

RESEARCH ARTICLE

Use of Virtual Reality as an Educational Tool: A Comparison Between Engineering Students and Teachers

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ABSTRACT Today, teaching faces several challenges, including students' difficulty in understanding abstract concepts and lack of motivation. To address these problems, the use of virtual reality (VR) has been explored as an innovative and potentially effective educational tool. However, so far, the effectiveness of VR applications and the perception of their use lack a clear and effective approach to be used to support education. The importance of addressing this problem lies in the need to improve the quality of teaching using emerging technologies. It is for this reason that it is important to find new strategies to improve the effectiveness of teaching using VR. In this context, this research presents the results of the FreeDev application, previously validated with 20 teachers and with 80 engineering students from a private university. FreeDev is a VR application designed to support the teaching of basic programming, it is aimed as an educational tool to provide an immersive experience to students on how to get started in programming and computational thinking. FreeDev has been well accepted, and both teachers and engineering students see it as a tool that can be used to support education. It is hoped that this research will contribute to the advancement of knowledge in the field of education.

INDEX TERMS Virtual reality, active learning, VR application, VR developer, authentic learning, active learning.

I. INTRODUCTION

Progress towards quality education was already slower than required before the pandemic, but after the restrictions imposed by Covid-19, there have been devastating impacts on education [1]. Quality education is one of the 17 Sustainable Development Goals (SDGs), according to the United Nations, and is the key to achieving and developing several of the other

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goals [1], [2]. When people can have access to education, there is a high probability that they will be able to escape the cycle of poverty [2]. In the pandemic, most governments decreed the temporary lockdown of educational institutions, affecting 91% of students around the world [3]. For this reason, the use of technology to support education became a necessity [3], [4]. The sudden "digital transformation" [5] made educational institutions adopt digital technologies as emerging in their eagerness to maintain the teaching and learning processes [6]. This created challenges for teachers

in adapting academic content to the all-digital scenario and the use of digital technologies to support the educational model [7], [8].

Currently, digital technologies have proven to be valuable tools to support the educational model, providing flexibility, personalization, and access to a wide range of educational resources [9], [10], [11]. The use of technologies in education can improve the quality and effectiveness of the learning process, offering students interactivity, collaboration, immediate feedback, and flexibility [9], [12], [13].

Examples of such technologies include virtual and augmented reality (AR/VR) [14], [15], [16], gamification [17], [18], mobile learning [19], [20], artificial intelligence (IA) [21], [22], cloud computing [23], [24], Internet of Things (IoT) [25], [26], among others. VR offers immersive experiences that can transport students to realistic virtual environments, which is impossible in a traditional learning environment [27]. Conversely, this technology fosters authentic learning, allowing students to interact with learning resources in a more hands-on and realistic way [28]. VR platforms such as, Spatial CVR and AltspaceVR enable students and teachers to collaborate on projects and engage in educational activities in a way that goes beyond the limitations of traditional teaching [29], [30]. VR affords students access to educational resources and simulated laboratories from around the world, without having to leave the classroom [31]. This feature provides a safe environment for students to acquire skills and perform practices and procedures without risk [32], [33]. In addition, this technology can tailor educational content to the individual needs of students, allowing them to learn at their own pace and according to their preferred learning style [27], [34].

Education has been facing several challenges, such as the difficulty students have in understanding abstract concepts and lack of motivation [15], [35]. To address these problems, the use of emerging technologies has been investigated as an innovative and potentially effective educational tool [36], [37]. VR has emerged as a disruptive technology with the potential to completely transform the way we interact with the world around us [16]. This has made this technology a useful tool for immersive learning and simulation of complex scenarios [38], [39]. Besides its application in training and simulation, VR has been increasingly used in certain collaborative learning environments [29]. However, until now, a clear and effective approach to evaluate the usability of VR applications has not been established. Nor has the perceived usefulness of VR as a support in higher education been evaluated.

This research focuses on the design and use of an immersive application called FreeDev, which uses a VR environment to encourage the learning of programming languages through logic and computational thinking. Unlike other similar initiatives in the current literature, the research does not focus only on the design of the application, but also performs usability analysis by students and teachers of a private university in Ecuador. In addition,

TABLE 1. Research objectives and questions.

RO1. To analyze the usability of FreeDev by teachers and students using the IBM-CSUQ (Computer System Usability Questionnaire) tool.
RQ1. Is the FreeDev application easy to use for students and teachers?
RO2. To analyze the perceived usefulness of FreeDev by engineering teachers
RQ2. Do teachers recommend using FreeDev as an educational tool?

it analyzes the perceived usefulness, both by teachers and students, in the implementation of FreeDev as a support tool in classes. The objectives of this research are detailed in Table 1.

This section introduces the reader to the use of emerging technologies such as VR to innovate online education. Section II shows the literature review. Section III presents the methodology used to achieve the proposed objectives. Section IV details the results obtained. Section V provides the discussion of the results. Section VI reports the conclusions and finally, section VII indicates the future work.

