ISSN 1816-6075 (Print), 1818-0523 (Online)
Journal of System and Management Sciences
Vol. 14 (2024) No. 11, pp. 93-114
DOI:10.33168/JSMS.2024.1106

Evaluation of Mobile Applications to Advance Router Configuration Skills

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Abstract. As knowledge of router configuration is becoming imperative for networking skills, this study examines mobile applications as flexible learning tools. The comparative evaluation of four mobile applications using specific evaluation parameters highlighted vital functionalities for effective learning. Similarly, a statistical study focused on evaluating factors such as F-value, completeness, and accuracy through data to determine the most efficient and useful application for router equipment configurations, obtaining that the application M. G.K.M (0.80) has obtained a high performance for each metric, followed by NTP ISO 27001 (0.76), which by a small margin is close in its result Remote Laboratory (0.67), finally, we have Master Minds (0.56) where a result is obtained below the expected but useful for other functional criteria. On the other hand, the results indicate that there is room for improvement in aspects such as synchronized resources, community forums, and iOS availability. The article provides an innovative perspective on app features that affect learning outcomes and guides suggestions for advancing mobile-based curricula. The app analysis helps determine fundamental usability standards for designing engaging, learner-centered apps.

Keywords: Mobile applications, M.G.K.M, NTP ISO 27001, Master Minds, Remote Laboratory

1. Introduction

The use of mobile devices is no longer limited only to making calls, but they already have many more features, Huaccachi & Mejía (2021), during the last few years, mobile apps have increased considerably. More and more people use this type of tool to complement their training or to obtain new knowledge independently. However, not all mobile apps are equally effective for learning. Therefore, a detailed analysis of them is essential. From that perspective, the number of mobile app downloads worldwide exceeded 200,000 in 2019, a steady increase since 2016. In 2020, more than 218,000 apps were downloaded. This number is expected to increase to 258,000 in 2022 and 278,000 in 2024 (Buck, 2023). Users are expected to spend 3.8 billion hours on mobile apps in 2022, an increase of 35% compared to 2019. However, given that only 2.6% of users are still using an Android app 30 days after downloading it, the mobile app retention rate is low (Fernández, 2023). According to Yi Min Shum, 78.7% of mobile connections are made via phones or smartphones, and Android phones and apps will generate $932 billion in revenue by 2023 (Shum, 2023).

First and foremost, it's critical to stress how straightforward and simple the application's design must be. It must be easy for users to access the information they need quickly and get it in a straightforward manner. Furthermore, it is essential that the data shown in the application is very well-structured, with the material grouped in a way that makes sense, according to Lucero & Álzate (2020). The accelerated adoption of mobile devices, as well as the growing need for mobile applications and services, are posing significant challenges for mobile and wireless network infrastructure (Zhang et al., 2019). Aiming to improve user experience, 5G systems under development seek to cope with the exponential increase in mobile traffic, facilitate real-time analytics, and enable efficient management of network resources (Zhang et al., 2019). (Sharaf, 2022), Proper development of an application helps telecommunication companies and other companies, in general, to accurately target their customers, tailoring their offerings to customers' needs and preferences, which increases service satisfaction.

The quality of the content is also crucial for learning mobile applications. The information provided must be accurate, up-to-date, and relevant. In addition, the content must be presented in an attractive and interactive way to adapt to the level and needs of the users (Máñez & Cervera, 2021). In addition, mobile learning is a different form of learning that allows people to be more productive while interacting or creating information using mobile devices, smartphones, or tablets. As a result, mobile learning offers several advantages, such as flexibility, accessibility, personalization, collaboration, and motivation (UNESCO, 2022). However, it also presents some challenges, such as security, privacy, quality, and assessment, as well as the digital divide. A UNESCO report indicates that during the COVID-19 pandemic, mobile learning has become particularly important, affecting more than 1.6 billion students in 190 countries. To maintain the continuity of distance education, governments, educational institutions, and teachers have used mobile learning (Álvarez & Jiménez, 2022). The report highlights good mobile learning practices in various regions of the world and makes suggestions for improving their implementation (Garay, 2020). As a result, according to the report by the consulting firm App Annie, education mobile apps worldwide increased by 90 % in 2020 compared to 2019 (Innotedec, 2022). India, Brazil, Indonesia, the United States, and Turkey were the countries that used these apps the most. In addition, the study indicates that Google Classroom, YouTube Kids, Duolingo, Photomath, and Simply Piano were the most downloaded educational apps (Estrada & Zapata, 2022; Máñez & Cervera, 2022).

The proliferation of mobile applications and the rapid adoption of mobile devices in recent years have made it difficult for users to find useful applications. Therefore, recommending apps is critical. Conventional methods base their recommendations on users' interests and app functionality through user ratings (Kong et al. 2021; Dahiya et al., 2023). The three main groups of filtering are based on the preferences, behavior, context, and opinions of other users: collaborative filtering, content-based filtering, and hybrid filtering (Alonso & Mirón, 2017). Machine learning, natural language processing, social network analysis, and context modeling, among others, can enhance these approaches, although

each has its own challenges and limitations. Apps that use app recommendations include Google Play Store, App Store, JustWatch, and X (formerly Twitter) (Alonso & Mirón, 2017). The number of apps available in the App Store and Google Play Store has increased rapidly in recent years, according to a study by Statista (Rootstack, 2022). By 2023, they will reach more than 4 million and 2 million, respectively. This leads to increased competition among app developers, making it more difficult for users to find the apps they are interested in. Therefore, app recommendation has become crucial for the success of app distribution platforms and user satisfaction (Rootstack, 2022).

It is also essential for mobile applications to provide constant feedback to users. In other words, it allows them to evaluate their progress and provide them with tips and suggestions to improve their performance. In this way, users can identify their own strengths and weaknesses for more effective learning, Ventura (2021). It is important that mobile applications provide the possibility to interact with other users and experts in the field. This will allow users to share their experience and understanding, ask questions, and get answers from those with more experience, Umaña & Baquero (2022). The analysis of mobile learning applications should consider content, content quality, comments, and interaction with other users and experts. Only in this way can it be determined that the mobile application is effective and if it can really help users gain new knowledge automatically and effectively. The purpose of this paper is to analyse mobile applications for learning router equipment configuration for students.

It was proposed for the analysis of previously made applications to identify their main functionalities that ensure proper operation and achieve a positive effect on learning new skills related to the configuration of router equipment, then analyse the integration of functionalities in mobile applications used in the study on the configuration of router equipment.

2. Literature Review

The following are the relevant theories addressed in the research, in relation to the development of mobile applications for teaching routing equipment configuration, competency awareness, and the use of IT in the field of academic training. These theories provide a solid framework for understanding the importance of technology integration in education and its impact on the learning process.

2.1. Router equipment configurations

In principle with respect to router configurations, having knowledge of configurable network protocols on router equipment can be beneficial when engaging in cybersecurity because it is a field that is constantly growing, as indicated in a report by the (ISC)2 Cybersecurity Workforce Study 2022, which surveyed 12,000 cybersecurity professionals, indicates that there is a shortage of approximately 3.4 million professionals in this field. This represents a 26.6% increase in the talent gap compared to the previous year, and this trend is expected to continue. While knowledge of network protocols is an important part of cybersecurity, it is essential to complement it with other knowledge and skills in other areas.

The configuration of network equipment is crucial for a network to function properly. Compatibility, capacity, ease of use, security, reliability, and scalability are crucial factors in network equipment configuration. As technology and network demands change over time, network equipment configuration requires technical expertise and constant updating (Cisco, 2022). The type, model, and manufacturer of the device determine the router configuration. Therefore, it is crucial to consult the appropriate information sources and follow best practices for configuring network equipment. Correctly configuring the router is crucial to optimize the connection and protect it from intruders or threats. (Cisco, 2022).

2.2. Mobile learning

The proliferation of educational mobile applications varies in quality and reliability, making it difficult to find effective applications. A lack of user-centered design and intuitive navigation can frustrate

students and hinder learning, Herrera (2020).

