Integrating Usability Principles through Gamification: A Case Study

Abstract– Gamification is a technique that involves the incorporation of game-like elements into non-game contexts, in this case integrated in education. However, applying this technique alone does not guarantee us a successful useful experience, therefore the usability principles must be integrated in the application design and development. This research integrates usability and gamification principles to improve the engagement of college undergraduate students in an operating systems course throw the design and development of an application to assist the learning experience in such course. A ten-questions questionnaire was designed and distributed among students to evaluate the proposed application. Results show the engagement achieved by students when using this type of application.

Keywords—Usability, gamification, user experience.

I. INTRODUCTION

In general terms, Usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specific context of use [1]. Therefore, Usability has a lot of impact on the user's satisfaction and the solution's success [2]. Due to the increasing need for proposing software as the solutions to numerous problems, usability has gained great attention in the software world for the past few years [3-4]. Developers and programmers are realizing that integrating usability as part of the user experience is very important when designing and coding, which opened the doors to almost always turning their design into a user-centered design [5].

In general terms, gamification is a technique that involves incorporating game-like elements into non-game contexts [6]. Gamification is an example of creating a problem-solving environment with camaraderie where tasks can be explored and enhanced in a goal-oriented manner because the main driving factor of deploying gamification is due to its motivational element [7]. Therefore, gamification has gained currency in the recent past and has widely been deployed in various disciplines such as business, marketing, and education amongst others.

This article presents the integration of usability and gamification principles to improve the rate and engagement college undergraduate students have in computer engineering courses. Specifically, the selected course was the Operating systems course. Such integration is shown throw the development of a mobile application to support the learning process. In addition, a ten-question questionnaire was designed to validate the user experience.

The rest of the paper presents the research background in section II, follows by intersection between usability and gamification in section III, the user interface design in section IV, settings and results in section V, and a summary and future work in section VI.

II. BACKGROUND

This section introduces the background for this research.

A. User experience and Usability

Usability is not the same as user experience, but a part of it. A good example to picture the importance of usability is to contemplate the example of a wooden table and its finish. We can say that the decoration of said table is the surface finish. The table, like programs, should be finished well. If a table is built out of the worst material, even the best finish cannot save it, and vice versa [8]. This table can maybe serve its purpose, but not to its fullest potential. The same can be said with programs, you can have amazing, clean code but a bad interface and bad usability and the application will not be useful; or the opposite, the application can be beautifully designed, but its code and logic does not work. That is why usability and user experience go beyond design, the program built needs to be "usable" from start to finish.
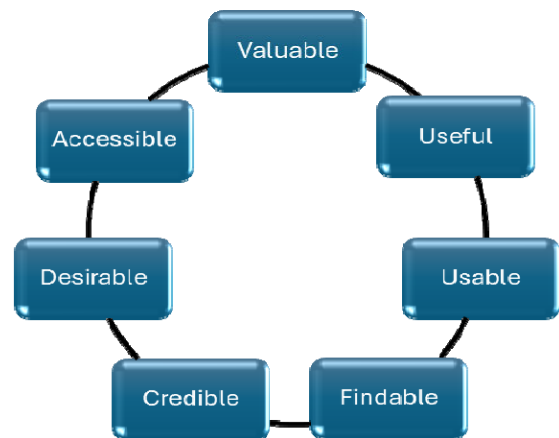

Fig. 1 The Seven Factors of Good User Experience [9]

To further evaluate the User Experience - UX, pictured in Figure 1, there are seven factors that influence good UX:
1. Useful: The application must have a purpose; it must deliver a practical benefit to users.
2. Usable: The application must allow users to achieve their end objective in an effective and efficient manner. That means without making mistakes due to confusion in the interactions with the interface.
3. Findable: It refers to the idea that the application must be easy to find including the information within it.
4. Credible: It refers to the ability of users to trust in the application. Not just making the job that it supposed to, but that the information provided with is accurate and fits the purpose of.

5. Desirable: It is related to branding, image, identity, aesthetic, and emotional design.
6. Accessible: The application must provide experience which can be accessed by users of a full range of abilities. This includes hearing loss, impaired vision, impaired motion among others.
7. Valuable: The application must deliver value. It must deliver value to the business which created it and to the users.