II. LITERATURE REVIEW

VR can be defined as a computer-simulated experience that mimics various physical environments to facilitate the understanding of its users [16]. This technology generates a virtual environment by amplifying characters, situations, or objects in three-dimensional form, which together increase the realistic feeling to the user of this technology [16], [40]. When users use this technology, they can receive sensory stimulations, such as vision, hearing, and touch, that seem in the virtual world [16], [38].

VR being an integrated technology whose principle is to build a 3D virtual spatial world, it can be used in multiple contexts [38], [41]. In recent years, VR technology has been used by professionals in multiple areas such as, sports training [42], medical care [43], and school trips [44]. Also, in other areas such as agribusiness [45], music [46], in remote navigation applications to help people to know unknown environments, such as museums, aquariums, natural parks or even cities [44].

From an education perspective, VR technology has been used for teaching foreign languages [47], anatomy [48], mathematics [49], [50], programming [51], biology [52] and in engineering education [53]. Furthermore, this technology is used to plan and practice complex surgical procedures, with the goal of improving accuracy prior to actual surgery [35]. VR can provide experiences that complement traditional education, allowing students to explore complex concepts in a more tangible way [54].

Two educational areas that conducted research on user perception using VR were, learning forensic scenarios [55], and gynecology training [56]. The results of the second research suggested that the perceptions of learners' use of VR (perceived usefulness, perceived ease of use, perceived enjoyment, perceived behavioral control, perceived internal control, perceived internal control, positive attitude, satisfaction, and confirmation with the system) resulted in an engaging experience that generated intention to use virtual reality training systems for learning [56].

With training as the main use, the adoption of this technology finds its natural path towards immersive educational environments [52], [57], [58]. Moreover, several educational researchers have recognized the use of this technology as beneficial to encourage and motivate authentic learning [47], [55], [58], [59]. These benefits make VR one of the most influential emerging technologies for educational innovation.

III. MOBILE APPLICATION DESIGN

The development of the FreeDev application was done with the help of Unity 2021.3.12f1 LTS software, in conjunction with Visual Studio 2022 Community Edition. These tools have been widely used for the design and construction of video games using VR technology. The characteristics of these platforms are explained in Table 2.

For the development of the application, the Oculus Meta Quest SDK was used, in addition to the following libraries:

- UnityEngine / UnityEngine.UI: for the connection and use of the internal functions of the Unity engine.
- UnityEngine.XR: for XR specific functionalities, which include VR.
- Oculus.Interaction: for the connection and interaction of the user with the Oculus Meta Quests.

In the development of an application, which is going to be used as support in education, it is essential to clearly and precisely establish the requirements and needs that are intended to be addressed [60], [61]. These elements will guide the creative process, ensuring that the application is effective in meeting its educational objectives [60]. Likewise, the design must ensure that the application motivates users and encourages them to use it [62] and [63]. Therefore, it should have a user-friendly interface, be simple, coherent, and intuitive, avoiding redundancy and offering interactive navigation [60], [61], [64], [65].

In this case, the requirements were identified in a previous study [66], and are listed in Table 3.

Subsequently, these activities were carried out within a set time frame, defined in Table 4. If problems arose, the team met briefly to resolve doubts and continue with the project. The priority of each cycle was determined by the final project objectives, and all stages received a priority rating of no less than nine. At the end of each cycle, the work done was reviewed, demonstrated, and adapted in a meeting with the entire team to finalize the development of FreeDev. Finally, the developed application has four levels, which are placed from the lowest level of difficulty to the most complicated.



FIGURE 1. Mathematical calculation exercise using FreeDev.



FIGURE 2. Student using FreeDev.

This to challenge the students to motivate them and foster a sense of discovery.

The following are images of the use of the designed application. Figure 1 shows how the exercises to be solved are presented. Each one of them contains all the necessary information, together with the blocks, to be able to build the necessary algorithm. This image displays information written in Spanish because the mobile application was designed in this language. Figure 2 presents a participant using the VR goggles to perform the FreeDev functional tests.

IV. METODOLOGY

Unlike other similar initiatives in the current literature, this research did not focus solely on the design aspects of the game, but on the evaluation of the perceived usability by teachers and students. For this purpose, the IBM-CSUQ tool [67] was used. Furthermore, a survey developed by the

TABLE 2. Development platforms used.

Development platforms	Features
Unity	Unity is a video game development platform that has different versions of long-term support (LTS). Also, it can be defined as a game engine that provides a complete environment for the development of 2D and 3D video games, as well as mixed reality (XR). The developed games can be exported for use in different devices such as, desktop computer, laptop, console, smartphone, tablet, Oculus, among others.
Visual Studio 2022	Visual Studio is an integrated development environment (IDE) produced by Microsoft. This software is used to write, debug, and compile programming code. It includes a package that can be installed to connect to Unity and debug code while running the application.

TABLE 3. Requirements for the design of mobile applications [66].

Requirements	Features
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

TABLE 4. Iterations required for the construction of the VR application.