In addition, Babalola & Omolafe (2022) indicate that mobile technology, with devices such as iPads and smartphones, offers students multimedia experiences and flexible resources, enabling learning without time or location constraints in formal and informal educational settings. These devices are affordable and widely accessible. The integration of E-Learning and M-Learning creates more structured and dynamic learning environments, facilitating collaboration and access to information and knowledge. This enables anytime, anywhere learning, improves response times, promotes collaborative learning, and enhances the interaction between learners, teachers, and peers (Cantillo, 2019).

It is worth noting the existence of Q-Learning (Jang et al., 2019) it could be stated that the Q-learning approach is one of the most prominent methods in the field of reinforcement learning and represents one of the most widely used strategies outside of policy. Since the introduction of Q-learning, numerous researchers have addressed its applications in reinforcement learning problems, and in the field of artificial intelligence, this learning has an involvement in chatbots and mobile applications.

2.3. Methodologies used

Behrang & Orso (2019), the use of mobile applications is becoming more and more common, and a lot of effort is invested in their testing to ensure their correct functioning. To reduce this effort and thus the overall cost of mobile application testing, techniques should be explored to migrate test cases between applications in the same category that would be useful for support. In relation to agile methodologies, there are several agile methodologies that have been used in recent times. Some of the most popular agile methodological approaches or processes implemented by researchers in various fields are XP methodology, Mobile-D, and Scrum (Muñoz, 2020).

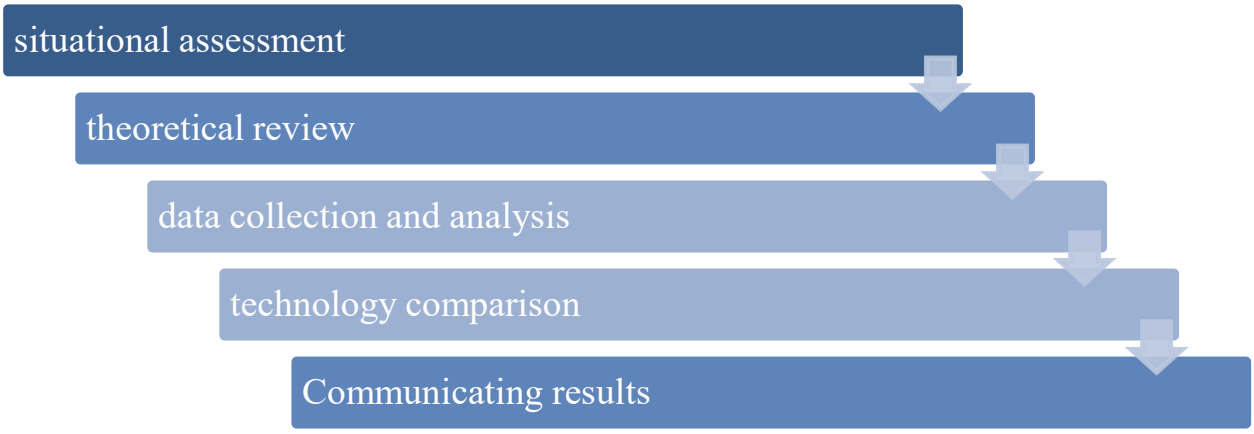

Fig. 1: Research Stage

Mobile applications for learning router configuration are an innovative and effective tool that can help students or users interested in this topic develop technical and digital competencies. A rigorous and systematic methodology is required to develop and evaluate such a mobile application, which consists of five steps: situational assessment, theoretical review, data collection and analysis, technological comparison, and communication of results. In addition, each step has its own objectives, activities, and products, which must be in line with the problem to be solved, user needs, quality standards, and research ethics (Mondal et al., 2023). The result should be a comparison of mobile applications that provide a meaningful, interactive, personalized, and motivating learning experience, and show their impact on user performance and satisfaction (Mondal et al., 2023).

2.4. Mobile application

Therefore, Herazo (2022) comments that mobile applications are divided into several categories. Gaming is the most popular, with companies dedicating resources due to its high profitability. Business and productivity apps are essential for tasks on the go, while educational apps, such as Duolingo, offer flexibility in learning. Mobile commerce apps provide convenient shopping experiences, and

entertainment apps, such as Facebook and Instagram, offer online options. Utility apps are used for specific tasks, and travel apps transform devices into guides for exploring visited places.

Kaur et al. (2022), smartphones and mobile devices have become ubiquitous in all aspects of human life. This has generated a strong need to develop software that is compatible with these devices. Developers must respond to this growing demand by delivering high-quality applications in a timely manner and within budget. In this context, development estimation and application testing play a crucial role, in driving the use of specific methodologies for their development.

2.5. Node JS

In this section, Shcherbakov et al. (2023) indicate that, in recent years, there has been a significant increase in interest in JavaScript execution in out-of-browser environments. A prominent example of this is Node.js, a widely adopted runtime server that facilitates the development of complete web applications. In addition, Node.js has a package management system called NPM, which stands out as the world's largest software repository, hosting millions of packages. Node.js is a tool that allows you to write applications for multiple platforms with a single code. Node.js, which is based on the JavaScript language, runs in a virtual machine and works with a variety of operating systems. Node.js is a fast and efficient environment that facilitates performance monitoring and concurrency (Shcherbakov et al., 2023).

2.6. Flutter

In Corbo (2022) scientific review he mentions Flutter differentiates itself by not employing native Android and iOS widgets, instead, it develops its own widgets using its own code, which implies that all the code linked to these widgets is integrated directly into the application, potentially resulting in an increase in its size. In short, Flutter simplifies the inclusion of custom widgets and provides an extensive range of widgets compatible with all major mobile operating systems.

Flutter is a tool that allows you to use a single code to create applications for different platforms. Flutter is based on Dart, a language easy to understand and use, and provides a wide range of visual elements and animations to create attractive interfaces. Flutter is an excellent choice for developers looking for efficiency and speed in their projects (Corbo, 2022).

2.7. Java

In addition, Corbo (2022) mentions that Java is versatile, and used to develop software, Android applications, and more. It runs on multiple platforms without the need for compilation. With object-oriented support, it is used in web applications, Android, and data analysis. Java and its tools evolve to meet the needs of developers globally.

Java is a language that allows the creation of applications for multiple platforms with a single code. Java, which is based on the object-oriented paradigm, runs in a virtual machine and supports a variety of operating systems. Java is a language widely used in a wide range of applications, from web applications to commercial applications. Java has many advantages, including its robustness, security, performance, and ease of use (Corbo, 2022).

3. Material and Methods

In this research, several scientific articles available in various databases, such as Redalyc, Scielo, Scopus, and other storage sources, were examined.

This made it possible to identify key points related to the procedures and phases of the application system. Keywords in Spanish, English, and Portuguese were selected to search for information in the repositories. This method builds on previous systematic evaluations and expands and refreshes the body of knowledge regarding current mobile health applications, with the purpose of providing information to guide future research and advances (Milne-Ives et al. 2020). The results of this search are detailed in Table 1, which shows the collection of data relevant to the research.

Table 1: Results of collected studies of mobile applications related to the acquisition of router configuration knowledge of router configuration.

Results of studies collected from mobile applications related to router configuration knowledge acquisition.				
Ref.	**Year**	**Title**	**Description**	**Country**
(Limpraptono et al. 2021)	2021	Development of a remote electronic telecommunications laboratory architecture based on mobile devices.	The purpose of this study is to address educational needs in the context of the Industrial Revolution 4.0 and the demands of online learning, accentuated by the COVID-19 pandemic. In addition, with the advancement of cellular communication technology and the increased capabilities of mobile devices, they can play a pivotal role in the development of remote laboratories.	Indonesia
(Macia, 2021)	2021	The implementation of agile methodologies in mobile applications will allow the creation of an interactive application for LAN (local area network) structuring using high-level programming languages.	This approach will help systems students by providing them with relevant programming information that can be useful in their future projects and increase their knowledge about augmented reality and its implementation in interactive mobile applications.	Colombia
(Aycho y Bustamante, 2021)	2021	They designed an application that uses microlearning together with mobile devices and pc for the learning of regulations in higher education.	The population and sample were 30 systems engineering students, where surveys were used as data collection methods and questionnaires as instruments.	Perú
(Montero, 2021)	2021	Study of a mobile application for learning network equipment using microlearning and gamification.	It determines a considerable increase in the advantage of using and incorporating mobile devices as a support during the acquisition stage of teaching network and telecommunications concept	Perú

Martimon et al. (2022). Reports that subjectively perceived quality and specificity were related to lower ratings of a mobile app. Further research is needed to analyse the consistency of the information provided by these apps with the guidelines, as well as to understand the long-term consequences of these apps on users. In addition, Aycho & Bustamante (2021) designed an application that uses microlearning together with mobile devices and PCs for learning regulations in higher education. Aycho and Bustamante (2021) because of its pre-experimental design, is a quantitative method and a type of applied research. The population and sample were 30 systems engineering students who used surveys as data collection methods and questionnaires as instruments.