B. Principles and Importance of Usability in an Application Design

In computer science, Usability is defined as a software quality attribute that allows users to perform a specific task without making mistakes [10]. Traditionally, software engineering processes do not explicitly address usability within their life cycles. Usually, Usability is considered when testing is conducted at the end of the cycle check if the application design satisfies the high-level requirements [11].

However, there are three mayor reasonings or corollaries when it comes to building applications with usability on mind [8]:
1. The software has no value in and of itself. The value that it has is added to it by users.
2. The users never want to think about the programs they are using, they rather think about how it can solve their problem or add value to their lives.
3. The software will always increase the happiness of the users by helping them solve the problem the program was built to solve.

In other words, the users do not care about the program, or the programmer, but what that program can do for them. Therefore, according to Nielsen [12], Usability has multiple components associated with five usability attributes:
1. Learnability: The system should be easy to learn to allow users rapidly to get some work done with the system.
2. Efficiency: Once the user has learned the system, a high level of productivity is possible.
3. Memorability: The system should be easy to remember, so the user should be able to use it after some period of not having used it, without having to learn everything again.
4. Errors: The system should have a low error rate, meaning that users make few errors during the use of the system.
5. Satisfaction: the system should be pleasant to use.

C. The Power of Gamification in a learning environment

Gamification aims at increasing users' positive motivation towards given activities or use of technology, working to increase the quantity and quality of the output of given activities [13]. Several studies have shown that gamification can be an effective approach to increase motivation and engage users [14]. In this context, it would be applied in an educational setting. Some of the gamification tools that can be applied in this setting are immediate feedback, visual progress tracking, badges, and competition. It can also promote collaboration and increase interaction in the classroom.

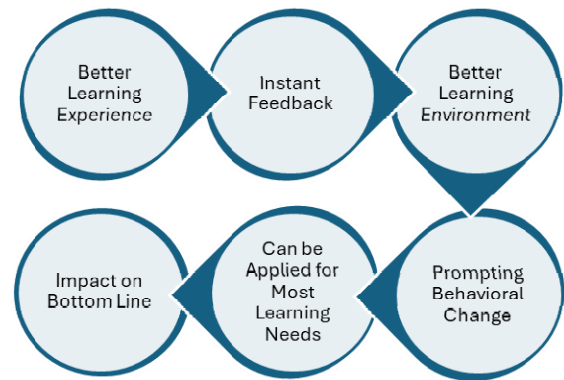Figure 2 presents some of the benefits of using gamification in a classroom setting.

Fig. 2 Gamification benefits in a classroom [15]

1. Better learning experience: The learner can experience "fun" during the game and still learning.
2. Instant feedback: The learner knows exactly what they got right and wrong.
3. Better learning environment: Help learners to practice real-world situations and challenges in a safe environment.
4. Prompting behavioral change: Points, badges, leaderboards motivate learners.
5. Can be applied for most learning needs: gamification can be used to fulfill most learning needs including soft skills, awareness creation and compliance.
6. Impact on bottom line: All previous benefits can create a significant performance gain for organizations.

According to Morschheuser et. Al. [16] there is a list of certain defined requirements that need to be considered when implementing gamification into a project. These requirements are: 1) the user's needs, motivation and behavior need to be understood to be able to apply them in the correct context, 2) the project's objectives need to be identified clearly, 3) gamification design ideas need to be tested as soon as possible in the cycle of the project, 4) a iterative design process needs to be followed, 5) there needs to be profound knowledge in game-design and human psychology, 6) assess if gamification is the right choice to achieve the objectives, 7) the organization must understand and support gamification, 8) focus on user needs in the ideation phase, 9) define and use metrics for the evaluation of the success in the gamification approach, 10) cheating control, 11) manage and monitor to optimize the gamification design in each phase, 12) consider legal and ethical constraints in the design phase and 13) always involve the users in the ideation and design phase.

However, there are some challenges when applying gamification for learning [15]:

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- Could possibly decrease student attention span.
- A lot of initial time is needed to plan the course or build the content.
- When choosing which elements to gamify, you must make sure to keep it relevant and useful.

III. THE INTERSECTION OF USABILITY AND GAMIFICATION

As discussed above, gamification can enhance the learning experience and promote student participation. This research takes advantage of recent studies that have proven that gamification has been successful in engaging students to be more proactive in learning. The key idea of this research is applying gamification in a classroom to motivate and keep the students engaged in the learning process.

