

## Article

# Towards the Integration of Emerging Technologies as Support for the Teaching and Learning Model in Higher Education

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**Abstract:** The pandemic caused by COVID-19 impacted the entire world, but the significant challenges to be faced during this crisis opened an opportunity for organizations to evolve toward a digital transformation. Educational institutions were a concrete example of the use of technologies, which were abruptly incorporated into the teaching–learning model. Although this initiative was initially a challenge for teachers and students, it has now become a tool for new innovative teaching models, such as hybrid, online, and flexible models. The impact of technology used in education has been beneficial due to emerging technologies (virtual reality, augmented reality, games, web applications, mobile applications, etc.), which have served as tools to facilitate and motivate studying. These educational trends contribute directly to the fourth Sustainable Development Goal (SDG). This research analyzes whether the use of a web application, as a support in the educational model, can make students better understand the subjects of network infrastructure and be more efficient when configuring equipment in a data network. Therefore, this research is based on the design of an educational web application based on Python libraries, which allows the configuration of networking equipment based on the concept of network automation with the application of a graphical user interface (GUI). The web application can be deployed with communication equipment or in conjunction with the GNS3 simulator. This versatility allows this web tool to be applied to the teaching of network equipment configuration in any mode of study (classroom, online, hybrid, or flexible). The results obtained in this research are encouraging and open the way for the implementation of network automation and Python libraries for educational applications that can be important tools within the teaching and learning models of higher education.

**Keywords:** education; innovative learning; learning models; automation; Python; web application



**Citation:** Criollo-C, S.; Govea, J.; Játiva, W.; Pierrottet, J.; Guerrero-Arias, A.; Jaramillo-Alcázar, Á.; Luján-Mora, S. Towards the Integration of Emerging Technologies as Support for the Teaching and Learning Model in Higher Education. *Sustainability* **2023**, *15*, 6055. <https://doi.org/10.3390/su15076055>

Academic Editors: Antonio-Manuel Rodríguez-García, María-Natalia Campos-Soto and Juan Carlos de la Cruz-Campos

Received: 27 February 2023

Revised: 22 March 2023

Accepted: 24 March 2023

Published: 31 March 2023



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## 1. Introduction

During the last decade, higher education has undergone significant changes marked by the development of technology and its influence on the new generation of students [1,2]. Current educational models have introduced innovative practices using digital technologies to enhance traditional education methodologies [3]. An example of this are the academic models that use blended learning, e-Learning, and mobile learning, as well as continuous and ubiquitous education initiatives and programs such as MOOCs, online classes, the use of mobile educational applications, augmented reality, virtual reality, web applications, etc. [4]. These models, being new and innovative, reveal a deficiency in learning; the causes of this deficiency can be associated with factors such as educational modality, educational materials and resources, learning challenges, and assessment methods [5]. In a traditional modality, the teacher becomes the main actor of learning; they are the one who defines

what and how students learn in the classroom, which is a controlled environment [6]. By eliminating the environment and the control that the teacher exercises over the group, problems increase, especially when the resources, activities, and methods of the face-to-face model are not adapted to the new modality [7]. These factors cause a lack of interest in the student, who by not having the physical presence of the teacher, avoids their participation, which can create gaps in learning that are difficult to identify until they become problems such as academic dropout [8].

Online, distance, and hybrid study modalities, due to the isolation caused by the pandemic, had an incredible surge [9]. It has been a challenge for higher education institutions to adapt to these changes due to the new educational needs and the digital culture of the new generation of students [10]. This adaptation can generate indicators, which must be properly addressed for a correct deployment in the implementation of new strategies and methodologies that use digital technologies in the educational context [11]. In addition, this need for the use of digital technologies in education arises from the new educational modalities and technological contexts in which students and their new learning needs are included [12]. Nowadays, the use of technology plays an important role in education, and an educational model that is shaped using digital technologies and emphasizes student-centered learning activities is possible [4,13]. The learning process using digital technologies can provide students with a self-paced learning environment [14]. In this way, students can learn according to their learning ability. In addition, it has been shown in several empirical studies that the use of technology can improve academic performance in students [15].

Nowadays, the development of technological skills in the educational context is a priority in formal education from early learning to higher education [16]. All this must go hand in hand with teacher training and professional development, which involves identifying the role of the teacher and the student to transform the learning environment [17]. These skills and innovative educational models supported by emerging technologies contribute directly to the fourth Sustainable Development Goal (SDG) [18]. This goal seeks to improve access to quality education and thus ensure the sustainable development of countries [19].