On the other hand, Montero (2021) in his study of a mobile application designed for learning network equipment using microlearning and gamification. Montero (2021) for its pre-experimental design, is a quantitative method and a type of applied research. The population and sample were 30 students. In education, different techniques offer great potential for learning, especially in practical areas, by providing students with contextualized knowledge that improves their skills for future work challenges. In this context, we develop an augmented reality mobile application to enhance local area network (LAN) teaching, covering planning, design, coding, and testing phases to achieve a functional and effective product, Macias (2021). Mobile learning is an educational approach that utilizes mobile tools, techniques, devices, and information communication technologies to facilitate educational tasks. It enables students to have continuous access to learning resources and engage with teachers and peers. The integration of mobile learning technology in university education offers several advantages,

including simplifying assessments, expediting the exchange of educational content, modernizing the learning process, creating a distributed mobile educational resource, promoting collaborative activities among students regardless of their locations, and serving as a portable library for educational materials. Additionally, the use of mobile devices is more practical in terms of space and mobility compared to traditional computers, making them a convenient and efficient choice for students to interact with each other and with instructors (Sattarov & Alamri, 2019).

According to Weichbroth (2020), usability evaluations are mixed with the aspects that make up the user experience, including not only the quality characteristics of the application but also the opinions, emotions, and preferences of users. All these findings highlight the importance of continuing research in the field of mobile app usability, with the aim of achieving agreement in both theory and practice among all involved. The academic literature on the integration of mobile technology in higher education demonstrates an increasing focus on how mobile devices are used in educational contexts, whether in face-to-face or online environments, rather than exploring the potential of mobile applications in teaching or research (Hinze et al., 2023). As long as they are designed and evaluated with users' needs, expectations, and preferences in mind, I believe that mobile applications have great potential to improve the quality and accessibility of higher education. Mobile apps can offer a personalized, adaptive, and motivating learning experience that suits the pace, style, and context of each student. In addition, they can facilitate quick and easy access to educational resources and content, as well as collaboration, communication, and feedback between students and teachers (Hinze et al., 2023). However, for mobile applications to be effective and satisfactory for users, it is necessary to carry out a rigorous evaluation of their usability, i.e., the ease of use, efficiency, usefulness, and satisfaction they provide (Hinze et al., 2023).

4. Results and Discussion

In this results section, it is essential to provide a detailed and accurate explanation of the findings obtained during the research, supporting them with rigorous analysis and data. In addition, an objective perspective should be maintained to avoid reaching excessive conclusions or inferences that lack support in the evidence presented. In table 02 below, we will examine the results of studies collected from mobile applications related to knowledge acquisition in router configuration.

Table 2: Results of collected studies of mobile applications related to router configuration knowledge acquisition.

Mobile applications related to router configuration learning				
Integrated Functions/Applications	**M.G.K.M** 	**NTP ISO 27001** 	**MASTER MINDS** 	**REMOTE LABORATORY** 
App Developers	Macias García, Karen Mayerly	-Aycho Contreras, John Ivan -Bustamante Meza, Eloy Yoel	Montero Olivares, Jhon Kevin	- F. Yudi Limpraptono - Eko Nurcahyo - Ahmad Faisol
Year of creation	2021	2021	2021	2021
Versions	V1.0.0	V1.0.0	V1.0.0	V1.0.0
Web link	https://repository.unad.edu.co/handle/10596/41878	https://repositorio.ucv.edu.pe/handle/20.500.12692/81827	https://repositorio.ucv.edu.pe/handle/20.500.12692/78330	http://eprints.itn.ac.id/5438/1/Paper%201%20The%20Development.pdf
User-friendly interface	x	✓	✓	✓

Mobile applications related to router configuration learning				
Methodology for development	✓	✓	✓	✓
User session management	x	✓	✓	✓
Integrated testing and evaluation	✓	✓	✓	✓
Include complementary resources	x	✓	✓	✓
Interaction and participation with other users	✓	x	x	✓
Synchronization and offline access	✓	✓	✓	✓
Development of concepts related to configurations	✓	✓	✓	✓
Includes availability on iOS devices	x	x	x	x
Includes availability on Android devices	✓	✓	✓	✓
Year of launch during the last 3 years	✓	✓	✓	✓

In addition, (Demir & Akpinar, 2018) state that mobile learning has a significantly positive effect on academic achievement compared to traditional learning and can also increase the level of incentive in students. In the article, references are made to several applications designed to address the teaching of configuration on router equipment. One example of this is the "Master Minds" application, created specifically for Android devices. Whereas since 2012, the Android operating system has maintained its leading position as the most widely adopted platform in mobile devices, such as smartphones and tablets. This enduring trend has also influenced the evolution of mobile technology, providing a solid foundation for the development of innovations and industry breakthroughs (Alzatlaee, Yerima & Sezer, 2020). Its main objective is to enrich and significantly improve students' understanding of the academic field of network equipment configuration. It is important to note that this application meets most of the guidelines considered in this study. On the other hand, contemplating the findings, we can confirm the significant improvement in learning through the use of mobile applications. We can mention, we have that in application 01 for (Macias, 2021), In the study conducted, it was possible to strengthen the understanding of the essential functions of a network, as well as the proper way to design and structure it, in addition to understanding the fundamental concepts that must be followed for a correct configuration.

In addition, we note that in the 02 application in their study (Aycho & Bustamante, 2021), they show the results of the analysis where an improvement of 61.28% is verified, which is a profitable result compared to the levels previously found. The application allows quick and efficient access to information, motivating the population to want to acquire new knowledge. Finally, in application 03 in the study (Montero, 2021), achieved with the implementation of the mobile application It was observed that the use of this instruction in the knowledge of network equipment had a beneficial effect, evidenced by a significant increase in the level of knowledge, motivation and satisfaction, as well as a reduction in learning time. As a result, there was an 80.47% increase in knowledge related to network equipment learning. Riasat et al. (2023) in their article, noted that after the usage period, favorable attitudes towards

the app lead to an increase in the frequency of in-app purchases as well as brand loyalty. In addition, the findings also indicate that smartphone screen size influences consumer attitudes and behaviors.

Nuanmeesri, (2023) developed a mobile application that demonstrated outstanding performance in terms of learning outcomes, user understanding, and user satisfaction, meaning that it could be effectively employed as a support tool. Loy et al. (2022) in their research, mobile applications are ranked by evaluating their fundamental features and functionality. Requirements are considered satisfied when they obtain a full score. Descriptive statistics were used to describe the characteristics of the applications in terms of their basic purpose. According to the results of the evaluation of the essential aspects of mobile applications, items related to the need for Internet connection, size less than 50 MB, absence of financial requirements, inclusion of educational content, and provision of advice through the applications were taken into account. Thanks to progress in cellular communication technology and the increasing capabilities of mobile devices, they play an essential role in the creation of remote laboratories. The remote lab applications are accessible via mobile devices, such as Android-based smartphones and tablets. The goal of this particular development was to meet the needs of remote experimentation in electronic telecommunications courses within the Electrical Engineering curriculum (Limpraptono et al. 2021).

