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RESEARCH ARTICLE

Usability and Workload Evaluation of a Cybersecurity Educational Game Application: A Case Study

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ABSTRACT Currently, social networks and Internet access have become a place that fosters risky experiences for their users, who are vulnerable and can become victims of violence, online abuse, extortion, etc. Therefore, it is considered necessary to make people aware of the appropriate use of information and communication technologies (ICTs) and Internet access, to minimize the risks and vulnerabilities associated with these practices. This research analyzes the use of a game-like mobile application called CiberSecApp, which was designed to support the teaching of basic cybersecurity. This application was designed as a game because gamification has been shown to generate motivation and keep users interested in long periods of time. In addition, the new generation of students perceives educational mobile apps as an innovative way to access educational content in a simple, ubiquitous, and portable way Unlike other similar initiatives in the existing literature, this research did not focus solely on the game design aspects, but also on evaluating the user experience. For this purpose, the IBM Computer Usability Satisfaction Questionnaires (CSUQ) and the NASA Task Load Index (TLX) were used to evaluate the usability of the mobile application and the mental workload generated by the participants. A total of 60 engineering students participated voluntarily in this research. The results obtained show that the use of gamification of educational content can support the teaching of cybersecurity by creating an intention of use and with a low mental workload for its users.

INDEX TERMS Gamification, mobile learning, cybersecurity, security, mobile games, mobile app, innovative learnig.

I. INTRODUCTION

The first massive cyberattack on the Internet took place in 1988, and since that day security has been an issue that has been urgently addressed [1]. The first adventurers in computer attacks were amateurs who had an in-depth knowledge of computer science and programming [2]. They used their skills to test the limits and capabilities of early computer systems [2], [3].

Cybersecurity is the practice of defending computers, servers, mobile devices, networks, and data from malicious attacks [4], [5]. Information networks have become an integral part of our daily life, these are used by all types of organizations, which directly or indirectly depend on these technologies to work effectively [6]. The network is used to collect, process, store and share large amounts of digital information, this infrastructure must ensure the confidentiality,

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integrity, and availability of this information [7], [8]. Today's world has evolved, mainly due to technological progress in recent years, and information and communication technologies (ICTs) have made life easier and freer for their users at a pace that has never been seen before [9], [10], [11], [12].

However, despite all the benefits and advantages that technology brings, there are risks to which users of new technologies are exposed [13], [14]. The development of ICTs and easy access to portable digital technology has contributed to the emergence of an issue of high social interest: problematic/abusive Internet use [3], [13], [15]. Technology, subtly, brings to our lives, our jobs, and businesses multiple advantages, but also threats [16], [17]. The main threat is related to the security of data networks and personal information shared over the Internet [18]. Computer risks that until a few years ago could only be seen as science fiction, have become real, the networks that are used and the information that is shared on the Internet suffer almost daily threats that attempt to steal the information to traffic or blackmail [8], [18], [19]. In addition, the easy, fast, and ubiquitous access to the Internet, are characteristics that can increase the mentioned problems and generate multiple more. With the advancement and popularization of technology, the dangers of computer security become increasingly stealthy and very relevant, for this reason it is important that people know about the dangers that exist in a world that is increasingly connected and dependent on Internet access [8], [19].

The importance of cybersecurity learning is of utmost relevance nowadays due to several factors such as Cyber threats including malware, phishing, ransomware, and other types of attacks are constantly increasing [20]. Cybercrime is a growing industry, and organizations and individuals are at risk of online attacks. On the other hand, cybersecurity is essential to protect sensitive information and personal data. With the increasing amount of digital information, data loss or theft can have serious consequences [21]. In many industries, there are regulations and laws that require cybersecurity measures, such as the General Data Protection Regulation (GDPR) in the European Union [22]. Failure to comply with these regulations can result in significant financial penalties. cybersecurity is essential in an increasingly digitized and connected world. Constant learning in this area is crucial to protect the information, operations, and reputation of organizations and to ensure the online safety of individuals [4].

There are several initiatives in the use of gamification for cybersecurity education, for example:

The Network Defense Training Game (NDTG) is a training platform that encompasses a series of cybersecurity events [23]. Here the player evaluates and defends a network by thwarting a potential enterprise security attack. Alternatively, Graham, K, et al. Show a novel serious game called Cyberspace Odyssey (CSO), which serves as a support for computer networking education and engages players in a race to successfully perform various cybersecurity tasks [24]. There is research describing the analysis of using games to teach about security equipment. It also shows the minimum requirements for designing and building a simple, configurable, team-oriented information security-oriented game [25].

Unlike other similar initiatives in the current literature, the research presented below does not focus solely on the game design but performs the analysis of mental workload and usability of a mobile application called CiberSecApp. For this purpose, the usability questionnaire of the IBM Computer System Usability Satisfaction Questionnaries (CSUQ) was used, which evaluated the usability of the mobile application [26], [27]. Moreover, for the study of mental workload, the NASA Task Load Index (TLX) instrument was used, which analyzes six dimensions: mental demand (MD), physical demand (PD), temporal demand (TD), performance (PE), effort (EF) and frustration level (FL) [27], [28]. It is important to analyze usability and mental workload, because these two factors directly affect the acceptance of technology as a support in education [29].

This paper is organized as follows. The first section introduces the reader to the topic of cybersecurity and the issues related to the problems encountered. The second section describes gamification in education. The third section shows the development of the cybersecurity application. The fourth section relates the methodology used to perform the usability and workload analysis. The fifth section indicates the main findings of the study. The sixth section details the discussion of the results obtained. Finally, the seventh section shows the conclusions, and the eighth section discusses future work.