This research is based on the design of an educational web application based on Python libraries, which allows the configuration of networking equipment based on the concept of network automation, using a graphical user interface (GUI). The design of the application contemplated the use of different modules within Python such as Netmiko, SQLAlchemy, and Bcrypt, which allow automated configuration of network equipment through the secure remote access protocol (SSH). These modules enable coding various scripts for different configurations on network devices. The GUI was designed using the Python module called Flask, which serves as an aid to consolidate a friendly interaction between the user and the developed program. Through the GUI, users can authenticate themselves through authorized logins to enter the program and write the necessary data for the type of equipment and configuration chosen. The web application is functional with communication equipment and with a network simulator called GNS3. This versatility allows this web tool to be used for teaching the configuration of network equipment in any mode of study (classroom, online, hybrid, or flexible) and for the configuration of network infrastructure equipment for small and medium-sized companies.

A case study was conducted with the designed application; for this purpose, a laboratory was used in a private university in the city of Quito-Ecuador, which is a Cisco academy. Therefore, all the equipment in the implementation phase was of this brand. The objective of this research is to analyze if the use of a web application, as a support in the educational model, can make students better understand the subjects on the network infrastructure and be more efficient when configuring the equipment in a data network. To this end, this paper introduces the reader to the current use of digital technologies for the innovation of the teaching and learning model. The rest of the article is organized as follows: Section 2 shows digital technologies and their use in education; Section 3 shows a literature review on the automation of data networks; Section 4 shows the methodology used for the creation

of the web tool; Section 5 shows a case study; Section 6 shows the discussion of the research; Section 7 shows future work; finally, Section 8 shows the conclusions of the research.

## 2. Emerging Digital Technologies in Education

Today's education has become one of the biggest challenges; in many countries, teachers face material shortages, lack of content, lack of equipment, and lack of opportunities for self-directed learning [20]. To address these challenges, educators are turning to the use of digital technologies to help improve the quality of teaching and learning [21]. The integration of technology in education can give way to the creation of educational models in online, face-to-face, blended, and hybrid modalities [7]. It is for this reason that the use of technology in education has the potential to reach people living in remote places, in conditions of vulnerability, and where there are no educational institutions, teachers, or libraries [22]. Therefore, it is expected that in the future, the use of digital tools will become the basis for the creation of new and innovative learning environments [23].

Higher educational institutions have several challenges to address for the deployment of digital technologies in education, but undoubtedly, a point in favor is the new generations of students [12]. Digital natives have a new way of accessing knowledge; they are technologically advanced, and this contributes to the use of technologies in the educational model [10]. In recent years, initiatives have been developed using digital technologies as a support in the educational model [15,24]. Some works use mobile applications for learning indigenous languages to preserve the culture of a country [25]. Another example is the use of augmented reality (AR) for learning enhancement in higher education [15,26,27]. Virtual reality has also been used in the educational context to create immersive educational environments so that students can observe how knowledge can be applied [28–30]. In recent years, the concept of gamification has become relevant in education through gamification [1]. Motivation, entertainment, and competition mean that this digital technology is being used in the educational environment with very encouraging results regarding learning [1,31,32].

Whether a technology is considered emergent depends on where it is being used, the domain and knowledge of its operation, and the application given to it [33]. An important characteristic of these technologies is that they do not need to have a limited life, even when they have been used for a long period of time. They can begin to become emerging when they are used in innovative ways in the service of people to achieve their objectives [34,35]. Emerging technologies for education (ELTs) are those that are being incorporated into education, which favor communication and allow easy access to educational information [36]. Some of the ELTs that contribute to an innovation system in higher education are mobile learning, MOOCs, social networks, gamification, augmented reality, virtual reality, and web applications [14,33]. The use of ELTs is quite diverse, for example, one research proposes the use of smartphones to run educational applications and contribute to improving the quality of teaching and learning. In addition, the author indicates that the use of mobile learning helps to compensate for the lack of infrastructure and the scarcity of school supplies and books in the place where the research was conducted [37]. They are also used for learning English as a second language for native speakers of Chinese [38]. One of the most widely used digital technologies is web pages which, depending on their design, can store information, generate educational games, serious games, manage learning resources, and automate processes, etc. [39–41].