In an evaluation focused on patient-facing oncology applications, which have the ability to record patient-reported outcomes. In addition, aspects such as their purpose, functionality, quality, and their ability to integrate with electronic medical records were considered important for the research. It is relevant to consider whether the application is available for free with in-app purchases or subscriptions. These apps analyze the data entered and provide medical guidance based on the answers, as described in the article by (Vercell et al. 2022). The contribution of the development of mobile applications to the teaching or learning of any subject in general is reinforced as it can be part of a complement in the training of students (Rodriguez, 2022). On the other hand, for the testing stage, the characters of this group of data were taken into account, where each group represented the data analysis of each service model that is integrated within the Router configuration learning addressed in the research. Therefore, the prediction method was used to provide an estimate for each class, which will be in the range of 0 to 1. In addition, the argmax method was used to return the class with the highest estimate. In this way, only the numbers 0 (bad) and 1 (good) are received. For this study we will consider three mobile applications that are more efficient and adaptable for router configuration.

Table 3: Service Software Report (M.G.K.M)

		Accuracy Score	
Predicted Label	Bad	86	4
	Well	1	9
		Bad	Well
		Real Etiquette	

Table 3, shows the results of the Confusion Matrix for the M.G.K.M. learning model, which correctly guesses 86 times for the Bad value and 9 times for the good value, respectively. However, you get one false positive and four false negatives; That is, he once preached that he was bad when he

was good and nine times, he preached that he was good when he was bad.

Table 4: Confusion Matrix for M.G.K.M. Router Configuration Model

	Precision	**Exhaustiveness**	**F-Value**
Bad	0.9885	0.955	0.9714
Well	0.6923	0.9	0.7826
Accuracy			0.80148

Therefore, we can calculate the accuracy and completeness of each class and thus the F1-scores for each label: The F1-score is the harmonic average of accuracy and completeness, where the F1-score reaches its best value at 1 (representing perfect accuracy and completeness) and its worst value at 0. It is defined using the F1-score equation:

F-Value = 2 X (Accuracy x Completeness) / (Accuracy x Completeness)

In this way, you have the following formulas in order to find the precision, completeness, F-value, and accuracy as it is:

Accuracy=TP/(TP+FP)

Comprehensiveness=TP/(TP+FN)

F-Value = 2 X (Accuracy x Completeness) / (Accuracy x Completeness)

In this way, **in Figure 2** the positive value equivalent to 0 is determined,

Accuracy = 86 / (86+1) = 0.988

Completeness= 86 / (86+4) = 0.955

F-value = 2 x (0.988x0.955) / (0.988+0.955) = 0.9714

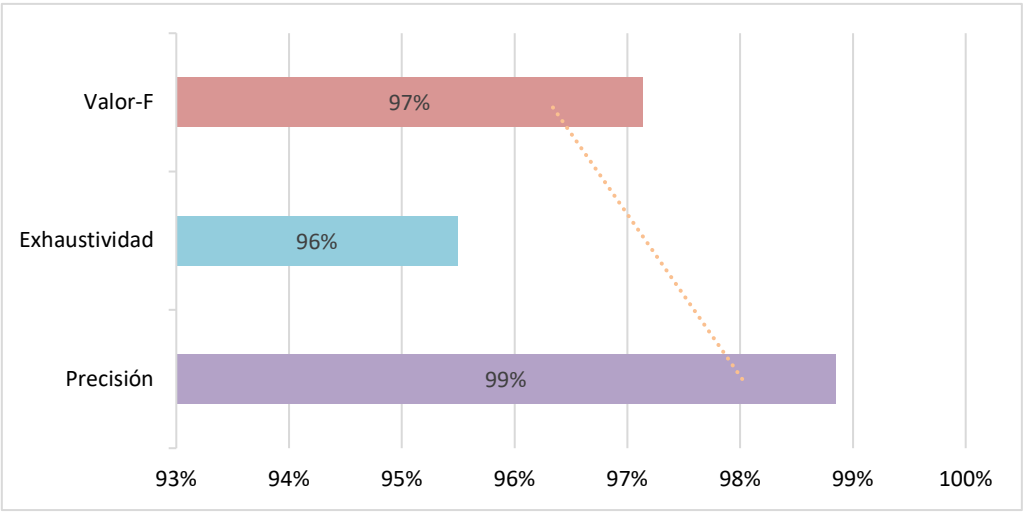

Fig. 2: Evaluation of performance at the training stage and validation of positive accuracy metrics for the router configuration model (M.G.K.M.)

In this way, **in Figure 3** the negative value equivalent to 0 is determined,

Accuracy = 9 / (9+4) = 0.692

Completeness= 9 / (9+1) = 0.90

F-value = 2 x (0.6923x0.9) / (0.6923+0.9) = 0.782

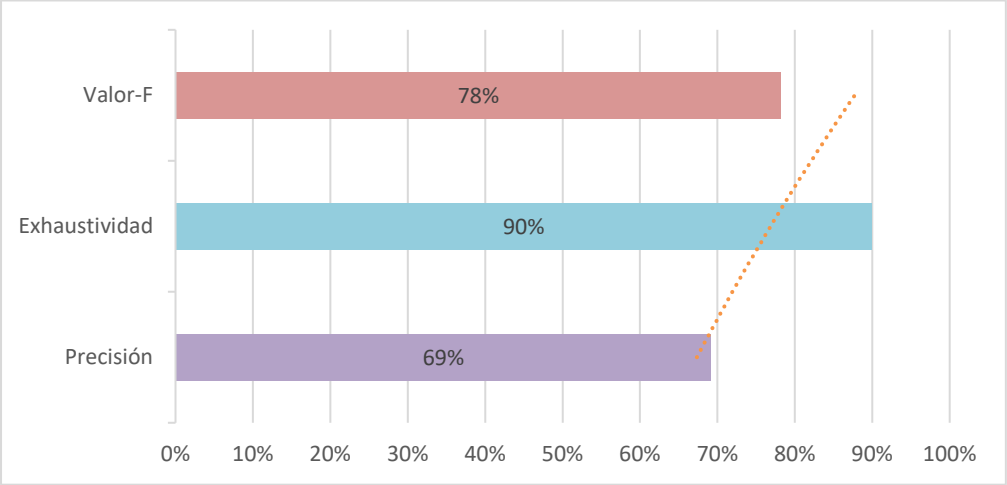

Fig. 3: Evaluation of performance at the training stage and validation of negative accuracy metrics for the router configuration model (M.G.K.M)

Subsequently, the result of the accuracy of the router configuration model (M.G.K.M) is obtained, from which the negative values have been obtained as positive in the F value which will help to get the result of the accuracy.

$$(0.9714x10) + (0.782x90) / 10+90 = 0.8014$$

Table 5: Service Software Reporting Matrix (NTP ISO 27001)

		Accuracy Score	
Predicted Label	Bad	88	2
	Well	3	7
		Bad	Well
		Real Etiquette	

Table 5 shows the results of the Confusion Matrix for the service platform, correctly 88 and 7 times for Bad and Good respectively. However, it also gets 3 false positives and 2 false negatives; that is, 3 times he predicted that he was Bad when he was actually good, and 2 times he predicted that he was Good when he was Bad.

Table 6: *Confusion Matrix for ISO 27001 NTP Router Configuration Learning*

	Precision	**Exhaustiveness**	**F-Value**
Bad	0.967	0.977	0.971
Well	0.77	0.70	0.733
Accuracy			0.7568

In this way, **Figure 4** determines the negative value equivalent to 0,

Accuracy = 88 / (88+3) = 0.967

Completeness = 88 / (88+2) = 0.977

F-value = 2 x (0.967x0.977) / (0.967+0.977) = 0.971

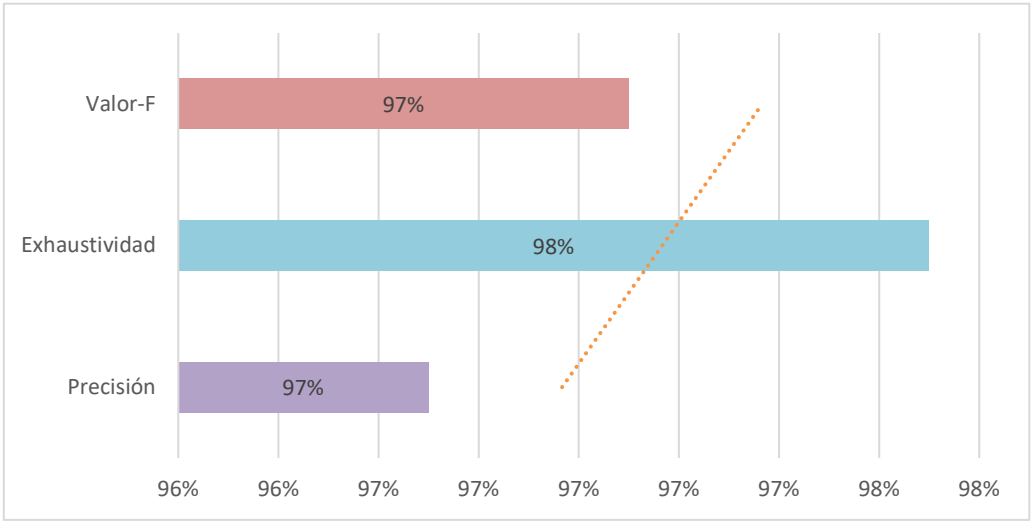

Fig. 4: Evaluation of performance at the training stage and validation of positive accuracy metrics for the router configuration learning model