II. GAMIFICATION IN EDUCATION

Currently, education faces a great challenge, which is to ensure that educational institutions offer quality education, as defined in the Sustainable Development Goals [30]. One of these objectives seeks to transform education through the support of new technologies and the design of innovative educational models. However, even smart educational technologies may lose their effectiveness if they fail to motivate students in their intended use [31]. It has been shown that gamification of education motivates students, and they feel more engaged in their learning [32], [33], [34]. Gamification in education can be defined as a developing approach to improve student motivation and engagement through the design of games in educational environments [35]. Games lack value unless people play them, so the design of these educational applications must generate emotions to create in players the intention of use and enjoyment [36]. In education, there have been two main purposes for gamification in education: the first was to encourage desired learning behaviors, and the second was to promote student participation in learning communities [37].

There is research on gamification in education that provide evidence on, improving skills such as critical thinking and decision making [38], [39], academic performance [40], [41], and communication skills [42]. There are many examples of the use of gamification in education. The Q-learning-G

TABLE 1. Development platforms used.

Development platforms	Characteristics
Microsoft Visual Studio	Visual Studio is one of the best tools for development because it has a very intuitive integrated development environment (IDE) that allows you to implement solutions on any platform, develop games and applications for Android, iOS, and Windows. It also has other complementary tools for game development such as Unity that strengthens the development of this type of applications.
Xamarin	Visual Studio offers an open-source cross-platform tool for the development of applications and games called Xamarin which is a developer platform composed of tools, programming languages and specific libraries for the creation of applications on Android, iOS, macOS, Windows. One of the advantages is that it offers coding in C#, in addition it offers an open-source cross-platform integration that allows you to create from a shared code base.

TABLE 2. Requirements for the design of mobile applications [46].

Requirements	Characteristics
Simple and easy to use	Provide ease in the game, the user should not get caught in the links of the different sections
Consistent interfaces	Use known functionalities that resemble computer menus
Nice design	Generate satisfaction, enthusiasm, and fun by using the different controls in the activities carried out by the application
Feedback	Provide an understanding of mistakes made to improve task interpretation
Multimedia content	Generate use intent by creating multimedia interfaces that attract the user's attention
Intuition	Avoid user disorientation due to total number of interactions
Motivation	Motivate the user with kind messages while progressing through the game

platform can be used to engage computer science students in gamified learning activities [37]. There is a study that analyzes how gamification in Massive Online Open Courses (MOOCs) affects participant engagement and seeks to identify what types of interactive gamification media are most useful in generating student interest and motivation for studying energy efficiency [43]. In Nigeria, a game called SpeedRocket was used to support mathematics teaching, the results indicate improvements in students' cooperation, participation, and engagement in their learning [44].

III. MOBILE APPLICATION DESIGN

The design of the mobile application was performed using the Visual Studio 2017 Enterprise platform and Xamarin. The characteristics of these platforms are detailed in Table 1.

The design of a mobile application must consider the characteristics of the various end users during its development stages. This is because problems can be generated that have to do with the usability and the intended use of the application [45]. The requirements identified for the design of the educational mobile application are detailed in Table 2. These requirements were identified in previous research on the use of mobile learning in education. In that initiative, a mobile application design was proposed to support the teaching of an indigenous language. In addition, a technology acceptance model was used to validate the participants' intention to use the application [46].

In the design of this game-like application, several libraries and add-ons were used, which guarantee the correct connection and access to the users, as well as the messaging service that will send notifications. These libraries were:

- Xamarin.Auth: to help authenticate users via standard authentication mechanisms, and store user credentials.
- Xamarin.FFImageLoading: to load images quickly and easily on Xamarin.Android.
- Xamarin.Firebase.Messaging: bindings for firebase messaging.

Libraries were also used to facilitate the design of the different screens and the menu of the mobile application, which served to display the information within the mobile application in an attractive way for the user. These libraries used were:

- CarouselView.FormsPlugin: to control for Xamarin forms.
- Com.Airbnb.Xamarin.Forms.Lottie: to render After Effects animations natively on Android.
- DLToolkit.Forms.Controls.FlowListView: to generate FlowListView for Xamarin Forms.

The requirements necessary to build an educational mobile application that is simple, intuitive and with a user-friendly interface are important to avoid user disorientation due to the total number of interactions that can be performed [31]. In addition, the design should ensure that the application

TABLE 3. Iterations required to build the mobile application.

Iteration Number	Definition	Priority (1 -10)	Iteration duration
1	The password provided must be secure and allow easy access.	7	3 weeks
2	The startup interface must be intuitive and display adequate information on the use of the application.	7	3 weeks
3	Information about the game levels and how to pass them must be provided	7	3 weeks
4	Every time the player passes a level, he must have a reward	7	3 weeks
5	When there are errors in the answers to the questions, there must be immediate feedback	7	3 weeks
6	The level of each game should evaluate the knowledge acquired at each stage.	7	3 weeks
7	Design of the first set of the level 1 of the application.	9	4 weeks
8	Design of the second set of the level 2 application.	9	4 weeks
9	Design of the third set of level 3 of the application.	9	4 weeks
	Total duration of mobile application development		30 weeks

TABLE 4. Example of construction of the first iteration.