## 3. Literature Review on Network Automation

Network automation is performed using software, which automatically performs the configuration, provisioning, management, and testing of data network devices [42]. This technology is used by organizations and service providers seeking to improve the efficiency of their network management and administration processes [43]. In addition, using network automation can reduce human errors and operational expenses involved in existing manual configuration [42,44,45]. Network automation tools can perform simple jobs such as basic

network mapping or much more complex jobs such as managing and evaluating the configuration of a technology infrastructure and provisioning resources needed for a virtual network [44]. Automation can be used in any type of network—for example, a local area network (LAN)—and even encompasses a wide area network (WAN). In addition, it can be used in data centers, in the cloud, and in wireless networks; that is, any network equipment that uses the command line interface (CLI) or an application programming interface (API) can be automated [42]. In recent years, as organizations have begun to digitally transform, their technology infrastructure has become much more complex, which has made way for new open-source programming languages, such as Python and Ruby, which have gained popularity for their ease of use and flexibility of work [42,46,47].

### 3.1. Network Automation Benefits

Some of the benefits associated with network automation are as follows:

- Reduce operational expenses. By eliminating manual tasks, network equipment provisioning, and management can be improved, allowing organizations to operate in an agile and efficient manner [44].
- Low probability of human error. Manual configurations bring with them errors, which can be quickly propagated in the network, and this can have significant consequences. This can be avoided if the task is automatically configured properly only once [42,44].
- Improves network efficiency. Automating the configuration processes in a technological infrastructure immediately improves network efficiency, as there is no need to perform time-consuming manual tasks [44].
- Improves network performance. Without the need for disruption from manual network configuration, organizations can offer and deliver a higher level of services consistently [46].
- Improves monitoring. Automation allows better control of the network, making it adaptable to specific needs. In addition, it allows for greater capacity and response to changes and better resolution of incidents and problems [44].

### 3.2. Network Automation Tools

For configuration automation in data network equipment, there are several platforms and protocols, based on scripts and software. These tools are open source, and examples of them are Ansible, Chef, and Puppet [48]. These tools offer an automation model and provide a library of common commands or workflows that can be easily used [45].

In recent years, automation has been used in the configuration of networking equipment. Software-based platforms have been developed that offer automation capabilities that work only with specific brands of networking equipment and use a specialized API [42,44,49]. All these tools simplify the amount of work and eliminate repetitive processes in the configuration of IT infrastructure equipment [50]. Some initiatives use Python libraries to perform data network automation, but these automation tools were not created for educational environments [44,46,51]. Examples include the web tool called Network Configuration Manager, which automates backups, monitoring, and change management, thus improving the productivity and reliability of the enterprise data network [52]. Another available web tool is Ansible Automation, which is used to install system software, automate daily tasks, prepare internal infrastructure, and improve data network security [45]. Mazin, et al. [51] in their research shows positive results regarding the efficiency of using automation in network equipment configuration versus using CLI, but their results were not analyzed in an educational environment with students.

Other network automation initiatives using emerging technologies include “Implementación de un sistema para la administración de las funciones básicas de un Cisco Meraki MR33 mediante Cisco Devnet y Amazon Alexa en el Data Center académico de la Universidad de las Américas”. Its objective was to implement a system for the administration and management of the functionalities of Cisco Meraki equipment through Cisco DevNet Sandbox and Amazon Alexa, using Python as a tool for the migration of the UCS

admin system [53]. In “Network Automation and Abstraction using Python Programming Methods”, a network was simulated in the GNS3 simulator with an Ubuntu container in Docker to run the Python scripts. Netmiko and Paramiko libraries were used to perform virtual network configuration, routing protocols, and backup configuration independently of the network equipment vendor [46]. The goal of “Diseño e implementación de un agente de administración, configuración y monitoreo para dispositivos de red Cisco” was achieved by using functions that enable serial communication between the computer running the program and the network equipment to which it is connected [54].

The research work presented in this paper differs from all previous initiatives in analyzing the understanding of a group of students regarding the configuration of network equipment using a web-based automation application. In addition, the analysis of usability, perception, and efficiency in the use of the automation application measured in a real higher education environment is performed.

#### 4. Web Application to Automate the Configuration of Networking Equipment

To achieve the objectives of this research, an educational web application was designed and built, which contains a GUI for the automated configuration of equipment in a data network or technological infrastructure.

##### 4.1. Programming Languages and Frameworks

The tools listed in Table 1 were used to develop the web application.