A. Gamification tools

Some gamification tools that can be applied are point systems, badges and achievements, quest and challenges, stories, and simulation. However, when designing and implementing gamification into a project, it is crucial to ensure that the application is as usable as possible. Therefore, the incorporation of usability concepts and principles are required in the gamified setting for the users to be able to understand the consequences of their actions and provide valid guidance. Those usability concepts include having a user centered design focused on personas, consistency, and feedback and error prevention [17].

For this research, nine mobile applications which applied gamification in an educational context were evaluated. These apps were: Mimo, Duolingo, Brilliant, Elevate, Kahoot, Zoho Sprints, Sturrel, ClassDojo, and Prodigy Math Game. There is worth noticing that those educational applications that applied gamification, there were some repetitive tools that were seen throughout all apps. Some of these tools were:

1) Points system: the user receives a certain number of points for completing assignments or achieving a goal.

2) Progress bar: graphical representation of the completion status of the level.

3) Badges: special badges were given when reaching certain levels, breaking records, or establishing streaks.

4) Leaderboards: display of public scores of everyone in the classroom to promote competition.

5) Lives or hearts: number of chances the player had to complete a particular level or quiz.

6) Quizzes: short tests that test the user's knowledge about the completed level.

7) Streaks: series of consecutive days in which the user had entered the app and made some kind of progress.

B. Gamification framework

Since this research aims to apply gamification in a classroom setting for greater academic achievement, we want to do it with the usability's principles in mind. That is the reason why some of those gamification tools were used repeatedly or seen in all gamification apps. It is important to emphasize that the introduction to gamification in the operating systems course will not be replacing the teaching process but complementing it. The framework that will be applied for building a gamified application for the operating systems course that implements usability and a user-centered design can be observed in Figure 3.
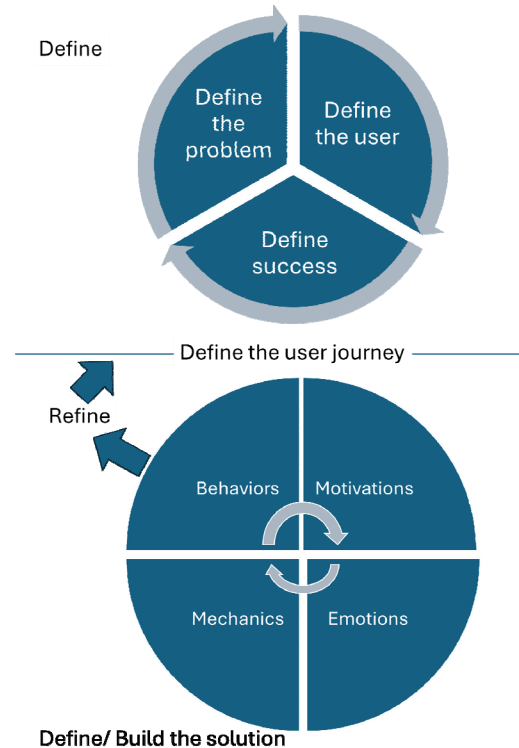

Fig. 3. Gamification Design Framework [15].

C. Personas as the key

To be able to create a user-centered design, we will be creating personas based on the students that are going to be using this application to engage more with their operating systems course. Personas are fictional characters that represent a possibility of the type of user that could be using the application. It can help develop a deeper understanding of users' motivations, preferences, and needs. These schemas usually have descriptions such as age, educational level, goals, needs, and a story which could help describe the interaction the user can have with the product. Figure 4 shows an example of a persona.
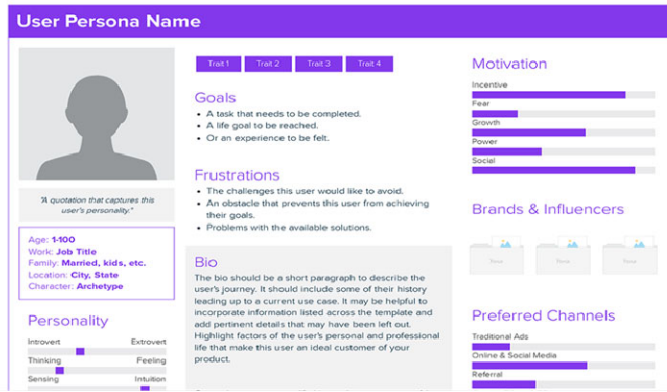
Figure 4: Persona Template [15]