Iteration Number	Definition	Priority (1 -10)	Iteration duration
1	Block design with instructions.	9	1 week
2	Interaction design	9	2 weeks
3	Block Customization	9	2 weeks
4	Immersive environment design	9	1 week
5	Design of user interface elements	9	2 weeks
6	Exercise verification	9	2 weeks
7	Syntax check	9	3 weeks
8	Export logic	9	2 weeks
9	Work level design (4)	9	2 weeks
10	Welcome and End Screen Layout	9	1 week
Total duration of mobile application development			18 weeks

authors, based on the research of Calvo-Morata. et al. [68], was used to find out whether teachers recommended the use of the application as a support in education.

A. PARTICIPANTS

This research had the participation of 80 students and 20 teachers from a private university of higher education in Quito-Ecuador. The participants were selected by convenience sampling. Of the 80 participants, 60 (75%) were male and 20 (25%) were female.

The 20 teachers, 18 (90%) were men and 2 (10%) were women. The age of the students ranged from 18 to 19 years. Of the 80 students, 71 of them were 18 years old and 9 of them were 19 years old.

B. EXPERIMENTAL PROTOCOL

Each participant accepted an informed consent provided through a web form. The use of questionnaires to participants did not require permission from an ethical committee,

because the students are part of the university that sponsored this research.

The experiment began with an induction on the use of the FreeDev application. Each participant was able to ask questions and make comments about the designed application. After that, they proceeded with the use of the FreeDev application (Figure 2), this work lasted approximately 25 minutes per student. The teachers finished the experiment much faster; they finished it in approximately 20 minutes. Each participant had to use the VR application, after which they had to answer two questionnaires. The information provided, allowed identifying the usability of the designed application, and the perceived usefulness of a VR application as a support in higher education. This information may be useful for teachers and educational institutions that want to include VR to innovate traditional methodologies and thus respond adequately to current learning challenges.

C. USABILITY ANALYSIS

To identify the usability of FreeDev, a survey provided by the IBM-CSUQ tool has been used [67], with the Likert 7 scale [69]. This questionnaire consists of 19 questions that evaluate the satisfaction that users experience when employing the developed application [67]. This questionnaire was developed with the purpose of obtaining data on the ease of use of the system (SYSUSE), the quality of the information provided (INFOQUIAL), the quality of the interfaces (INTERQUIAL), and an overall evaluation of the application and its ease of use (OVERALL). The questions are shown below:

1) QUESTIONS SYSUSE (QSY)

- Q1 Overall, I am satisfied with how easy it is to use this system.
- Q2 It is simple to use this system
- Q3 I can effectively complete my work using this system.
- Q4 I am able to complete my work quickly using this system.
- Q5 I am able to efficiently complete my work using this system.
- Q6 I feel comfortable using this system.
- Q7 It was easy to learn to use this system.
- Q8 I believe I became productive quickly using this system.

2) QUESTIONS INFOQUIAL (QIF)

- Q9 The system gives error messages that clearly tell me how to fix problems.
- Q10 Whenever I make a mistake using the system, I recover easily and quickly.
- Q11 The information (on-screen messages and guidance or other documentation) provided with this system is clear.
- Q12 It is easy to find the information I need.
- Q13 The information provided with the system is easy to understand.

- Q14 The information is effective in helping me complete my work.
- Q15 The organization of information on the system screens is clear.

3) QUESTIONS INTERQUIAL (QIT)

- Q16 The interface of this system is pleasant.
- Q17 I like using the interface of this system.
- Q18 This system has all the functions and capabilities I expect it to have.

4) QUESTION OVERALL (QOV)

- Q19 Overall, I am satisfied with this system.

D. PERCEIVED USEFULNESS ANALYSIS

When designing an educational application, it is not only important that it works well, but also that teachers find it potentially applicable to their classrooms. Therefore, a survey was used to measure the perceived usefulness of FreeDev as a support for teaching programming.

The following are the questions used, based on the research of Calvo-Morata et al. [68]:

- QA Do you think this game is applicable in classrooms to motivate learning and computational thinking?
- QB Do you think the game offers students insight into programming logic?
- QC Would you use this game in your classroom?
- QD Would you use other games in your classroom?
- QE Do you consider the game as an effective tool to motivate guided learning in class?
- QF Would you recommend this game for use as an educational tool in classrooms?

This survey additionally provides a choice question.

After using this game, choose one or more words that describe your perception? (Useful, Entertaining, Easy to use, Friendly, Motivating, Intuitive, prefer not to answer).

V. RESULTS

A. USABILITY ANALYSIS

1) STUDENTS

Table 5 shows the mean, standard deviation, and median results for the four categories of the IBM-CSUQ tool. Table 6 displays the top, average, and bottom values associated with the tool used for the usability analysis. Figure 3 illustrates these results in graphical form. On the other hand, Figures 4 and 5 present in graphical form the responses of the 80 participants grouped by male and female gender respectively. These data provide insight into how these groups experience the usability of the designed application. The graphs allow us to identify possible significant differences between males and females regarding the usability of the FreeDev application for its application in education. This can be crucial to fully understand the results.