Iteration number	1
User	Administrator
Risk in development	High
Priority	9
Assigned Sprint	1-A
Programmer in charge	Programmer _1
Description	The application needs to be easy to access and authenticate so users are required to have an ID and password.
Observations	Users and passwords will be created by the administrator and will be securely issued to users who will use the mobile application.

generates motivation and intention to use it [47], [48]. The user's perception regarding the use of the application must be pleasant, the navigation between the different interfaces of the game must be easy and intuitive [49], [50]. Each screen must be presented in a coherent way, with appropriate colors, and with enough information for the user to enjoy using it [51]. Therefore, the application to be designed should have a friendly interface, be simple, coherent and intuitive, avoid redundancies, have an interactive navigation, use colors, fonts and text types that avoid confusion. The images used should be in high resolution, it should use messages with emotive and polite words. Multimedia and interactive material should also be incorporated, feedback should be immediate, instructions should be clear so that the user understands what to do in each part of the game [31], [50], [52], [53].

The mobile application has three small interactive games that were developed to reinforce basic cybersecurity knowledge. In addition, the design of the interfaces was intended to make the application entertaining, easy to use and to motivate learning.

To achieve the objective of the mobile application design, Scrum was used, which is an agile methodology used to work collaboratively in the achievement of a project [54]. For this purpose, nine iterations were defined, of which the first six lasted three weeks, and the last three, in which the games for the three levels were developed, lasted four weeks each. This can be seen in Table 3 and 4.

Table 3 indicates the nine iterations, which were defined by the research group to complete the design of the mobile application with the requirements specified in Table 2. Table 4 shows the development of iteration number one. Each of the iterations were developed based on the established risk and priority. The priorities were established based on the time available to develop each of the iterations. The description and observations are important to be able to analyze it individually and generate feedback.

Each iteration contemplated the selection of requirements and time planning for each activity that was defined in the development of the mobile application [54]. Subsequently, each iteration was executed within the established time, and if there was anything new, the research group met for 30 minutes to resolve all doubts and continue with the development. The risk in the development had to do with the uncertainty of being able to correctly perform what was requested in the

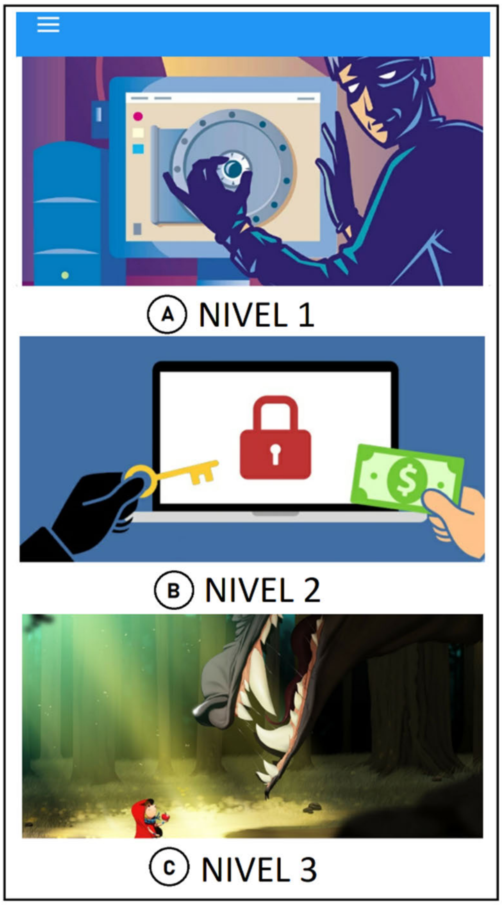

FIGURE 1. Three game levels designed in the mobile application. A = Level 1; B = Level 2; C = Level 3.

mobile application. Finally, the review, demonstration and adaptation of the fulfillment of each iteration was carried out in a meeting with the entire working group to finalize the construction of the CiberSecApp application.

Figure 1 below shows the main screen of the designed mobile application. This image contains information written in Spanish because the mobile application was designed in this language. This figure shows the home screen with the 3 levels of the game. The levels in the game indicate, in ascending order, increasing difficulty and require, to play the game, a greater mastery of cybersecurity concepts.

The three levels of the game were designed based on rewards, because this increases the player's enjoyment of recreational games [55]. Additionally, rewards in games positively affect the player's interest. Therefore, improved attention and retention of educational content can be achieved [55]. The types of rewards can be ease, glory, sensory feedback, access, sustenance, and praise [56]. For this game, feedback, ease, and praise were used.

Level one was designed as a multiple-choice survey. This level showed immediate feedback when there was an error and, when there was a success, it showed praise accompanied by points. Level two was developed based on the traditional "Hangman" game, which allows you to answer questions about cybersecurity in an entertaining way. The idea of this level is to guess the incomplete word, and, for each correct guess, you save a character from being hanged. In this level, praise is used to create motivation and enjoyment in the player.

Level three was designed based on the story of Little Red Riding Hood. This story was chosen because it is very popular in Ecuadorian literature and most of the citizens know it. In this level we challenge the player to identify the safety risks that can be found in the dialogues between Little Red Riding Hood and the wolf, using feedback when there is a mistake and praise when there is a success. Applying a situation well known to all and placing it in the context of cybersecurity can enhance learning about the security concepts it is intended to address [57].

IV. METHODOLOGY

The mobile application was designed as a game because gamification has been shown to generate motivation and keep users interested in long periods of time [32]. However, an evaluation of the usability and mental workload associated with the use of the mobile application is necessary. This user experience can positively affect the technological acceptance and the intention to use the mobile application. For this purpose, the NASA TLX instrument and the CSUQ tool were used to evaluate the mental workload of the users and the usability of the mobile application. These tools were used because they have become the most widely used evaluation standards for this type of analysis [26], [27]

Participants: Sixty students participated in this research, who were selected by convenience sampling and belong to a private university in quito-ecuador. each participant accepted an informed consent given through a web form. The use of questionnaires to participants did not require permission from an ethics committee, because the students are part of the university that sponsored this research. Therefore, only a letter of sponsorship signed by the dean of the faculty giving consent for the work to be done was issued.

