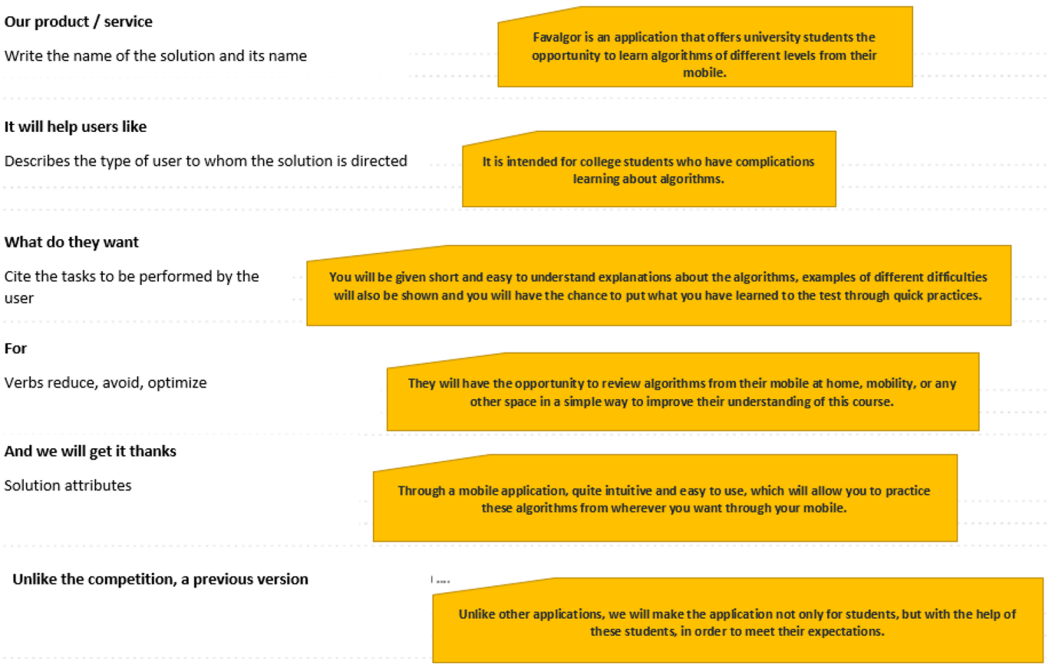

Figure 4 Elevator pitch

4.3 Ideate

Considering the two previous stages of empathizing and defining, multiple ideas originated to determine the application's functionality. In this way, the needs of the students will be aligned with the facilities provided by technology.

A list of ideas was established, choosing the most relevant and meeting the needs of the university students (see Figure 5).

Figure 5 Business canvas

(1) The mobile application has to be easy to use;
(2) Must allow registration by mail;
(3) You must have a registry for new users;
(4) The application must allow access by username and password;

(5) It must have a consultation forum where users can ask questions or doubts that other users answer;
(6) The application must have a main menu;
(7) It must have an alert for notifications and reminders;
(8) The application must have exercises of different levels to practice what has been learned;
(9) Must have questionnaires to test the knowledge acquired.

4.4 Prototype

Next, you will be able to appreciate the Login screen; here, we decided on the colours that will be used for the app. Next, we have the registration screen, where the students will create a user to use the app and save their progress (see Figure 6).

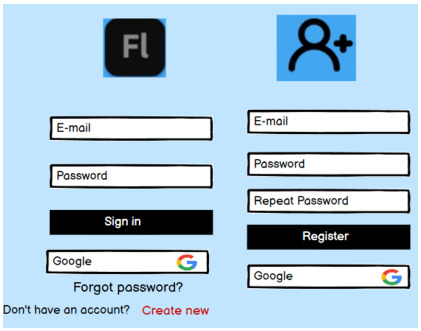

Figure 6 Login and register

Now you will see the home screen, where you can find the different topics of the app. Here below, you can see the lessons scene, where the students will decide their level of knowledge and find a lesson according to them (see Figure 7)

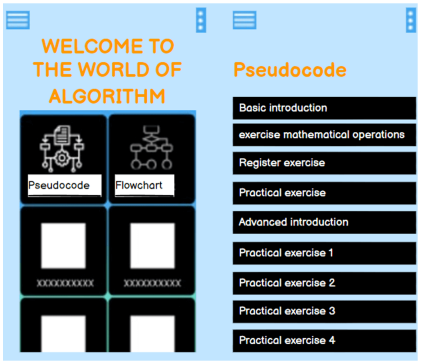

Figure 7 Home and lessons

Next is the menu screen, and below, you can appreciate the exercise screen, where we try to permit the students to see an example of a problem. Then they will resolve another similar exercise (see Figure 8).