2) TEACHERS

Table 7 shows the mean, median and standard deviation results for the four categories of the IBM-CSUQ tool. Table 8

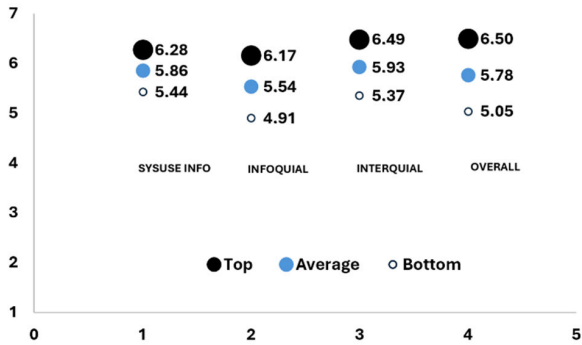


FIGURE 3. General results of the IBM-CSUQ survey of teachers.

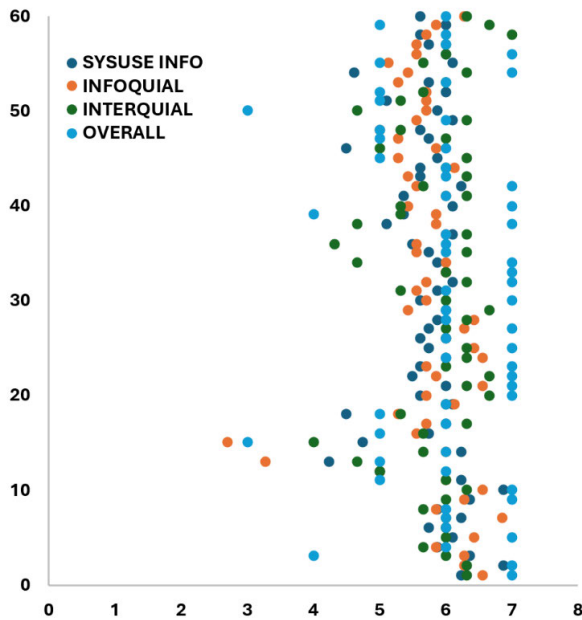


FIGURE 4. Response of participants in the IBM-CSUQ survey (Male).

lists the top, average, and bottom values associated with the tool used for the usability analysis. Figure 6 illustrates these results in graphical form. Gender was not considered for this analysis since the population was very small and there were only two women in it.

B. PERCEIVED USEFULNESS ANALYSIS

1) STUDENTS

Figures 7 and 8 show the perception that men and women have regarding the usefulness and use of FreeDev as a support in the educational model. In addition, Figure 9 presents the words that the students chose to describe the application. Most of the students perceive the application used as entertaining and useful.

2) TEACHERS

Figure 10 shows the high perception that teachers have of the usefulness of the FreeDev application as a support for initial programming education. For this analysis, gender was not considered since the population was very small and there were only two women in it.

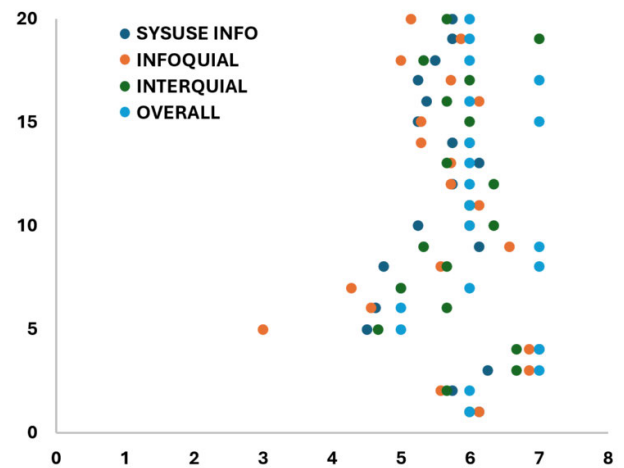


FIGURE 5. Response of participants in the IBM-CSUQ survey (Female).

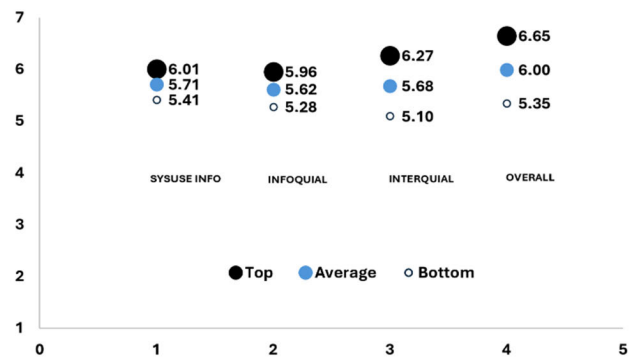


FIGURE 6. General results of the IBM-CSUQ survey of students.