IV. USER INTERFACE DESIGN

To engage students in their operating systems course through gamification, we have decided to create an app that integrates usability principles through a user-centered design. We have decided to use a design which is pleasant to the eye, which lets users know what's always happening, that is minimalist, is consistent, and is efficient to use all while integrating a proven gamification framework. At following, several activities GUI are presented. These activities were developed using FIGMA. At the top, a white background is used for each activity, while at the bottom the black color is used for the background. First, Figures 5 shows the login activities. Figure 6 shows activities for time processing analysis time depending on the scheduling algorithm. Figure 7 shows another example of time processing analysis.
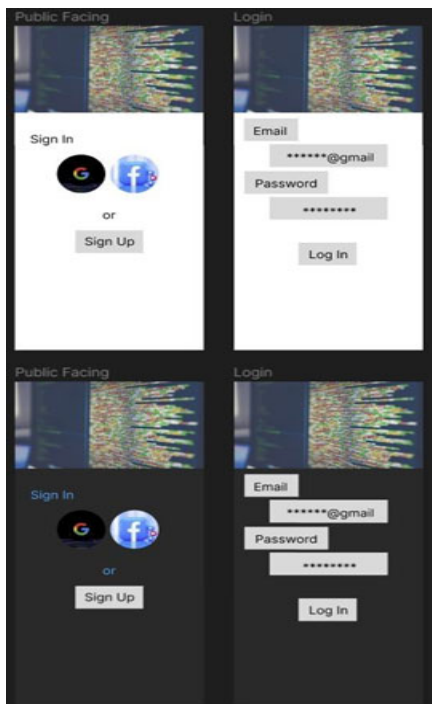