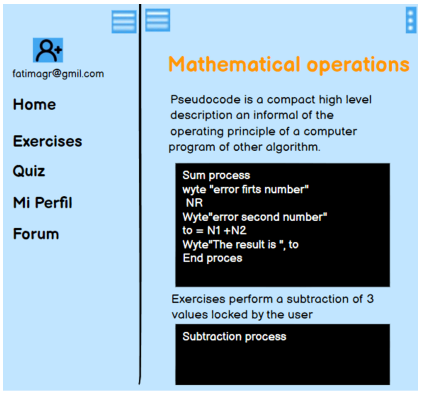

Figure 8 Menu and exercises

Now you will see the quiz screen, where the users will decide the quiz level to measure their

knowledge, and next, you can appreciate an example of how the students will see the quiz and answer some basic questions (see Figure 9).

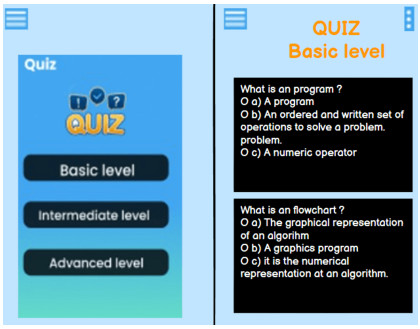

Figure 9 Quiz and exam

Below is the forum screen where the students will leave their questions or help someone else with a problem. Finally, you can see the profile screen where the students will see their information and make modifications if necessary (see Figure 10).

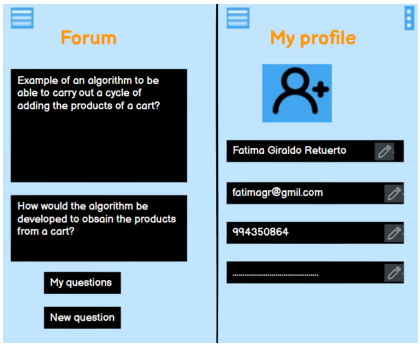

Figure 10 Forum and profile

4.5 Test

4.5.1 First survey

In order to complete this stage, the students were surveyed about their opinion of the prototype design, and the feedback shown below was obtained:

(1) Most find they are comfortable with the application colours;
(2) Most of them found the login pleasant to look at;
(3) Most think that this type of teaching application should be implemented;
(4) They think that their academic performance would improve;
(5) They would like there to be more learning applications.

To be the first advance of the prototype, it meets the expectations of the students. However, they consider that improvements can still be made.

From the responses obtained in the surveys of university students of the first engineering cycles of the UTP about the design of a mobile application for learning algorithms, we were able to conclude that implementing a mobile application based on The prototype would help to meet the needs in learning algorithms, since thanks to the various exercises, exams that the application has, it would support the improvement of the understanding, motivation, and performance of the students in their algorithm classes. The research coincides with the author (Ruan et al., 2019) on academic performance.

4.5.2 Last survey: Favalgor

To test the final design of the Favalgor application, we surveyed 61 users who gave us various points of view and opinions regarding the design presented.

The following table concerns the first question asked in the questionnaire. It deals with the opinion of the students about whether the design of the application is pleasing to the eye, where the respondents answered the following:

As seen in Table 1, around 57 users out of almost 61 respondents strongly agreed or agreed that the application design is pleasing to the user's eyes.

The second question asked in the survey will be presented, the objective of which was to know if the application was intuitive in terms of its use for users; where obtained the results in Table 1.

Table 1 Level of liking according to the design of the app

As far as design is concerned, did you find the application pleasant?	Count of: As far as design is concerned, did you find the application pleasant?
Strongly agree	21
Agree	36
Neither agree nor disagree	2
In disagreement	1
Strongly disagree	1
Total	61

Table 2 shows us that at least 53 of the respondents strongly agreed or agreed that the application presented was intuitive in terms of the interaction of the screens and the actions that the buttons presented would have, nor did they comment on having problems distinguishing buttons of those who were not. In this third question, we sought to know if the users found the content presented in the application design entertaining as an advance, where we obtained the results in Table 2.