Thus, in **Figure 5,** the positive value equivalent to 0 is determined,

Accuracy = 7 / (7+2) = 0.77

Completeness = 7 / (7+3) = 0.70

F-value = 2 x (0.77x0.70) / (0.77+0.70) = 0.733

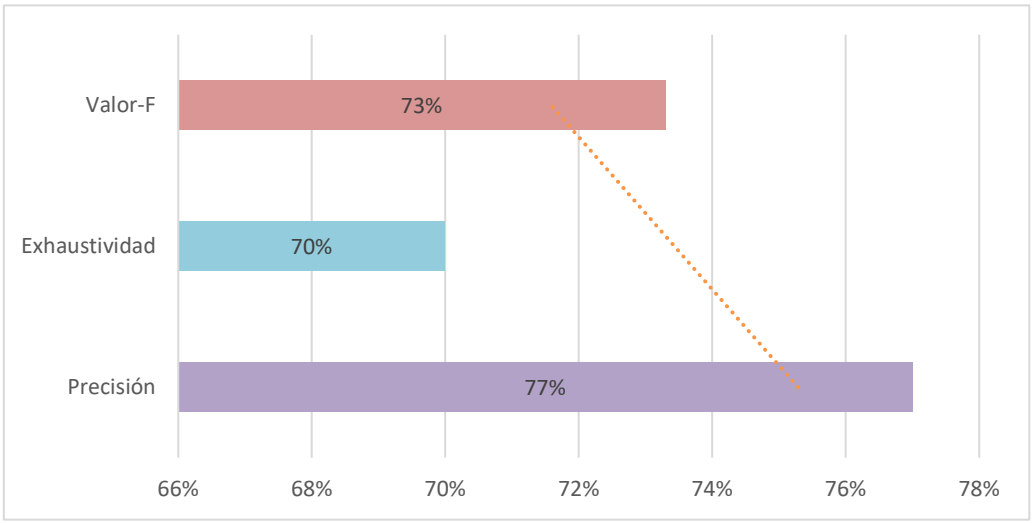

Fig. 5: Performance evaluation at the training stage and validation of negative accuracy metrics for the router configuration learning model (NTP ISO 27001)

On the other hand, we have the final result of the accuracy of the router configuration learning model (NTP ISO 27001), from which the negative values have been obtained as positive in the F value which will help to get the result of the accuracy.

$$(0.971x10) + (0.733x90) / 10+90 = 0.7568$$

Table 7: Router Configuration Learning Report (Master Minds)

		Accuracy Score	
Predicted Label	Bad	83	7
	Well	4	6
		Bad	Well
		Real Etiquette	

Table 7 shows the results of the Confusion Matrix for the development of Master Minds router configuration, it gets it right 83 and 6 times for bad and good respectively. However, it also gets 4 false positives and 7 false negatives; That is, 4 times he predicted that he was bad when he was actually good, and 7 times he predicted that he was good when he was bad.

Table 8: *Confusion Matrix for Learning Router Configuration (Master Minds)*

	Precision	**Exhaustiveness**	**F-Value**
Bad	0.954	0.922	0.9376
Well	0.461	0.60	0.521
Accuracy			0.5632

In this way, **Figure 6** determines the negative value equivalent to 0,

Accuracy = 83 / (83+4) = 0.954

Completeness= 83 / (83+7) = 0.922

F-value = 2 x (0.954x0.922) / (0.954+0.922) = 0.9376

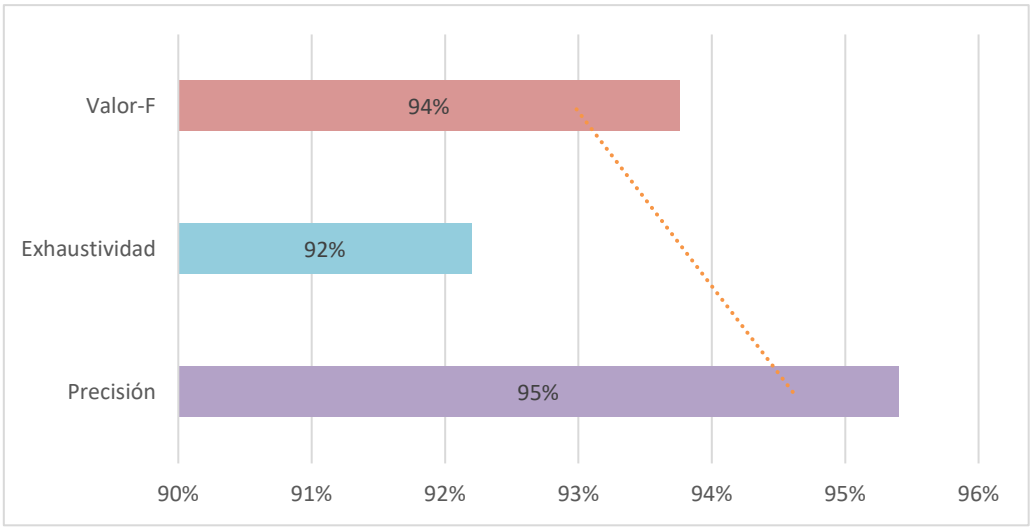

Fig. 6: Evaluation of performance in the training stage and validation of positive accuracy metrics *for router configuration learning* (*Master Minds*)

In this way, in **Figure 7** the positive value equivalent to 0 is determined,

Accuracy= 6 / (6+7) = 0.461

Completeness = 6 / (6+4) = 0.60

F-value = 2 x (0.461x0.60) / (0.461+0.60) = 0.521

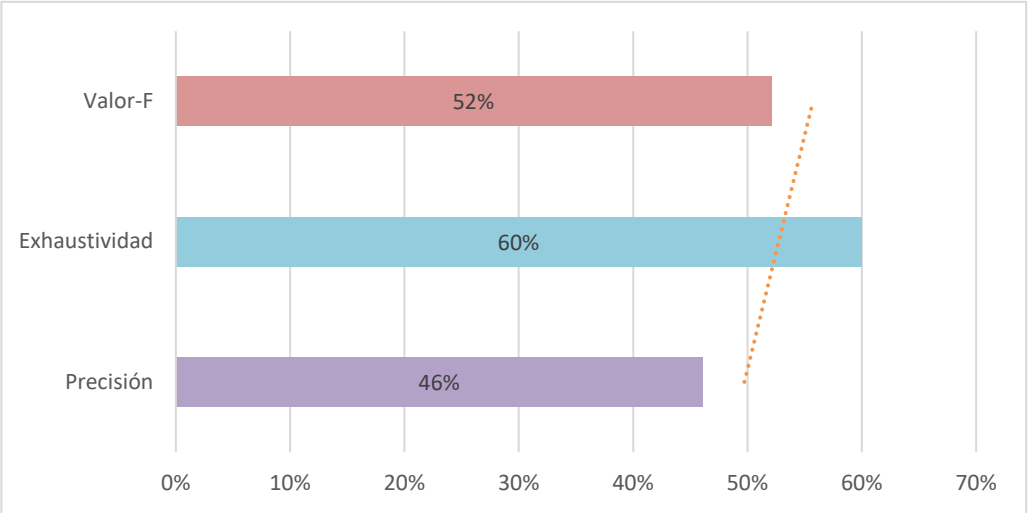

Fig. 7: Evaluation of performance in the training stage and validation of negative accuracy metrics for learning router configuration (Master Minds)

Finally, we have the final result of the accuracy of the router configuration learning model (Master Minds), from which the negative values have been obtained as positive in the F value which will help to get the result of the accuracy.

$$(0.9376x10) + (0.5217x90) / 10+90 = 0.563$$

Table 9: Service Software Report (Remote Laboratory)

		Accuracy Score	
Predicted Label	Bad	85	5
	Well	3	7
		Bad	Well
		Real Etiquette	

Table 9 shows the results of the Confusion Matrix for the Remote Laboratory learning model, where 85 and 7 times for Bad and Good respectively. However, it also gets 3 false positives and 5 false negatives; that is, 3 times he predicted that he was Bad when he was actually good, and 5 times he predicted that he was Good when he was Bad.