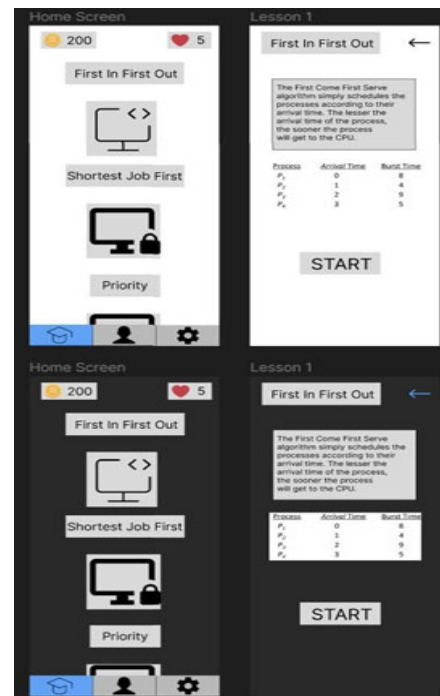Figure 5: Login activities

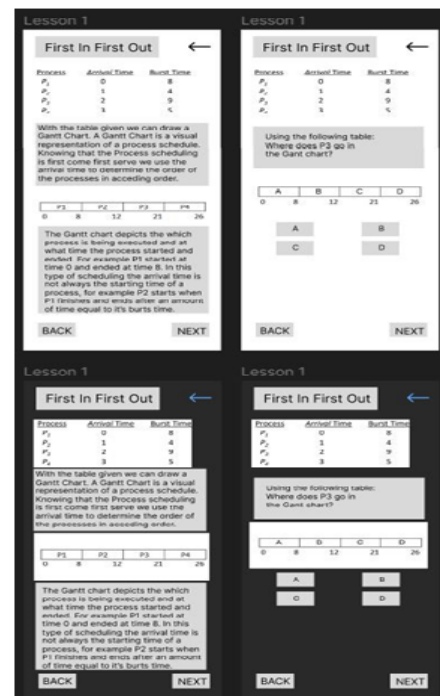Figure 6. Time Processing activities

Figure 7. Time Processing activities

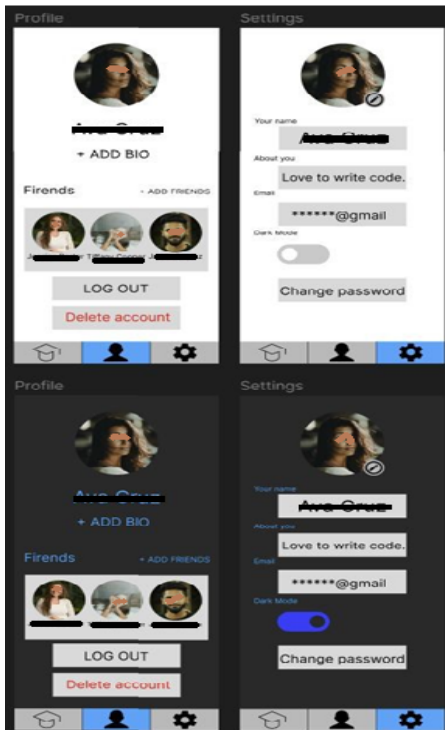Finally, figure 8 shows the profile and setting activities.

Figure 8. Logout and setting activities.

V. SETTINGS AND RESULTS

This section presents the analysis of the findings of a questionnaire form about an application which implements gamification elements with a user centered design, answered by Computer Engineering students coursing their third year of college or further. The application was designed with usability principles in mind, incorporating gamification elements so that the students could implement it as a tool in their courses.

This section describes how, according to these students, the application could meet its potential in terms of effectiveness.

A. Questionnaire and research group

The selected course for the validation is the Operating System course, specifically the selected subject was the processing time analysis of several schedule disciplines: first in – first out, the shortest job first, priority-based scheduling, and the round robin technique.

After a short presentation, the students were given a short questionnaire which its purpose was to get their opinions to see how this application could cater more to its user, and to put it in the right path for success, since most of its end users will be students. The list of questions is as follows:

1. Have you ever heard about gamified apps?
   o Yes
   o No
2. Do you often use apps with gamification elements in it?
   o Yes
   o No
3. Have you used a tool like this one in a classroom setting before?
   o Yes
   o No
4. What year are you coursing?
   o First Year
   o Second Year
   o Third Year
   o Fouth Year+
5. What is your favorite game mechanic?
   o Badges
   o Points
   o Leaderboards
6. What particular aspect(s) of the application do you like?
7. What particular aspect(s) of the application do you dislike?
8. What would you add to this application to make it more successful?
9. Would you implement a tool like this one into your current studying habits?
   o Yes
   o No
10. Please rank what you look for in order of importance when using an application like this one (5 - greatest important and 1 – less important) Table 1.

Table1. Importance ranking for question 10.

Aspect	1	2	3	4	5
Design					
Game					
Familiarity					
Relevant game mechanics					
Simplicity					
Consistency					
Competitive Aspect					
Interacting with instructor/class mates					

B. Results

Seven students coursing their third year or further of college were gathered to receive an introduction to this research's main purpose – integrating usability principles through gamification in an application that implements a user centered design. The results for each question are as follows:

1. The first question: Have you ever heard about gamified apps?

Four students answered yes, the other three had never heard of it. The graphical interpretation can be seen below in Figure 9.
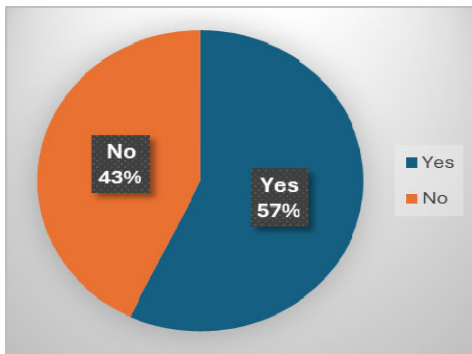
Figure 9. Results for the first question.

2. The second question: Do you often use apps with gamification elements in them?

Although in question 1, most students answered that they had heard about gamified apps, in these questions it resulted that only 2 students often used this type of app while the other 5 did not. A graphical interpretation can be seen in Figure 10.
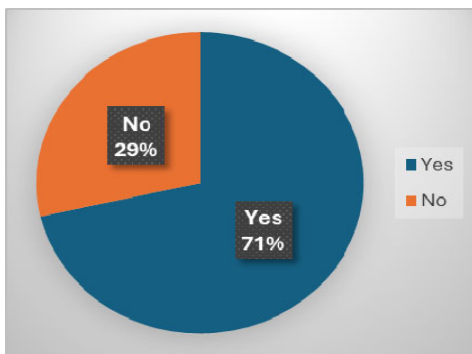

Figure 10. Results for the second question.