The age of the participants was between 18 and 20 years. Of the 60 participants, 57 were male (95%) and 3 were female (5%), 42 were 18 years old and 18 of them were between 19 and 20 years old. Likewise, 100% of them reported that they had their own mobile device and Internet access at home, only 96% had a mobile data plan. On the other hand, 48 of them had a mobile device with Android operating system (OS), and 12 had a mobile device with iOS OS, only 4 of them had two mobile devices, one with Android and one with iOS.

Tasks: Participants were required to complete the following tasks:

- Initial test: initial questionnaire that users had to complete before the start of the game, which contained questions to evaluate basic cybersecurity concepts. The

initial test questions were obtained from a course that is part of the CISCO Academy [50]. This course is free of charge for the university students who participated in this research.
- Use of CiberSecApp: users tested the application for about 20 minutes, or until all levels of the game were completed.

Post-test: after finishing the game, users were asked to fill out the initial questionnaire again.

Usability: after finishing the game, users were asked to answer a usability questionnaire.

Workload: after finishing the game, users were asked to answer a workload survey produced while using the application.

A. USABILITY ANALYSIS

For the analysis of the usability of the CiberSecApp application, a survey provided by the IBM-CSUQ tool [26], with the Likert 7 scale [58]. This document consists of 19 questions that interpret the satisfaction perceived by the users when using the application designed [26]. As can be seen in Table 5, this survey was designed to provide information about the usability of the system (SYSUSE), the quality of the information presented (INFOQUIAL), the quality of the interfaces (INTERQUIAL), and a general validation of the application and its usability (OVERALL).

B. MENTAL WORKLOAD ANALYSIS

The NASA tool (TLX) is a popular technique for measuring mental workload [27]. It uses six dimensions: mental demand, physical demand, time demand, performance, effort, and frustration level, on a scale of 1-20, where 1 is the least important value, and 20 is the most important value. This can be seen in Table 6. These dimensions are used to derive an overall average workload score [28]. A comparison was also made between each of the six dimensions to identify which aspect of the compared pairs contributes most to the workload of the task performed. There are 15 possible combinations of pairs between the scales.

Based on the responses to the initial test, and the results of the usability and workload analysis, tried to test the following hypotheses:

- *H1: There is a positive variation in cybersecurity concepts before and after using the app*

- *H2: The mobile application is easy to use for learning basic cybersecurity concepts.*

- *H3: The level of mental workload when using the app is low.*

A single-group pretest-posttest design without a control group was chosen because of the low number of students willing to participate in this research.

V. RESULTS

The results obtained in this research are presented below.

TABLE 5. IBM-CSUQ tool question.

Questions SYSUSE
1. Overall, I am satisfied with how easy it is to use this system.
2. It is simple to use this system.
3. I can effectively complete my work using this system.
4. I am able to complete my work quickly using this system.
5. I am able to efficiently complete my work using this system.
6. I feel comfortable using this system.
7. It was easy to learn to use this system.
8. I believe I became productive quickly using this system.
Questions INFOQUIAL
9. The system gives error messages that clearly tell me how to fix problems.
10. Whenever I make a mistake using the system, I recover easily and quickly.
11. The information (on-screen messages and guidance or other documentation) provided with this system is clear.
12. It is easy to find the information I need.
13. The information provided with the system is easy to understand.
14. The information is effective in helping me complete my work.
15. The organization of information on the system screens is clear.
Questions INTERQUIAL
16. The interface of this system is pleasant.
17. I like using the interface of this system.
18. This system has all the functions and capabilities I expect it to have.
Question OVERALL
19. Overall, I am satisfied with this system

A. INITIAL TEST

As part of the activities reported to the students, they were asked to solve a test, prior to the use of the mobile application, on basic knowledge of cybersecurity. After using the CiberSecApp, the same test was taken again, and the results obtained were compared. In the test prior to using the application, the average score was 7 out of a maximum of 10 points. However, in the second test, after the use of the mobile application, the results showed an average of 8.47. This result indicates that the use of the mobile application generated an improvement of 14.47% in the overall average. This result confirms the first hypothesis *H1* and shows that there is a positive variation in cybersecurity concepts after using the mobile application.

On the other hand, a small survey of three questions with Likert scale 7, about cybersecurity knowledge was conducted, these were:

Q1. What do you know about cybersecurity?

Q2. How would you rate your ability to learn how to use an application you have never used before?

Q3. Would you like to learn cybersecurity topics with a game-type mobile application?

Figure 2 shows the answers obtained from the participants. It can be observed that most of them have little knowledge

TABLE 6. NASA-TLX rating dimension description [27].