Table 10: Confusion Matrix for the Remote Laboratory Router Configuration Model

	Precision	**Exhaustiveness**	**F-Value**
Bad	0.9659	0.94	0.952
Well	0.70	0.583	0.6361
Accuracy			0.8695

On the other hand, **Figure 8** shows the negative value equivalent to 0,

Accuracy = 85/ (85+3) = 0.9659

Completeness = 85 / (85+5) = 0.94

F-value = 2 x (0.9659x0.94) / (0.9659+0.94) = 0.952

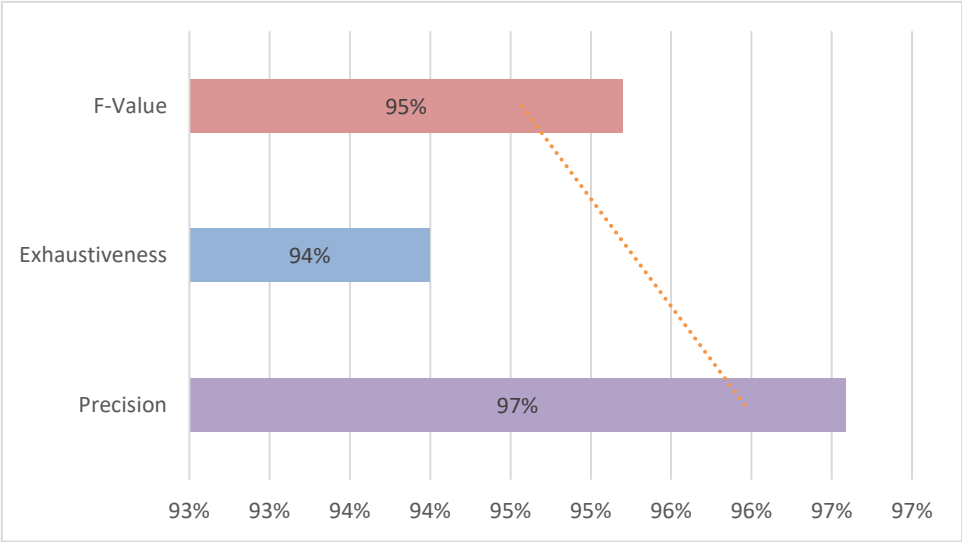

Fig. 8: Statistical Percentage Performance for Validation of Positive Accuracy Metrics for Router Configuration in Remote Laboratory

Thus, in **Figure 9,** the positive value equivalent to 0 is determined,

Accuracy = 7 / (7+3) = 0.70

Completeness = 7 / (7+5) = 0.583

F-value = 2 x (0.7x0.583) / (0.7+0.583) = 0.6361

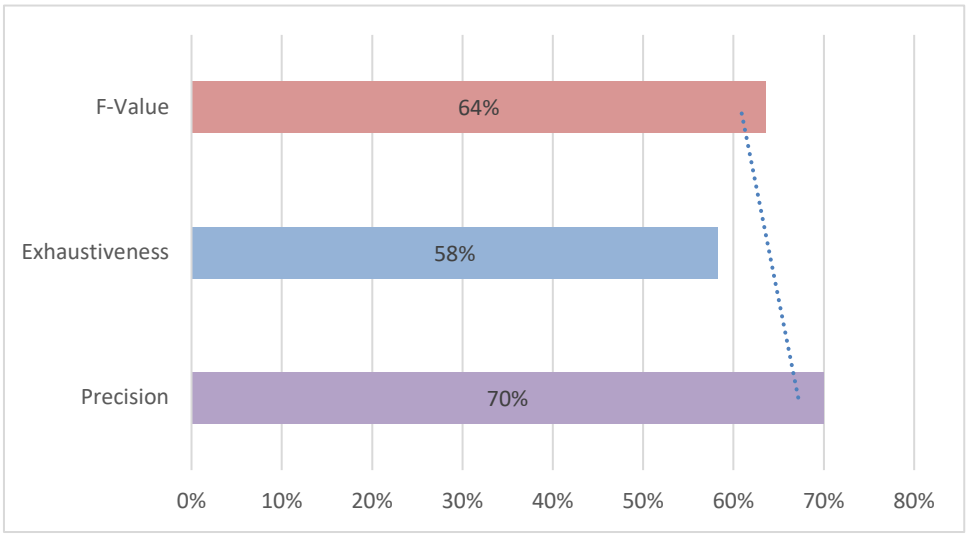

Fig. 9: Statistical Percentage Performance for Validation of Negative Accuracy Metrics for Router Configuration in Remote Laboratory

On the other hand, we have the final result of the accuracy of the Remote Laboratory router configuration model, from which the negative values have been obtained as positive in the F value that will help to get the result of the accuracy.

$$(0.952x10) + (0.6361x90) / 10+90 = 0.66769$$

Table 11: Confusion Matrix for Service Model

Service Model	Class	Accuracy	Precision	Exhaustiveness	F-Value
M.G.K.M	Bad	0.8	0.99	0.96	0.97
	Well		0.69	0.9	0.78
NTP ISO 27001	Bad	0.76	0.97	0.98	0.97
	Well		0.77	0.7	0.73
MASTER MINDS	Bad	0.56	0.95	0.92	0.94
	Well		0.46	0.6	0.52
REMOTE LABORATORY	Bad	0.67	0.97	0.94	0.95
	Well		0.70	0.58	0.64

By detailing the confusion matrix, the calculation of the accuracy, precision, completeness, and F-value metrics of each service model used for this study will be explained. The results can be seen in

table 11, each model has demonstrated high performance, but M.G.K.M has obtained better results for each metric, followed by NTP ISO 27001, an adequate margin was also considered, such as REMOTE LABORATORY, which by a small margin is close in its result, finally we have MASTER MINDS where a result is obtained below the two previous models. That is why we have the precision results for each model evaluated within the data analysis research focused on learning the configuration of the router equipment.

In summary, the appropriate tools for configuring the Router, which was taken into account for the statistical results, were considered by three very notable models for the research study, where it is worth highlighting the difference of each style that was used. Therefore, the applicability of either model can be fully considered.

5. Conclusion

After carrying out a comprehensive evaluation of the characteristics of various learning applications, the following significant conclusions can be drawn.

The comparative analysis deduces core functionalities in mobile applications that enable positive router configuration learning experiences, including interactive user interfaces, assessable resources, and community participation. The importance of personalized, learner-driven content for skill acquisition is emphasized while suggesting enhancements to motivate continued usage. Through multi-dimensional evaluation, the study prescribes a reference model prioritizing design factors of emerging mobile technologies for flexible networking education. Guidelines for mobile application development are directed at the dual objectives of convenience and effective progress tracking during independent learning modules.

The development of educational applications for configuring routers involves a number of technical, pedagogical, and security aspects that must be considered to ensure the success of the project. By providing a practical, flexible, and customized way to learn the skills needed to configure routers, these applications can help improve user learning. In addition, the type of router, its location, its Internet connection, its operating system, and its development environment should be considered. In addition, the application should be designed using artificial intelligence techniques, following the principles of ubiquitous learning and adapting the content and context to each learner. Finally, appropriate security measures must be taken to protect the router and the application from any potential threats.