3. The third question: Have you used a tool like this one in a classroom setting before?

The same ones that had answered that they had heard of gamification apps before were the ones that admitted to using this type of application in a classroom setting, while the two students that had not heard about this type of application were the ones that answered no. A graphical interpretation can be seen below in Figure 11.
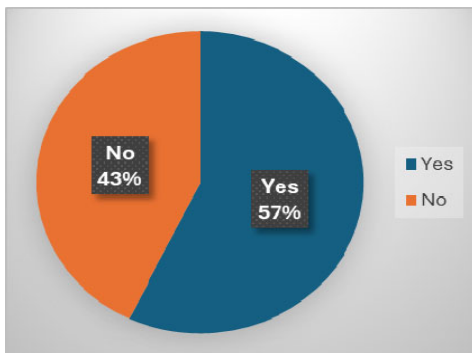

Figure 11. Results for the third question.

4. The fourth question: What year are you coursing?

Four of them were third year students and the other three were coursing their fourth year or more of college. A graphical interpretation can be seen in Figure 12.
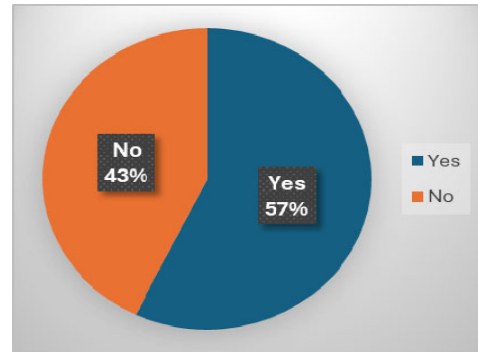

Figure 12. Results for the first question.

5. The fifth question: What is your favorite game mechanic? Leaderboard was number one with 4 responses, followed by points which obtained 2 responses, and badges only received one vote. A graphical representation can be seen in Figure 13.
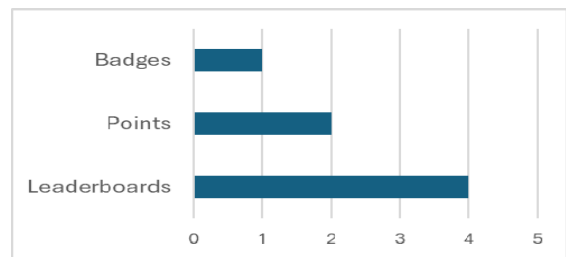

Figure 13. Results for the first question.

Table 2. Results for the sixth question.

Data	Count
Change the educational environment to a more relaxed and fun one. Encourages the student to enter the academic world as a complementary hobby to gaming.	1
1. The option of linking accounts you already have instead of creating a new one 2. Dark mode 3. Concept of currency and lives and unlocking new topics completing the previous ones	1
I like the idea in general, being able to complete missions to keep progressing. The examples given in pictures.	1
The part of the idea of the app I liked so much.	1
I like the simplicity of it.	1
I like the whole idea of it since it demonstrates a unique way of learning that makes the whole process fun and enjoyable in a lot of ways.	1
The fact that users can learn in an even comfortable environment about hard, technical topics.	1

6. The sixth question: What particular aspect(s) of the application do you like?

Most of the answers included how they liked that it was something different being implemented into classrooms and

that it allowed them to learn about these hard topics in a comfortable manner, making it a fun and enjoyable experience. The detailed answers can be further analyzed below in Table 2.

7. The seventh question: What particular aspect(s) of the application do you dislike?

Most of them answered that they did not like the fact that it had too much text. Others said that it needed to be given a more "game like" aspect. The detailed answers can be further analyzed below in Table 3.

Table 3. Results for the seventh question.

Comments	Count
Lots of text. The excessive use of written contexts of the themes would make the user not feel like a gaming environment.	1
I don't dislike it but would suggest bettering the color design and maybe a logo to make the application stand out from others and be unique.	1
Too much text, It would benefit a lot by having shorter text, it can also be the same but in different pages so it would be more attractive to read	1
For the moment I like all the implementations.	1
There's too much text for a game. I would like it to be simplified	1
Personally, I would modify the UI to give it a more game like aspect.	1
Too much text	1

Table 4. Results for the eighth question.