Title	Description	Escala
Mental Demand (MD)	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?	1-20
Physical Demand (PD)	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?	1-20
Temporal Demand (TD)	How much time pressure did you feel due to the rate or pace at which the tasks or task, elements occurred? Was the pace slow and leisurely or rapid and frantic?	1-20
Performance (PE)	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?	1-20
Effort (EF)	How hard did you have to work (mentally) to accomplish your level of performance?	1-20
Frustration Level (FL)	How insecure, discouraged, irritated, stressed, and annoyed or secure, gratified, content, relaxed, and complacent did you feel during the task?	1-20

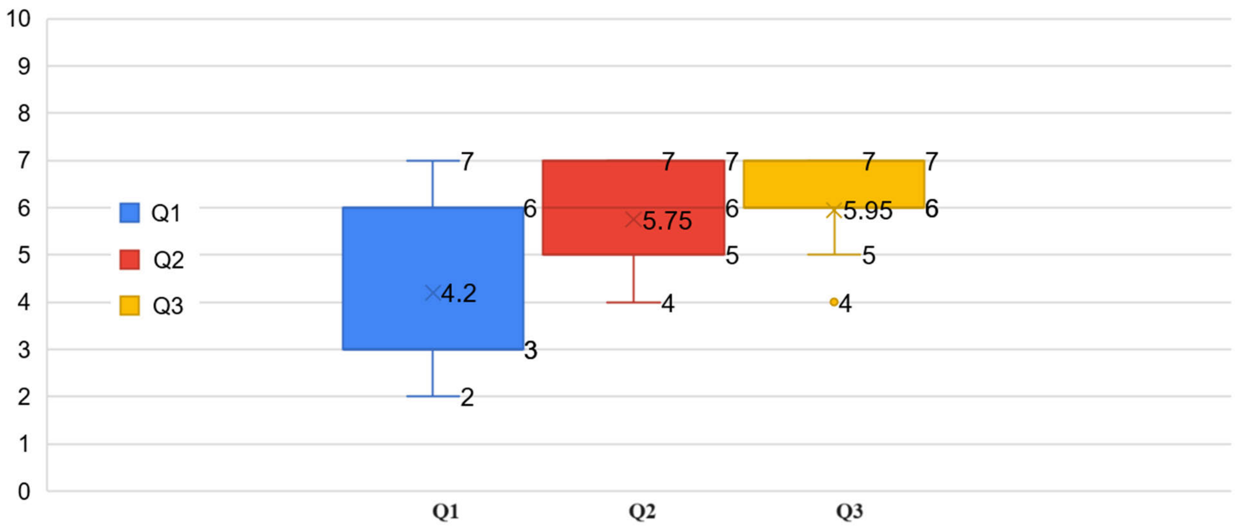

FIGURE 2. Answer to questions Q1, Q2, yQ3.

about cybersecurity topics, but they are willing to learn using a mobile application. Also, most of them believe that they are capable of learning how to use an educational mobile application

B. USABILITY ANALYSIS

Table 8 shows the mean, median and standard deviation results for the four categories of the IBM-CSUQ tool. Figure 3 shows the results of the IBM-CSUQ questionnaire in graphical form, here a positive result can be seen, since most of the participants responded with "I agree" and "I strongly agree" to the questions asked. Table 8 shows that the usability of the system (SYSUSE) had a positive trend, which is superior to INFOQUIAL and INTERQUIAL, both in the minimum value (4.95), as well as in the average of the results ($\mu = 5.68$). These data indicate that the mobile application is easy to use and generates user satisfaction. Similarly, the quality of the information presented (INFOQUAL) has the second-best result in the average ($\mu = 5.58$), but the lowest minimum value (4.54). This indicates that the information presented in the application should be more accurate and less abundant on screen. On the other hand, the quality of the interfaces (INTERQUIAL) had the lowest average value ($\mu = 5.54$), which indicates that it can be improved, thus it is considered necessary to incorporate a detailed user manual. These results suggest a positive overall satisfaction (OVERALL), which was reflected in the results obtained. These showed that the average overall satisfaction was ($\mu = 5.82$), a minimum value of 4.64 and a standard deviation of ($\sigma = 1.17$).

TABLE 7. Mean (μ), standard deviation (σ) and median (m) per question IBM-CSUQ.

IBM-CSUQ	Question	μ	σ	M
SYSUSE	1. Overall, I am satisfied with how easy it is to use this system.	6.02	1.08	6
	2. It is simple to use this system.	6	1.01	6
	3. I can effectively complete my work using this system.	5.4	1.36	6
	4. I am able to complete my work quickly using this system.	5.83	0.78	6
	5. I am able to efficiently complete my work using this system.	5.5	1.19	6
	6. I feel comfortable using this system.	5.75	1.04	6
	7. It was easy to learn to use this system.	5.67	1.36	6
	8. I believe I became productive quickly using this system.	5.28	1.32	6
INFOQUIAL	9. The system gives error messages that clearly tell me how to fix problems.	5.42	1.45	6
	10. Whenever I make a mistake using the system. I recover easily and quickly.	5.77	1.66	6
	11. The information (on-screen messages and guidance or other documentation) provided with this system is clear.	5.6	1.68	6
	12. It is easy to find the information I need.	5.42	1.92	6
	13. The information provided with the system is easy to understand.	5.52	1.57	6
	14. The information is effective in helping me complete my work.	5.68	1.14	6
	15. The organization of information on the system screens is clear.	5.68	1.36	6
INTERQUIAL	16. The interface of this system is pleasant.	5.7	1.32	6
	17. I like using the interface of this system.	5.6	1.37	6
	18. This system has all the functions and capabilities I expect it to have.	5.33	1.3	6
OVERALL	19. Overall, I am satisfied with this system	5.82	1.17	6

TABLE 8. General results of the IBM-CSUQ survey.

	SYSUSE INFO	INFOQUIAL	INTERQUIAL	OVERALL
Top	6.42	6.62	6.50	6.99
Average	5.68	5.58	5.54	5.82
Botton	4.95	4.54	4.59	4.65
Median	5.75	5.86	5.67	6.00
Standard Deviation	0.74	1.04	0.95	1.17

Question 18 is the lowest rated question (μ = 5.33, σ =1.30 and M = 6), indicating that the mobile application needs more functions and services, these can be suggested by the participants who used the application for this research. The highest rated questions are question 1 (μ = 6.02, σ =1.08 and M = 6) and question P2 (μ = 6 σ =1.1 and M = 6), which indicate that participants perceive ease of use, and that most of them felt comfortable using the application. Figure 3 shows the values obtained for each category of the IBM-CSUQ tool. In summary, the results of the questionnaire were perceived as very positive. SYSUSE and OVERALL have the highest values, reflecting that the overall satisfaction in using the application is strongly related to its ease of use, which answers hypothesis *H2*.