This study’s quantitative assessment provides salient empirical insights on leveraging agile management to improve construction industry competitiveness within China’s dynamic business environment. The research particularly demonstrates how agile practices like iterative planning and visualization can effectively equip construction enterprises to tackle uncertainty, foster participative cultures, and engineer resilient structures. While generalizability is constrained geographically, the work elucidates practitioner perceptions, change management challenges, and analytical nuances involved in embedding agile capabilities – issues overlapping many emerging market contexts. Future research can build on these findings to systematically track performance gains from tailored agile strategies across Chinese construction life cycles and supply networks through mixed-method investigations. In summary, the comparative analysis of learning application functionalities reveals that these tools have a significant potential to improve knowledge related to router configuration. The diversity of functionality and content available allows learning to be tailored to the individual needs of users, promoting the use of these applications. As new applications are added to this end, it is important to consider the selection of those that best fit the user's instructional objectives and tendencies, thus ensuring an enriching and effective learning experience.

Acknowledgments

We are very grateful to all the people who contributed knowledge and made this article a success.

References

Al-Hunaiyyan, A., Alhajri, R. & Al-Sharhan, S. (2018). Perceptions and challenges of mobile learning in Kuwait. *Journal of King Saud University-Computer and Information Sciences*, *30*(2), 279-289. Disponible en: https://www.sciencedirect.com/science/article/pii/S1319157816301434.

Almaiah, M., Alamri, M. & Al-Rahmi, W. (2019). Applying the UTAUT model to explain the students' acceptance of mobile learning system in higher education. *Ieee Access*, *7*, 174673-174686. Recuperado de: https://ieeexplore.ieee.org/abstract/document/8918396

Alonso, J. & Mirón, J. (2017). Aplicaciones móviles en salud: potencial, normativa de seguridad y regulación. *Revista Cubana de Información en Ciencias de la Salud*, 28(3), 1-13.

Álvarez, E. & Jiménez, R. (2022). Aprendizaje móvil mediado por apps: Impacto para la innovación en ambientes educativos en América Latina. *Horizontes Revista de Investigación en Ciencias de la Educación*, 6(26), 2265-2278.

Alzaylaee, M. K., Yerima, S. & Sezer, S. (2020). DL-Droid: Deep learning based android malware detection using real devices. *Computers & Security*, *89*, 101663. Recuperado de: https://www.sciencedirect.com/science/article/pii/S0167404819300161

Aycho Contreras, J. I. & Bustamante E. (2021). Aplicación móvil con microlearning y gamificación para el aprendizaje de la norma técnica NTP-ISO/IEC 27001: 2014. Disponible en: https://repositorio.ucv.edu.pe/bitstream/handle/20.500.12692/81827/Aycho_CJI-Bustamante_MEY-SD.pdf?sequence=1&isAllowed=y

Babalola, E. & Omolafe, E. (2022).Effect of Developed Mobile Application on Undergraduates Academic Performance in Computer Science. *ASEAN Journal of Science and Engineering Education. [en línea], vol.* 2, no. 3, pp. 215-222. Disponible en: https://ejournal.upi.edu/index.php/AJSEE/article/view/44833.

Balaskas, A., Schueller, S., Cox, A. L. & Doherty, G. (2021). The functionality of mobile apps for anxiety: systematic search and analysis of engagement and tailoring features. *JMIR mHealth and uHealth*, 9(10), e26712. Recuperado de: https://mhealth.jmir.org/2021/10/e26712

Behrang, F. & Orso, A. (2019, November). Test migration between mobile apps with similar functionality. *In 2019 34th IEEE/ACM International Conference on Automated Software Engineering (ASE) (pp. 54-65)*. IEEE. Recuperado de: https://ieeexplore.ieee.org/abstract/document/8952387

Buck, A. (2023). 57 Mobile App Download, Usage and Revenue Statistics for 2024. Retrieved 19 1, 2024, from https://www.mobiloud.com/es/blog/estadísticas-de-aplicaciones-móviles

Cantillo, C. (2019). Mobile applications as support for virtual education: E-learning+ M-learning. In *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*. Recuperado de: https://laccei.org/LACCEI2019-MontegoBay/full_papers/FP241.pdf

Castro, C. (2020). Impacto del aprendizaje basado en proyectos en las competencias de redes y comunicaciones I en estudiantes de ingeniería, Lima 2020. Disponible en: https://repositorio.ucv.edu.pe/handle/20.500.12692/49473

Cisco (2022). Chapter: Basic Router Configuration. Retrieved 24 1, 2024, from https://www.cisco.com/c/en/us/td/docs/routers/access/800M/software/800MSCG/routconf.html

Corbo, A. (2022). What Is Java? builtin [en línea]. Disponible en: https://builtin.com/software-engineering-perspectives/java.

Dahiya, R., Kashyap, A., Sharma, B., Sharma, R. K. & Agarwal, N. (2023). Security in Mobile Network:

Issues, Challenges and Solutions. EAI Endorsed Transactions on Internet of Things, 10. https://doi.org/10.4108/eetiot.4542

Demir, K. & Akpinar, E. (2018). The Effect of Mobile Learning Applications on Students' Academic Achievement and Attitudes toward Mobile Learning. *Malaysian Online Journal of Educational Technology, 6(2), 48-59*. Disponible en: https://files.eric.ed.gov/fulltext/EJ1174817.pdf.

Estrada, B. & Zapata, C. (2022). Definición de un meta-modelo para el diseño de aplicaciones de software educativo basado en usabilidad y conocimiento pedagógico. *CIT Informacion Tecnologica*, 33(5), 35–48. https://doi.org/10.4067/s0718-07642022000500035

Fernández, R. (2023). Numero de descargas mundiales de apps mundo. Retrieved 24 1, 2024, from https://es.statista.com/estadisticas/574024/numero-de-descargas-mundiales-de-apps-mundo/

Garay, J. (2020). Aplicaciones de dispositivos móviles como estrategia de aprendizaje en estudiantes universitarios de enfermería. Una mirada desde la fenomenología crítica. RIDE. *Revista Iberoamericana para la Investigación y el Desarrollo Educativo,* 10(20), 2020. https://doi.org/10.23913/ride.v10i20.594

Herazo, L. (2022). ¿Qué es una aplicación móvil? TECNOLOGÍA [en línea]. Disponible en: https://anincubator.com/que-es-una-aplicacion-movil/.

Hilario, F., Dávila, M. & Liendo, M. (2023). Analysis and Development of a Mobile Application to Improve the Semantic Memory of Children with Down Syndrome. *Journal of System and Management* Sciences, 13(2), 346-356. Recuperado de: http://www.aasmr.org/jsms/Vol13/No.2/Vol.13.2.24.pdf

Hinze, A., Vanderschantz, N., Timpany, C., Cunningham, S., Saravani, S. & Wilkinson, C. (2023). A study of mobile app use for teaching and research in higher education. Technology, Knowledge and Learning, 28(3), 1271-1299. Recuperado de: https://link.springer.com/article/10.1007/s10758-022-09599-6

Huaccachi, P. & Mejía, A. (2021). Aplicación móvil para el aprendizaje de acciones ante violencia a menores de edad. Disponible en: https://repositorio.ucv.edu.pe/handle/20.500.12692/77712

Innotedec (2022). Mobile Learning. Retrieved 24 1, 2024, from https://blogs.uoc.edu/educacion-digital/tendencias/aprendizaje-movil-mobile-learning/

ISC (2022). (ISC)2 Cybersecurity Workforce Study a critical need for cybersecurity professionals persists amidst a year of cultural and workplace evolution. Retrieved 24 1, 2024, from https://www.isc2.org/-/media/Project/ISC2/Main/Media/documents/research/ISC2-Cybersecurity-Workforce-Study.pdf?rev=ae39d66a4616478792d38da57fb80564&hash=31B8381DC81AD70B9B6DA6FF84534B33

Jang, B., Kim, M., Harerimana, G. & Kim, J. (2019). Q-learning algorithms: A comprehensive classification and applications. IEEE access, 7, 133653-133667. Recuperado de: https://ieeexplore.ieee.org/abstract/document/8836506

Kaur, A. & Kaur, K. (2022). Systematic literature review of mobile application development and testing effort estimation. *Journal of King Saud University-Computer and Information Sciences, 34(2), 1-15. Recuperado de* https://www.sciencedirect.com/science/article/pii/S1319157818306074