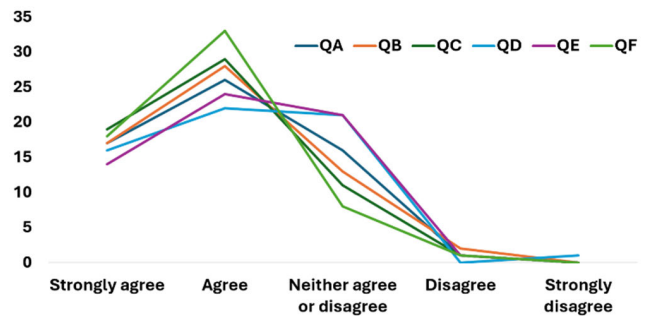


FIGURE 7. Answer to questions QA, QB, QC, QD, QE, and QF (Male).

VI. DISCUSSION

A. OBJECTIVE 1

The IBM CSUQ tool is widely used and recognized in the field of usability, it also guarantees in this research, effectiveness, ease of use, wide coverage, standardization, and adaptability [67].

1) USABILITY-STUDENT ANALYSIS

The usability study revealed a positive result in the case of students. In the survey formulated, most of them, in general, answered “I agree” and “I strongly agree” to the questions

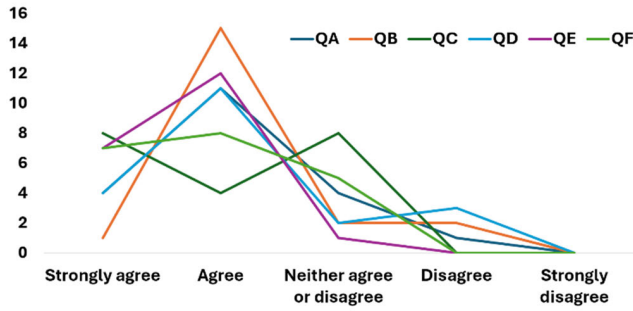


FIGURE 8. Answer to questions QA, QB, QC, QD, QE, and QF (Female).

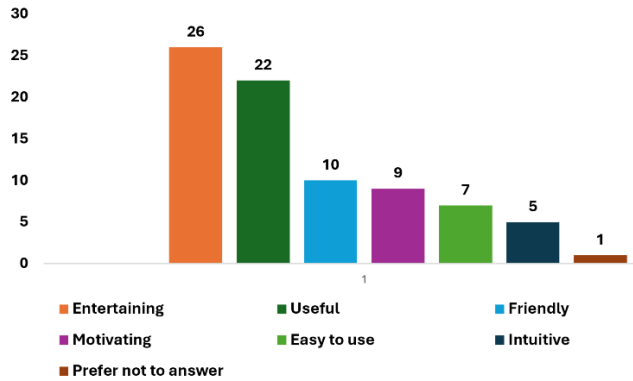


FIGURE 9. Using words to describe the application.

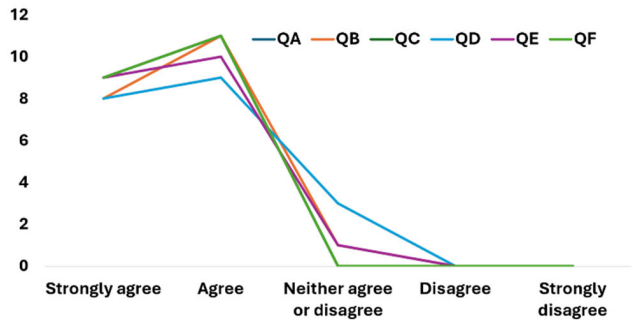


FIGURE 10. Answer to questions QA, QB, QC, QD, QE, and QF.

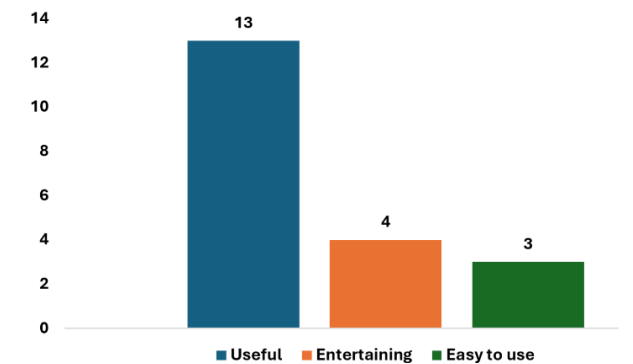


FIGURE 11. Using words to describe the application.

asked. This can be seen reflected in Table 5, Table 6 and Figure 3. The data presented here show that the quality

TABLE 5. Mean (μ), Standard deviation (σ) and median (M) of teachers.