C. MENTAL WORKLOAD ANALYSIS

To evaluate the mental workload, the NASA-TLX tool was used in the 60 students, all of whom were evaluated in a university laboratory and responded to a survey to analyze the six dimensions of workload distinguished by the NASA-TLX: mental demand (MD), physical demand (PD), temporal demand (TD), performance (PE), effort (EF), and frustration level (FL), and range of response. These data can be seen in Table 9.

TABLE 9. IBM-CSUQ results (1 – 20).

Students	MD	PD	TD	PE	EF	FL
60	7.75	1.00	6.32	10.88	5.62	3.62

It can be observed, in Table 9 and Figure 4, that the perceived performance (PE) by students had the highest rating, this shows that, students perceive that they can perform

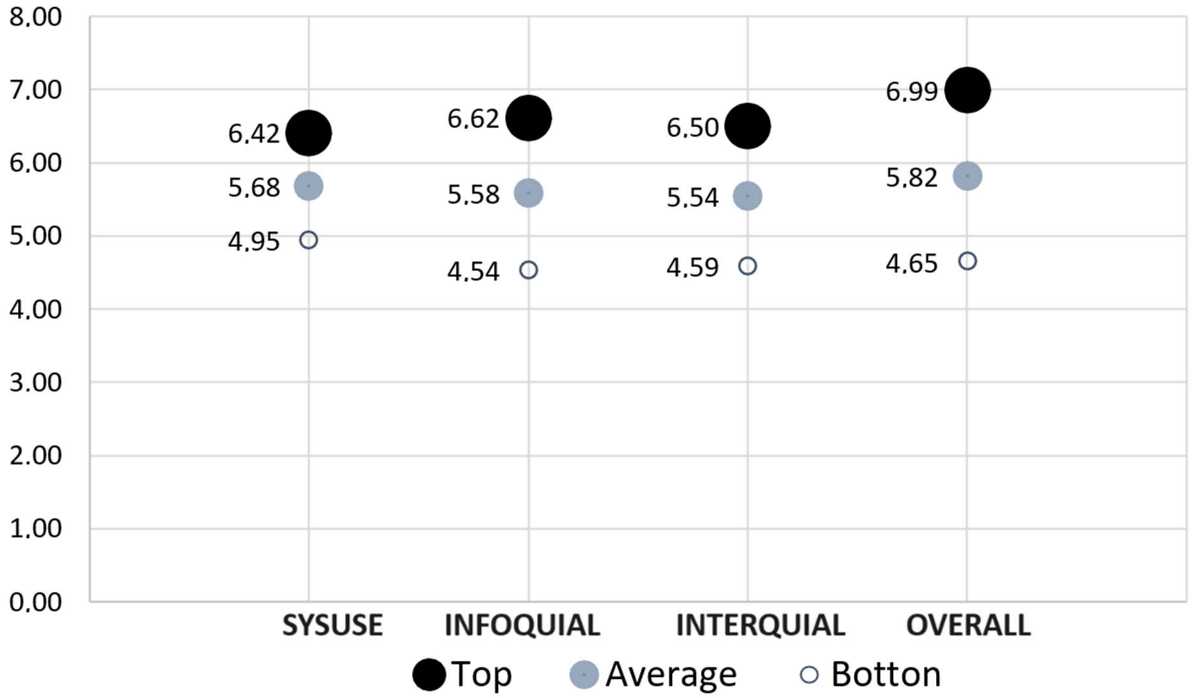

FIGURE 3. Response to questions Q1, Q2, and Q3.

TABLE 10. NASA-TLX dimension pair analysis.

Students	MD-PD	MD-EF	MD-FL	MD-PE	MD-TD	PD-FL	PD-PE	PD-TD	PE-TD	EF-PD	FL-EF	FL-PE	EF-PE	FL-TD	TD-EF
MD	58	48	45	46	44										
PD	2					10	17	24		12					
TD					16			36	25					35	29
PE				14			43		35			42	23		
EF		12								48	34		37		31
FL			15			50					26	18		25	

better when using the mobile application. From here on, the responses are only on the scale of 1-10; that is, in the lowest 50% of the load associated with the remaining five dimensions of NASA-TLX. Second place goes to mental demand (MD), indicating that the use of the mobile application was an initially demanding task. The third place goes to temporal demand (TD), which means that the time pressure felt by the student to complete the tasks of the application was low.

The fourth place goes to the effort made (EF), which indicates that the students perceived a low level of mental effort when using the mobile application. The fifth place goes to the frustration level (FL), which shows that students perceived a minimum frustration in the use of the application. Finally, it can be said that students did not perceive any physical demand (PD) to complete the activities in the mobile game.

Table 10 shows the perception of the students in the pair analysis of the six dimensions of the NASA TLX. With this information we proceeded to calculate, in a qualitative manner, the mental workload generated in the students who used the CiberSecApp application.