Comments	Count
Cooperative or competitive multiplayer. For the cooperative, it helps the user to create experiences with their partners and the administrator (for example, the teacher). The competitive one encourages the user to practice and improve their skills, however it is necessary to avoid the generation of toxic competitive spirits between users.	1
To incentivize the return of a person into the application, I would suggest a completion/progress bar-like element. 2. A daily login or reward calendar could also help to incentivize the users to come back and use the application a lot more frequently	1
Daily and weekly challenges. A trophies system by completing parts. If you fail an answer, get another example with different numbers so you can't "cheat" by answering all in different orders	1
In my opinion to this app need to be more striking to attract more community.	1
I would put more variety, not just concepts of Operating System	1
I would modify the UI Design to give it a more "game like" aspect. I would add a dark mode and an option to modify font colour in certain areas.	1
The developer should include a button to hide big paragraphs so it can be visually appealing to the end user. User can then tap the button to view the full text.	1

8. The eighth question: What would you add to this application to make it more successful?

Most of them answered that it would be good to add more gamification elements such as daily challenges, competitive multiplayer and a progress bar, while other commented about the UI such as reducing text and giving it a more game like aspect. Detailed answers can be further analyzed below in Table 4.

9. The nineth question: Would you implement a tool like this one into your current studying habits?

The seven of them answered that they would. A graphical interpretation can be seen in Figure 14.
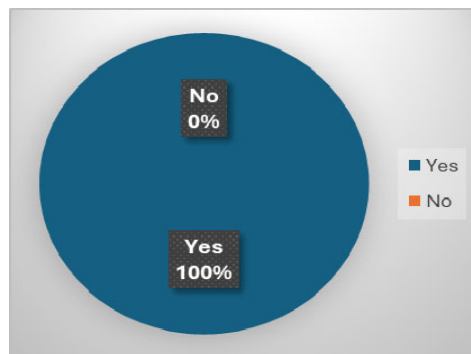

Figure 13. Results for the nineth question

10. Please rank what you look for in order of importance when using an application like this one (5 - greatest important and 1 – less important).

For the last question, students were given certain aspects such as: design, games, familiarity, relevant game mechanics, simplicity, consistency, competitive aspect, and interactivity. They were asked to rank these in order of importance when using an application like the one that was being presented to them. For design, 43% answered that it was important while the other 57% answered that it was very important. For the game's aspect, 29% answered that it was maybe important, 57% answered that it was important and 14% answered that it was very important. For the familiarity aspect, 14% answered that it was maybe important, 57% answered that it was important and 29% answered that it was very important. For the relevant game mechanics, 29% answered that it was maybe important, 43% answered that it was important and 29% answered that it was very important. For the simplicity aspect, 33% answered that it was maybe important, 33% answered that it was important and 33% answered that it was very important. For the consistency aspect, all students answered that it was very important. For the competitive aspect, 29% answered that it was somewhat important, 29% answered that it was maybe important and 43% answered that it was very important. For the interactivity aspect, 14% answered that it was maybe important, 14% answered that it was important

and 71% answered that it was very important. Figure 10 pictures these results through a graphical representation.

Table 5. Results for the tenth question.

Aspect	1	2	3	4	5
Design				3	4
Game			2	4	1
Familiarity			2	4	2
Relevant game mechanics			2	3	2
Simplicity			2	2	2
Consistency					7
Competitive Aspect		2	2		3
Interacting with instructor/classmates			1	1	5

VI. SUMMARY AND FUTURE WORK

Integrating usability principles into a gamified application for the operating systems course is crucial for it to be successful. Considering the usability principles, the gamified application should be easy to use, clear, and have straightforward instructions. Additionally, game elements that are aligned with the educational objectives will be integrated as discussed before.

To validate the application, a ten-questions questionnaire forms was designed and distributed to several students. The suggestions and opinions given by the students were applied to the user centered designed and will be applied throughout all the work done in this research. In addition, more lessons of the operating systems course will be included in the application, looking forward to explaining it and putting it in a way that students can engage with it and understand them.

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