Table 2 Level of liking according to the easy understanding of the app

Do you think the application is intuitive?	Count of: Do you think the application is intuitive?
Strongly Agree	21
Agree	32
Neither agree nor disagree	6
In disagreement	1
Strongly disagree	1
Total	61

In Table 3, according to the opinion of the users regarding the advancement of the content that the application would present, at the moment, we only show an advance of Pseudocode as a basis to understand the computer algorithms, and we show the Title of the Flow Diagram where 55 users responded strongly agree or agree that the content was at least interesting and entertaining to learn something new. As a fourth question, we wanted to know if the application was striking and interesting enough for users to be willing to recommend its use to their acquaintances, family and friends; where we obtained the following results:

Table 3 Level of liking according to the content of the app

Did you find the content of the app interesting?	Count of: Did you find the content of the app interesting?
Strongly agree	33
Agree	22
Neither agree nor disagree	4
In disagreement	1
Strongly disagree	1
Total	61

As seen in Table 4, around 55 respondents told us that they strongly agreed or agreed in recommending the application due to its pleasant, friendly interface and content. As a last question, we asked the respondents to give us a score between 1 Very Bad and five Very Good.

Table 4 Number of Users willing to recommend the app

Would you recommend using this application to your friends?	Count of: Would you recommend using this application to your friends?
Strongly agree	28
Agree	27
Neither agree nor disagree	3
In disagreement	2
Strongly disagree	1
Total	61

Table 5 shows that more than 50% of those surveyed gave us a good score. Finally, we asked the respondents to provide us with their comments on improvements or new things we could implement that could motivate or enthuse them to use the application more.

Some of the most prominent comments were the following:

(1) As a reminder, a guide could be added to explain the application and your progress or pending;

(2) Be able to link with Facebook or a phone number;

(3) Place a more cheerful colour tone;

(4) With faster loading, the design can be improved with better colour palette and more interactive colours;

(5) Ways to solve exercises faster;

(6) Analyze the theory of colours to have a better combination between them and make it more visually pleasing;

(7) The application looks perfect, intuitive, and pleasant in design; I would add some themes;

(8) Add buttons or options to go back more quickly since that makes it difficult for me; add a progress bar or a graphical column of progress (in this way, it is more motive to move forward);

(9) It has a search engine option to see the options regarding the subject or subjects related to the word;

(10) A video tutorial for you to learn quickly and to use the app.

Table 5 Score level assigned to the app design by users

Row labels	Count of: From 1 to 5, what score would you give it? Taking one as Very bad and five as very good.
1	1
3	6
4	32
5	22
Total	61

In summary, during this last survey, we were able to obtain diverse and varied opinions regarding things not so difficult to solve, such as the use of colours for the application to be developed, as well as ideas of new things to implement within the application so that be more attractive and interesting to use by users.

They gave us exciting recommendations to implement, such as placing a bar that shows the progress or progress that users have up to that moment or placing a guide in the application that tells you about your progress, pending or reminders of progress; it was also striking. Another interesting comment was implementing a search engine for words related to the different topics presented in the application. The team will consider all the comments we received in this last survey to find a way to implement them if accepted. Thanks to these, the application development work can be started safely and focused on what is being done.

5 Conclusions and future work

From the study of the current situation of the students of the first engineering cycles of the Technological University of Peru, it can be concluded that many factors influence the low performance, lack of motivation, and interest of university students. In addition, the pandemic we have been going through since last year led to the virtuality of education, which increased algorithm learning difficulties (Papadakis, 2022). Developing this learning application is vital since good results were obtained in other countries; in this way, Peruvian students would achieve learning with less difficulty (Yirci et al., 2016). While carrying out this work, the team could test their creativity and teamwork, obtaining a clear outline of what they wanted to do from the first advance (Zourmpakis et al., 2022). The implementation of the Design Thinking methodology allowed us to focus on our target audience during its realization and thus be able to make a prototype that ended up pleasing more than 80% of the surveyed users, thus achieving the expectations that were raised from the beginning regarding the functionality of the tool. In addition, the prototype provided an approximate perspective of the actual operation of the application, allowing us to obtain extraordinarily enriching Feedback that we will take into account for the next phase of the work.

Conflicts of interest

The authors declare that they have no conflict of interest.

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