Tables 11 and 12 were used to calculate the data obtained from the NASA-TLX surveys, which are: evaluation table and table of scores of the NASA-TLX tool. Table 11 shows the quantitative calculation of mental workload in student number one. In Table 11 column A, refers to the weight of MD, i.e., how many times MD is repeated in Table 10, compared to its peers. Column B is the score obtained in MD in Table 9. Column C and D responds to a simple multiplication of B x 5 and C x A. The total quantitative score, which defines the perception of student one regarding the mental load in the use of the mobile application, was 595 points. This value, according to Table 12, indicates that student one perceives a medium mental workload when using the mobile application.

Table 12 shows the total result of the level of mental workload perceived by the students who participated in this research. It can be observed that there are 34 students

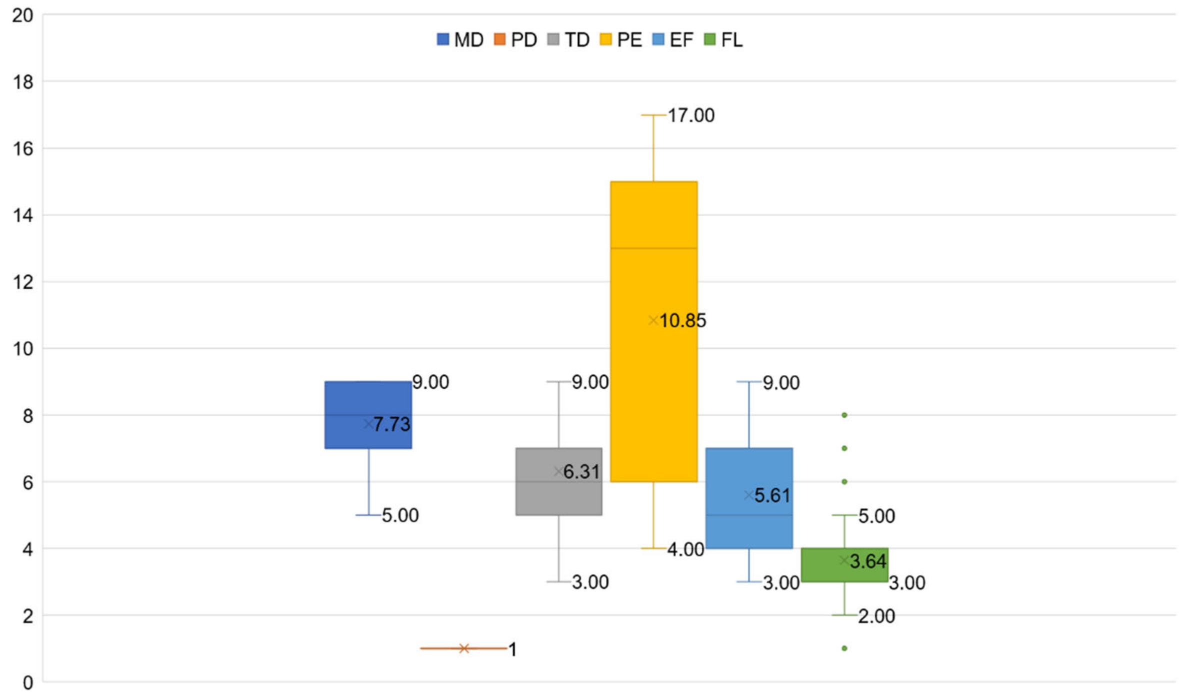

FIGURE 4. Answers to the six categories of NASA-TLX.

TABLE 11. NASA TLX evaluation table.

Student 1	A) Weight	B) Score	C) Converted score (B x 5)	D) Weighted Score (C x A)
MD	5	9	45	225
PD	0	1	5	0
TD	4	7	35	140
PE	2	13	65	130
EF	3	6	30	90
FL	1	2	10	10
Total	15	38	190	**595**

TABLE 12. NASA TLX scoreboard.

NASA TLX	Mental Workload Level
Score less than or equal to 500 points	34 (Low)
Score greater than 500 points and less than 1,000 points	26 (Medium)
Score over 1,000 points	0 (High)

(56.67%) who perceive a low level of mental workload when using the application.

On the other hand, the remaining 26 students (46.33%) perceive a medium level of mental workload when using the application. It is important to note that there is no student who perceives a high level of mental load associated with the experiment conducted. Therefore, it can be concluded that most of the students perceive a low level of mental load when using the mobile application, which responds to hypothesis *H3*.

VI. DISCUSSION

A. INITIAL TEST

Students improved after using the mobile application in the initial test average, they went from 7 points to 8.47. To discuss this scenario, one must consider several factors that could be contributing to the improvement in students' grade point average (GPA) after using a cybersecurity mobile gaming app. The mobile app was designed in a way that students learn more effectively than simply studying theory. Games are often interactive and engaging, which could make students pay more attention and retain information better [40]. On the other hand, the app allows students to apply cybersecurity concepts in a game-like manner. This could contribute to deeper understanding of the topic and be reflected in better performance on the test. It may also be that the application of game elements in non-game contexts often increases students' motivation [32], [33]. If they are more motivated to learn, they are more likely to try harder and pay more attention in the subject, which could translate into better test performance. The mobile app includes immediate feedback on student performance. This allows students to correct errors quickly and improve their understanding, which could lead to a better average on the test [31].

B. USABILITY ANALYSIS

The data obtained provide an interesting insight into the usability of the mobile application evaluated using the IBM-CSUQ. The data indicate that system usability, which is an essential component of application usability, trended positively. This indicates that the mobile application is easy to use and satisfies most users. The quality of the information presented in the app is also important; the data suggest that there could be room for improving the accuracy of the information and reducing the abundance of information on the screen. This could increase user satisfaction. On the other hand, the analysis conducted shows that the quality of the interfaces can be improved. This suggests that users may find aspects of the interface that could be more intuitive or effective. Overall satisfaction, which is an important measure of application usability, appears to be positive, users are mostly satisfied with the application. However, the standard deviation of 1.17 and average of 5.82 suggests that there is some variability in satisfaction, meaning that some users may have less satisfactory experiences than others.