Kong, F., Horsham, C., Ngoo, A., Soyer, H. P. & Janda, M. (2021). Review of smartphone mobile applications for skin cancer detection: what are the changes in availability, functionality, and costs to users over time?. *International Journal of Dermatology, 60(3), 289-308*. Recuperado de: https://dl.acm.org/doi/abs/10.1145/2684822.2685322

Limpraptono, F. Y., Nurcahyo, E. & Faisol, A. (2021). The development of electronics

telecommunication remote laboratory architecture based on mobile devices. *International Journal of Online and Biomedical Engineering (iJOE), 17(03), 26*. Recuperado de: http://eprints.itn.ac.id/5438/1/Paper%201%20The%20Development.pdf

Loy, M. J., Goh, K. W., Osili, N., Ming, L. C., Dhaliwal, J. S., Hermansyah, A. & Lee, K. (2022). Features and Functionalities of Medical Mobile Applications for the Endemic Phase of COVID-19: Review and Content Analysis. *Progress In Microbes and Molecular Biology, 5(1), 1-17*. Recuperado de: https://repository.unair.ac.id/124450/

Lucero, J. & Álzate, O. A. (2020). Aplicaciones móviles para el estudio de la anatomía humana. *International Journal of Morphology, 38(5), 1365-1370*. Disponible en: https://www.scielo.cl/scielo.php?pid=S0717-95022020000501365&script=sci_arttext

Macias, K. (2021). Aplicación móvil interactiva para android y en lenguaje de programación java que haga uso de la realidad aumentada para el mejoramiento, innovación y dinamización de la enseñanza de redes locales (lan). Disponible en: https://repository.unad.edu.co/handle/10596/41878

Máñez, C. & Cervera, J. (2021). Aplicación móvil para niños con dificultades de aprendizaje en la automatización del proceso de reconocimiento de palabras. *Información tecnológica,* 32(5), 67-74. Disponible en: https://www.scielo.cl/scielo.php?pid=S0718-07642021000500067&script=sci_arttext

Martinon, P., Saliasi, I., Bourgeois, D., Smentek, C., Dussart, C., Fraticelli, L. & Carrouel, F. (2022). Nutrition-related mobile apps in the French app stores: *Assessment of functionality and quality. JMIR mHealth and uHealth, 10(3), e35879*. Recuperado de: https://mhealth.jmir.org/2022/3/e35879/

Milne-Ives, M., Lam, C., De Cock, C., Van Velthoven, M. H. & Meinert, E. (2020). Mobile apps for health behavior change in physical activity, diet, drug and alcohol use, and mental health: systematic review. *JMIR mHealth and uHealth*, *8*(3), e17046. Recuperado de: https://mhealth.jmir.org/2020/3/e17046

Min, S., So, K. & Jeong, M. (2019). Consumer adoption of the Uber mobile application: Insights from diffusion of innovation theory and technology acceptance model. *Journal of Travel & Tourism Marketing*, *36*(7), 770-783. Recuperado de: https://www.tandfonline.com/doi/abs/10.1080/10548408.2018.1507866

Mondal, R., Tang, A., Beckett, R., Millstein, T. & Varghese, G. (2023, November). What do LLMs need to Synthesize Correct Router Configurations? In Proceedings of the 22nd ACM Workshop on Hot Topics in Networks (pp. 189-195).

Montero , J. (2021). Aplicación móvil con microlearning y gamificación utilizando la mayéutica como estrategia de aprendizaje de equipos de redes. Disponible en: https://repositorio.ucv.edu.pe/handle/20.500.12692/78330

Muñoz, C. (2020). Aplicación de la metodología mobile-d en el desarrollo de una app móvil para gestionar citas médicas del centro Jel Riobamba (Bachelor's thesis, Riobamba: Universidad Nacional de Chimborazo). Disponible en: http://dspace.unach.edu.ec/handle/51000/7073.

Nuanmeesri, S. (2023). Mobile application for the purpose of marketing, product distribution and location-based logistics for elderly farmers. Applied Computing and Informatics, 19(1/2), 2-21. Recuperado de: https://www.emerald.com/insight/content/doi/10.1016/j.aci.2019.11.001/full/html

Riasat, H., Akram, S., Aqeel, M., waseem Iqbal, M., Hamid, K. & Rafiq, S. (2023). Enhancing Software Quality Through Usability Experience And HCI Design Principles. vol, 42, 46-75. Recuperado de: https://www.researchgate.net/profile/Khalid-Hamid-7/publication/368409527_enhancing_software_quality_through_usability_experience_and_hci_design_principles/links/63e697326425237563a28b8c/enhancing-software-quality-through-usability-experience-and-hci-design-principles.pdf

Rodríguez Valerio, Daniela. (2020). Más allá de la mensajería instantánea: WhatsApp como una herramienta de mediación y apoyo en la enseñanza de la Bibliotecología. *Información, cultura y sociedad, no 42, p. 107-126*.Disponible en: http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1851-17402020000100107

Rootstack (2022). Mira las mejores prácticas para el desarrollo de aplicaciones móviles. Retrieved 24 1, 2024, from https://rootstack.com/es/blog/mira-las-mejores-practicas-para-el-desarrollo-de-aplicaciones-moviles

Sattarov, A. & Khaitova, N. (2020). Mobile learning as new forms and methods of increasing the effectiveness of education. *Архив Научных Публикаций JSPI*. Recuperado de: http://www.idpublications.org/wp-content/uploads/2019/12/Full-Paper-MOBILE-LEARNING-AS-NEW-FORMS-AND-METHODS-OF-INCREASING-THE-EFFECTIVENESS.pdf

Sharaf Addin, E. H., Admodisastro, N., Mohd Ashri, S. N. S., Kamaruddin, A. & Chong, Y. C. (2022). Customer mobile behavioral segmentation and analysis in telecom using machine learning. *Applied Artificial Intelligence*, *36*(1), 2009223. Recuperado de: https://www.tandfonline.com/doi/full/10.1080/08839514.2021.2009223

Shcherbakov, M., Balliu, M. & Staicu, C. A. (2023). Silent spring: Prototype pollution leads to remote code execution in Node. js. *In USENIX Security Symposium 2023*. Recuperado de: https://www.usenix.org/system/files/sec23summer_432-shcherbakov-prepub.pdf

Shum, Y. (2023). Estadísticas de la conectividad móvil y apps en el mundo 2023. Retrieved 24 1, 2024, from https://yiminshum.com/estadistica-movil-apps-mundo-2023/

Umaña, L. & Baquero, J. (2022). Uso de aplicaciones móviles como herramienta de apoyo tecnológico para la enseñanza con metodología steam. *Revista Politécnica, 18(36), 75-90*. Disponible en: https://www.redalyc.org/journal/6078/607872732006/607872732006.pdf

UNESCO (2022). Mejores prácticas de aprendizaje móvil. Retrieved 24 1, 2024, from https://www.unesco.org/es/digital-education/mobile-learning-practices

Ventura, L. (2021). Aprendizaje Invertido como modelo pedagógico aplicado al curso Desarrollo de Aplicaciones Móviles de un instituto superior en Lima Metropolitana. Disponible en: https://tesis.pucp.edu.pe/repositorio/handle/20.500.12404/20319

Vercell, A., Gasteiger, N., Yorke, J. & Dowding, D. (2022). Patient-facing cancer mobile apps that enable patient reported outcome data to be collected: a systematic review of content, functionality, quality, and ability to integrate with electronic health records. *International Journal of Medical Informatics*, 104931. Recuperado de: https://www.sciencedirect.com/science/article/pii/S1386505622002453

Weichbroth, P. (2020). Usability of mobile applications: a systematic literature study. Ieee Access, 8, 55563-55577. Recuperado de: https://ieeexplore.ieee.org/abstract/document/9042272

Zhang, C., Patras, P. & Haddadi, H. (2019). Deep learning in mobile and wireless networking: A survey. *IEEE Communications surveys & tutorials*, 21(3), 2224-2287. Recuperado de: https://ieeexplore.ieee.org/abstract/document/8666641