**Table 1.** Tools used to develop the web application.

Programming Language/Framework	Definition
Python	It is a computer programming language that is often used to create websites and software, automate tasks, and perform data analysis. Python is a general-purpose language, which means that it can be used to create a variety of programs for different purposes [42,55].
WTForms	It is a flexible form validation and rendering library for web development in the Python programming language. This library can work with any web framework and any template engine of choice [56].
Netmiko	It is a multivendor Python library that facilitates the process of connecting to network devices through the SSH protocol, allowing better management and administration of network equipment through programs or scripts. In addition, it works with a variety of equipment—for example, Arista vEOS, Cisco ASA, Cisco IOS, Cisco IOS-XR, Cisco SG300, HP Comware7, HP ProCurve, Juniper Junos, and Linux Servers [57].
Flask	It is a framework for a lightweight web application that is developed for easy deployment. Moreover, it is scalable for complex applications, making it one of the most popular Python web application frameworks. Flask makes it easy for the developer to freely choose the tools and libraries he needs [58].
Jinja	It is a modern templating language for Python developers. It is used to create HTML, XML, or other markup formats that are returned to the user via an HTTP request [59].
Bootstrap	It is a giant collection of practical and reusable bits of code written in HTML, CSS, and JavaScript. Additionally, it is a front-end development framework that allows developers and designers to quickly create fully responsive websites [60].

##### 4.2. Configuration Modes in Network Equipment

The executable file Putty with an SSH client is used for secure access to communication equipment and input and output peripherals (monitor and keyboard). This tool allows securely connecting to remote servers and communication equipment through a serial session allowing remote administration of equipment within a data network [61].

The Internetwork Operating System (IOS) is the software used by most Cisco-branded equipment [62]. It is responsible for the management of interfaces, resources, routing, routing, quality of service (QoS), security, etc. There are several modes of operation for

configuration through the CLI, which are hierarchically structured, and each of them allows specific tasks. The IOS configuration modes are hierarchically defined as follows:

- User mode (User EXEC)
- Privileged execution mode (Privileged EXEC)
- Global configuration mode
- Specific configuration modes

To automate the network configurations, Cisco IOS commands were used to manually configure the protocols and services.

Table 2 shows the commands that should be configured manually through the CLI and which were automated to be configured more easily through the graphical interface of the designed application.

Figure 1 shows the Python code of the application designed for configuring virtual local area networks (VLANs). A VLAN is a collection of network devices or nodes that communicate with each other as if they form a single local area network, but each VLAN is a different network [44]. VLANs are used to segment enterprise networks and divide broadcast domains. To configure VLANs, communication equipment must support the IEEE8202.1Q standard.

```
@app.route('/vlan', methods = ['GET', 'POST'])
@login_required
def vlanPage():
    output = ''
    vlan_form = VlanForm()
    if vlan_form.validate_on_submit():
        try:
            output = createVlans(ip_address=vlan_form.ip_address.data,
                                username=vlan_form.username.data,
                                password=vlan_form.password.data,
                                vlan_numbers=vlan_form.vlan_numbers.data,
                                vlan_names=vlan_form.vlan_names.data)
            flash('Successful configuration!', category='success')
        except ssh_exception.NetmikoTimeoutException:
            flash('Can not connect to the specified device', category='danger')
        except ssh_exception.NetMikoAuthenticationException:
            flash('Incorrect username/s or password/s', category='danger')
    if vlan_form.errors != {}:
        for errorMsg in vlan_form.errors.values():
            flash(f'There is an error within the configuration data: {errorMsg}', category='danger')
    return render_template('vlan.html', form=vlan_form, config_output=output)
```

**Figure 1.** Path code for VLAN creation.

Figure 2 shows the GUI presented to the user to enter the data required to create a VLAN using the developed web tool. The first field to fill in is the IP address of the computer where the VLAN is to be created. Next, a username and password are entered for the SSH connection to the computer. Next, you add the ID number corresponding to the number of VLANs you want to create. In addition, you add the name corresponding to each VLAN separated by a comma. Finally, to execute the configuration, click on “Submit” and verify that the execution was successful by checking the output screen. As shown in Figure 2, the GUI is user-friendly and very easy to use to achieve the necessary configurations in the proposed network. It is important to note that users need some knowledge of data networks and IP addresses to access the computers involved through SSH.

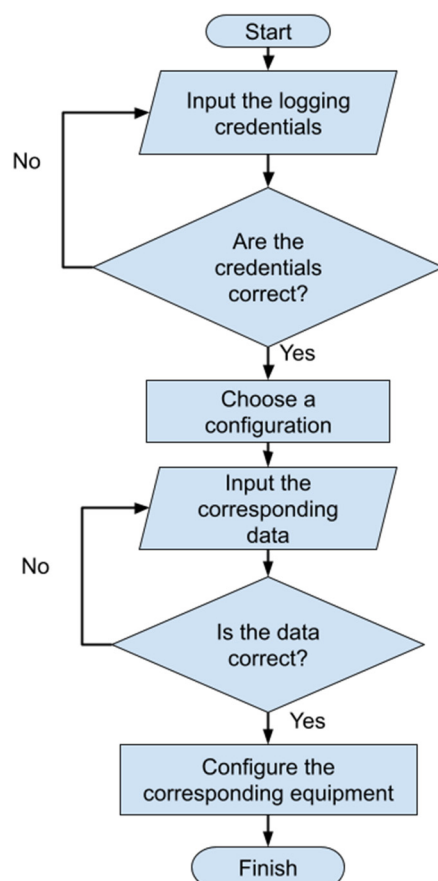
The operation of the web application can be summarized in the flow diagram presented in Figure 3. This diagram shows the functionality of the application and the steps required for the correct configuration of the network devices. It is important to note that the application ensures a level of security by requesting authentication for access to the configuration.