Overall, these results are promising, as they suggest that the mobile application is mostly easy to use and satisfies its users. However, there are areas identified for improvement, such as the accuracy of the information presented and the quality of the interfaces. Incorporating a detailed user manual could be an effective way to address shortcomings in the quality of the interfaces. In addition, it would be important to continuously monitor usability and collect feedback from users to make further improvements and ensure an ever-improving user experience.

Furthermore, the low score on question 18 "This system has all the functions and capabilities I expect it to have" may suggest that the application does not currently meet all user needs or that there is room to expand the capabilities and features offered. It is important to consider participants' suggestions to identify what additional features might be valuable and how they can be implemented. Conversely, the results obtained for question 1 "Overall, I am satisfied with how easy it is to use this system." and 2 "It is simple to use this system." is a positive sign and suggests that the current user interface is effective and that most users are comfortable using the application.

The standard deviation (σ) in the ratings is important. A standard deviation of 1.30 for question 18 suggests that user opinions vary significantly on the need for more features and services. On the other hand, lower standard deviations for questions 1 and 2 indicate greater uniformity in the perception of ease of use and convenience.

Based on these results, it can be concluded that while most users find the application comfortable to use, there is a demand for additional functions and services. To improve the usability of the application, it is advisable to consider the suggestions of the participants and evaluate how these additional functions can be implemented effectively. It is also important to continue to collect user feedback and conduct ongoing usability testing to ensure that the application continues to meet the evolving needs of users.

C. MENTAL WORKLOAD ANALYSIS

The results of the mental workload assessment using the NASA-TLX tool provide valuable information on how students perceived the workload in using the designed mobile application.

The highest rating on perceived performance, with an average of 10.85 on a scale of 1 to 20, indicates that students felt quite confident and satisfied with their performance on the task. Such a high average suggests that students felt that they performed the task well and felt competent at it. Mental demand (MD), with an average of 7.73, indicates that the task required a significant level of mental effort and concentration on the part of the students. Although this was not the highest dimension, it is an indication that the task was not trivial and required active thinking and processing of information. Temporal demand (TD) scored an average of 6.31, suggesting that the task had some time pressure. This time pressure could have contributed to the mental demand (MD), as students may have felt the need to complete the task within a specific time frame. With an average of 5.61, the rating on effort (EF) expended is moderate. This indicates that students put forth effort, but not overwhelming effort. Maintaining sustainable effort is important for long-term performance. The frustration level (FL), with an average of 3.64, is relatively low. This suggests that students did not experience significant levels of frustration during the task, which is positive, as frustration can negatively affect performance and satisfaction. Finally, the fact that all students rated physical demand (PD) with the lowest value (1) indicates that the task did not involve significant physical effort. This is relevant to differentiate between mental and physical workload, especially in academic tasks.

The results show that students experienced moderate mental workload on the task, with high perceived performance and relatively low levels of frustration. Time pressure and mental demand appear to have been key factors. These findings may be useful for designing future tasks and adjusting workload to optimize student performance and satisfaction.

It is important to consider these results in the context of students' individual needs and capabilities.

VII. CONCLUSION

The use of evaluation tools such as the IBM-CSUQ and the NASA TLX, to evaluate a game-like educational mobile application intended to teach cybersecurity, is a valuable strategy for obtaining information on usability, cognitive load, and user satisfaction.

The IBM-CSUQ provides information about the app's usability, including ease of use, efficiency, and effectiveness. If CSUQ scores are high, it indicates that the application is easy to use and that users can perform cybersecurity-related tasks effectively.

The NASA TLX assesses the cognitive load experienced by users when interacting with the application. If NASA TLX scores are low, it suggests that the application does not impose excessive cognitive load on users, which is important for effective learning.

Both IBM-CSUQ and NASA TLX can provide information on user satisfaction. If users report high levels of satisfaction, they are likely to be happy with the application and are willing to continue using it to learn about cybersecurity.

These tools can also identify areas for improvement in the application. For example, if the score on INTERQUIAL in the CSUQ is low, it could signal that the user interface needs improvement.

Specific scores on different dimensions of the NASA TLX can also help identify where users experience the most intense cognitive load.

The results of these assessments can be compared to previously established standards or targets. For example, if a minimum satisfaction level or acceptable cognitive load threshold is defined, the results can be compared to these criteria to determine if the application meets expectations.

Using NASA TLX and IBM-CSUQ to evaluate a cybersecurity game-like educational mobile app can provide valuable information about the app's effectiveness in terms of usability, cognitive load, and user satisfaction. These tools will help designers and developers identify areas for improvement and ensure that the app delivers an effective and enjoyable learning experience for users.

VIII. FUTURE WORK

Future work should focus on optimizing the user interface, the quality of the information. In addition, future researchers should encourage users to provide direct feedback on their experience with the application. This may include surveys, feedback forms, and suggestion boxes for users to share their opinions and concerns. This collection of feedback can improve the outstanding and ongoing user experience.

Future work should also focus on improving the user experience, reducing mental workload, and ensuring that the game is engaging, effective and satisfying for players. This may involve a combination of improvements, level design, feedback, and customization.

In addition, future research should focus on analyzing student performance and achievement, and whether the mobile application really supports education. To this end, more participants should be included in the study, and experimental and control groups should be used to demonstrate whether gamification can improve the retention of learned concepts.

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