IBM-CSUQ	Question	μ	σ	M
SYSUSE	Q1	6.03	0.84	6
	Q2	6.01	0.82	6
	Q3	5.88	1.01	6
	Q4	5.65	0.94	6
	Q5	5.56	1.05	6
	Q6	6.08	0.92	6
	Q7	6.00	0.99	6
	Q8	5.69	0.96	6
INFOQUIAL	Q9	5.44	1.21	6
	Q10	5.48	1.41	6
	Q11	5.38	1.44	6
	Q12	5.83	0.87	6
	Q13	5.51	1.22	6
	Q14	5.49	1.09	6
	Q15	5.66	1.07	6
INTERQUIAL	Q16	5.99	0.77	6
	Q17	5.96	1.04	6
	Q18	5.84	0.91	6
OVERALL	Q19	6.04	0.91	6

TABLE 6. General results of the IBM-CSUQ survey of teachers.

	QSY	QIF	QIT	QOV
Top	6.28	6.17	6.49	6.50
Average	5.86	5.54	5.93	5.78
Bottom	5.44	4.91	5.37	5.05
Median	6.00	5.71	6.00	6.00
Standard Deviation	0.42	0.63	0.56	0.73

of the interfaces (INTERQUIAL: Q16 - Q18) has a positive trend, which is superior to the usability (SYSUSE), and to the information presented (INFOQUIAL) in the application used (FreeDev) both in the maximum value (6.49) and in the average of the results (5.93). These values show that, when using FreeDev, students perceive a high quality of the interfaces, which allowed them to solve the exercises in a better way. Similarly, the usability of the system (SYSUSE: Q1 - Q8) obtained the second-best result, both in the maximum value (5.86) and in the average (5.86). This means that FreeDev is designed in such a way that students can interact with it intuitively and without difficulties. If the application is easy to use, it is very likely that students will adopt it and will want to use it for their learning. The quality of information presented in FreeDev (INFOQUIAL: Q9 - Q15) has the lowest value of the four categories (SYSUSE, INTERQUIAL, INFOQUIAL, and OVERALL), both in the

TABLE 7. Mean (μ), Standard deviation (σ) and median (M) of students.

IBM-CSUQ	Question	μ	σ	M
SYSUSE	Q1	5.55	1.15	5
	Q2	5.35	0.93	5
	Q3	5.75	0.91	6
	Q4	5.85	0.81	6
	Q5	5.75	0.79	6
	Q6	6.05	0.76	6
	Q7	5.60	0.82	6
	Q8	5.80	1.06	6
INFOQUIAL	Q9	5.55	1.15	5
	Q10	6.00	1.08	6
	Q11	5.55	1.00	5.5
	Q12	5.35	1.95	6
	Q13	5.35	1.14	5
	Q14	6.15	0.75	6
	Q15	5.40	0.94	5
INTERQUIAL	Q16	6.00	0.65	6
	Q17	5.50	1.32	6
	Q18	5.55	1.05	6
OVERALL	Q19	6.00	0.65	6

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

	QSY	QIF	QIT	QOV
Top	6.01	5.96	6.27	6.65
Average	5.71	5.62	5.68	6.00
Bottom	5.41	5.28	5.10	5.35
Median	5.69	5.57	5.83	6.00
Standard Deviation	0.30	0.34	0.59	0.65

maximum value (6.17), and in the average (5.54). Low information quality can negatively affect the user experience and can decrease users' confidence in the application. This result suggests that the design of the application may and should be improved in terms of the presentation of information on the screen, which should be clear and accurate for the best use of FreeDev by students.

Finally, the overall satisfaction data (OVERALL: Q19) show that, there was positive satisfaction, with scores ranging from 5.05 to 6.50, with most scores being close to the average of 5.78, with a standard deviation of 0.73, indicating some variability in student responses.

Question Q11 "The information (on-screen messages and guidance or other documentation) provided with this system is clear" scored the lowest ($\mu = 5.38$). This result means that there are specific areas where the mobile application may need improvement, for example, in the clarity of the information provided. Question Q6 "I feel comfortable using

this system" obtained the highest rating ($\mu = 6.08$). This value means that they are having a positive experience in terms of usability, design and overall satisfaction, which may lead to higher user retention and positive recommendations towards the application.

2) USABILITY ANALYSIS-TEACHERS

The usability study yields a positive result, since most of the teachers responded with "I agree" and "I strongly agree" to the questions formulated in this research. Table 7, Table 8, and Figure 6 demonstrate that, after using FreeDev, teachers perceive that the quality of the interfaces (INTERQUIAL: Q16 - Q18) have a positive tendency, which is superior to the usability (SYSUSE) and the information presented (INFOQUIAL) in the application used, both in the maximum value (6.27) and in the average of the results (5.68). These values show that, when using FreeDev, teachers perceive a high quality of the interfaces, which allowed them to solve and complete the exercises quickly. Likewise, the usability of the system (SYSUSE: Q1 - Q8) has the second best result, both in the maximum value (6.01) and in the average (5.71). This result indicates that, although teachers perceive the usability of the system adequately, there is room for improvement. It is important to identify the specific areas where users feel that usability could be improved and work on them to provide a smoother and more satisfactory experience. The quality of information presented in the application (INFOQUIAL: Q9 - Q15) presents the lowest values of the four categories (SYSUSE, INTERQUIAL, INFOQUIAL, and OVERALL), with an average value of 5.62, a high value of 5.96, and a minimum value of 5.28. Low information quality can negatively affect the user experience and can decrease users' confidence in the application. This suggests that the design of the application can and should be improved in terms of the presentation of information on the screen, which should be clear and accurate for the best use of FreeDev by teachers. Finally, the overall satisfaction data (OVERALL: Q19), reveal that, there was positive satisfaction, with scores ranging from 5.35 to 6.65, and that most of the scores are close to the average of 6.00, with a standard deviation of 0.65, indicating little variability in the teachers' responses.

Questions Q12 "It is easy to find the information I need" and Q13 "The information provided with the system is easy to understand" were the questions with the lowest score ($\mu = 5.35$), indicating that the mobile application needs to improve the visualization of the information displayed while in use. Question Q6 "I feel comfortable using this system" scored the highest ($\mu = 6.05$). This means that they are having a positive experience in terms of usability, design and overall Author Name: Preparation of Papers for IEEE Access VOLUME XX, 2024 satisfaction, which may lead to higher user retention and positive recommendations towards

These results contrast with data obtained in other studies measuring the usability of emerging technologies for use in education. In this context we can see the research of Zhao et. al. [70] in which several educational games

focused on teaching programming were designed through the NEWTON project. The results demonstrate, as in our research, that most users, consider the levels in the game to be aesthetically designed, the user interface to be pleasing, and easy to use. In addition, users strongly believe that the use of a gamification strategy helped them to better understand programming concepts, increased their interest in the courses, and contributed to better results.

On the other hand, Silvennoinen et. al. [71] identified several usability challenges in training surgical simulators using VR. The biggest challenge they found was the visual design and presentation of information in the simulation environment. Furthermore, the simulator does not provide feedback on errors or when the task is completed. This result shows that, as in FreeDev, the quality of information in a VR environment must be clear to guide the user in achieving tasks.

Despite this, the usability results, in this research from both students and teachers, evidence that the FreeDev application has a solid foundation, ensuring usability and a presentation of the interfaces that user's rate positively. However, they also suggest that there is room for improvement in the presentation of system information. To improve the presentation of information, some design improvements could be considered, such as simplifying the information, using icons or graphics to facilitate understanding, and ensuring that key information is easily visible to users. Ultimately, it can be said that the FreeDev application is easy to use for both students and teachers, the participants perceive the application as user-friendly and easy to understand. Moreover, the quality of the interfaces (INTERQUAL) and the usability of the system (SYSUSE) obtained positive scores, which supports the idea that the application is accessible and functional for users. However, it is important to note that the quality of information presented in the application (INFOQUAL) had the lowest minimum value, suggesting that the presentation of information on the screen may need to be improved to enhance the user experience.

Furthermore, the application presents an intuitive and easy-to-navigate interface, which makes it easier for users to access the content and provides an immersive and enriching experience. On the other hand, it can be indicated that the use of emerging technologies has great potential to enhance the learning of programming by providing a unique and memorable learning experience through virtual reality. In conclusion, these results may be indicative that FreeDev is an effective and promising tool to enhance the learning process of students in programming.

B. OBJECTIVE 2

1) PERCEIVED USEFULNESS-STUDENTS

Most students answered the questions using the rating of 3, 4 and 5 on a Likert scale, suggesting that they consider the application useful and beneficial to their learning. In the case of males, the QF question "Would you recommend this game for use as an educational tool in classrooms?"

scored the highest and shows that males strongly recommend the use of this application. Furthermore, it indicates that not only do they consider the application useful, but they also value it highly and are willing to recommend its use to others. In the case of females, the QE question "Do you consider the game as an effective tool to motivate guided learning in class?" scored the highest. This suggests that women consider the FreeDev app as an effective tool to motivate guided learning in class. Furthermore, this indicates that women value the app's ability to encourage participation and interest in learning in the educational environment. This result is important, as motivation is a key factor in the learning process. A tool that can motivate students to actively participate in their learning can have a positive impact on their academic performance and their attitude towards learning in general.

These results are very encouraging and suggest that the FreeDev application has great potential as an educational tool in the classroom. The positive perception of the students and their willingness to recommend the application suggest that it is having a positive impact on their learning and that it could be a valuable tool for improving teaching and learning in the classroom. On the other hand, the results of the QE question "After using this game, choose one or more words that describe your perception?", provide a more detailed view of the students' perception of the app. It is positive to see that most students find it entertaining and motivating, suggesting that the app is effective in capturing their interest and keeping their attention. This is important because a motivating and engaging learning environment can increase student participation and engagement. In addition, it is encouraging that a significant number of students found the application user-friendly and easy to use, suggesting that the interface is accessible. This is essential to ensure that students can use the application effectively and smoothly, which can contribute to a positive learning experience. It is interesting to note that fewer students found the app to be particularly useful or intuitive. This could indicate areas where the app could be improved to better meet user needs and expectations.

Importantly, students perceived the FreeDev app to have positive aspects, such as its ability to entertain and motivate students, as well as aspects that could be improved, such as its usefulness and ease of use. These findings can be useful in identifying areas for improvement and optimizing the application to provide an effective and satisfying experience for users.

2) PERCEIVED USEFULNESS-TEACHERS

In the case of teachers, two groups (male and female) were not considered, due to the low number of female participants in the experiment. The results report a strong positive perception of the usefulness of FreeDev as a support in the educational model. The questions QA "Do you think this game is applicable in classrooms to motivate learning and computational thinking?", QC "Would you use this

game in your classroom?”, and QF “Would you recommend this game for use as an educational tool in classrooms?”, had the highest scores in the questionnaire. This means that teachers see the potential of the application to enhance the learning experience and promote important skills such as critical thinking and problem solving. Furthermore, there is a genuine interest in integrating the app into real educational environments. Not only do teachers see the value of the application, but they are also willing to implement it in their educational practices and most importantly, recommend it to their colleagues.

Based on the results obtained, it can be indicated that both teachers and students consider that the use of VR can offer immersive and exciting learning experiences that can capture the attention of students and make them feel more involved in the learning process. Therefore, FreeDev can facilitate the teaching and learning of programming, and both teachers and students recommend it for use to support education.

VII. CONCLUSION

Overall, the recommendation by teachers and students for the use of VR application in education highlights its value and relevance in today’s educational context. These positive results support the idea that the integration of VR technology in education can have a significant positive impact on the teaching and learning process, enhancing the educational experience, and preparing students for the challenges of today’s digital world.

The use of the IBM-CSUQ tool to evaluate an educational VR application is a valuable strategy for obtaining information about usability and user satisfaction. This can translate into increased satisfaction, engagement, and efficiency in the use of the FreeDev application.

The IBM-CSUQ generates information about the usability of the application, including ease of use, efficiency, and effectiveness. If CSUQ scores are high, it means that the application is easy to use and that users can learn effectively. In addition, it can provide information on user satisfaction. If users report high levels of satisfaction, it is likely that they are happy with the application and are willing to continue using it to learn.

This tool can also identify areas for improvement in the application. For example, if the “INTERQUAL” score on the CSUQ is low, it could signal that the user interface needs improvement. On the other hand, the IBM CSUQ provides a structured and scientifically validated framework for measuring the usability of a VR application. This enables objective results on usability and user experience, which is critical for identifying areas for improvement and making informed design decisions.

IBM CSUQ helps identify specific usability issues that may be affecting the user’s experience with the VR application. This allows designers and developers to proactively address these issues and improve the overall quality of the application.

The perceived usability of FreeDev demonstrates the potential and effectiveness of the application in the educational environment. The favorable results suggest that both teachers and students value the application as a useful and beneficial tool for the teaching and learning process. These positive results can be attributed to several factors, such as the app’s ability to facilitate understanding of complex concepts, its ability to enhance student motivation and engagement, and its ability to provide a more interactive and engaging learning experience. Also, the positive perceived usefulness by teachers may be due to the application’s ability to improve teaching efficiency and facilitate the personalization of learning.

For this research, a sample of 80 students and 20 teachers was used through convenience sampling, due to the accessibility and availability to participate, without any compensation, in the study. Although the sample may seem small, it is important to note that this study focused on evaluating the usability of a virtual reality application for teaching programming, and participants were specifically selected based on their interest and experience in this field. In addition, although the sample is primarily from a single university, it is worth noting that this institution has a very diverse and representative student and faculty population in terms of academic background and levels of programming knowledge. The results of our study provide valuable information on the usability of virtual reality application in an educational context, and we believe that the results are relevant and generalizable to other similar educational institutions. We are confident that these results will contribute significantly to the existing body of knowledge in this field.

VIII. FUTURE WORK

Given that the lowest value in the IBM CSUQ survey was for the aspect of “INFOQUAL” (quality of the information presented in the application), future work could focus on improving this aspect to increase the perception of usefulness and, that students and teachers can use it and exploit its capacity for use in education.

It is also important to conduct feedback sessions with students and teachers to gather their opinions and suggestions on how to improve the presentation of information in the application. This could include incorporating interactive elements, simplifying technical terminology, among other aspects.

Performing usability testing can improve the quality of the information presented in the application. This could include conducting eye-tracking studies to analyze how users interact with the information in the interface and which areas may be confusing or unclear.

Finally, collaboration with experts in pedagogy and instructional design is important to develop effective strategies for improving the design of the application. This could include incorporating active teaching techniques and the use of multimedia resources to improve retention and comprehension of information for use in education.

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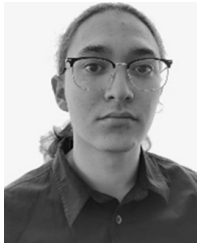
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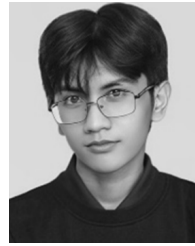
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