**Table 2.** Commands used for configuration using the CLI.

Basic Commands to Monitor the Initial Configuration of the Equipment		
Equipment Configuration Mode	Command for the CLI	Command for the CLI
router#	show running-config show version show protocols show vlan show ip interface brief show ip route show access-list	These commands are used to display data related to the current configuration of the equipment, such as protocols and VLANs, among others.
router(config)#	IPv4 addressing configuration interface type number ip address ip address mask no shutdown	These commands are used to assign an IP address to the interface of a network computer.
router(config)#	DHCP protocol configuration for dynamic IPv4 address allocation ip dhcp pool pool name network ip mask domain-name domain name dns-server server ip	With these commands you can configure a network computer as a DHCP server.
router(config)#	Configuration of dynamic routing protocols, RIP, RIPv2 and OSPF router ospf ospf id router-id router id network ip wildcard area	These commands can be used to configure the OSPF protocol on the routers.
router(config)#	router rip version 2 network ip address no auto-summary	These commands are used to configure the RIP protocol on the network equipment.
switch(config)#	Creating and configuring a virtual LAN (VLAN) vlan vlan id name vlan name	These commands are used to create VLANs with their respective names on the computers.
switch(config)#	Configuring security on layer two communication equipment ports on the switch interface type number switchport mode access switchport port-security switchport port-security maximum MAC address number switchport port-security mac-address sticky switchport port-security violation shutdown   restrict   protect	These commands are used to configure layer two port security on network equipment.
router(config)#	Initial configuration of a layer three equipment, the router username username password password Username username privilege privilege level	With these commands you can create a new user on a network computer.
router(config)#	Static routing configuration for communication between different data networks ip route network-ip network mask next hop ip	These commands are used to create a static route to another network.

VLAN Configuration	
Device IP Address	192.168.10.40
Username	jaime
Password	•••••
VLAN numbers	10, 20, 30
VLAN names	soporte, finanzas, marketing
<input type="button" value="Submit"/>	

**Figure 2.** Configuration and testing for VLAN creation.



**Figure 3.** Application flowchart.

## 5. Case Study

In this section, the use of the automation application will be analyzed; a usability analysis will also be performed using the IBM CSUQ tool [63].

### 5.1. Web Application Usability Analysis

#### 5.1.1. Participants

Each participant accepted an informed consent given through a web form. The students were classified into two groups (1 and 2); this classification was made according to the



level of theoretical and practical knowledge regarding the configuration of communication equipment using the CLI. Group 1 has basic knowledge regarding the configuration of network equipment, and group 2 has advanced knowledge regarding the configuration of network equipment. Each group of participants received an explanation of the use of the automation application. The participants were able to ask questions after using the application. Once their doubts were clarified, when they were sure they had mastered the application, they performed the requested tasks. The experimentation lasted about 60 min; once the tasks were completed, they were asked to complete the IBM CSUQ survey.

- Group 1: 25 students
- Group 2: 25 students

### 5.1.2. Tasks

Both groups of students had to perform five tasks:

- Simulate the data network in Packet Tracer or GNS3 software
- Configure the network using the CLI in Packet Tracer
- Configure the network using the automation application in GNS3
- Respond to the IBM CSUQ usability survey
- Choose a word that describes the application from a group of delivered words.

### 5.2. Use of Web Application

The web application was used in a private university in Ecuador with two groups of engineering students. The participants were selected by convenience sampling. The age of the participants ranged from 19 to 21 years old. Of the 50 participants, 28 were 19 years old, 25 were 20 years old, and 3 were 21 years old. All participants reported that they were aware of and had used a web application and knew how to use the CLI to configure communication equipment.

In group 1 are the participants who have basic knowledge about the configuration of communication equipment. In group 2 are the students with more advanced knowledge about the configuration of communication equipment. The two groups performed the network configuration using the CLI and the web application. Group 1 configured the network in Figure 4, and group 2 configured the network in Figure 5.

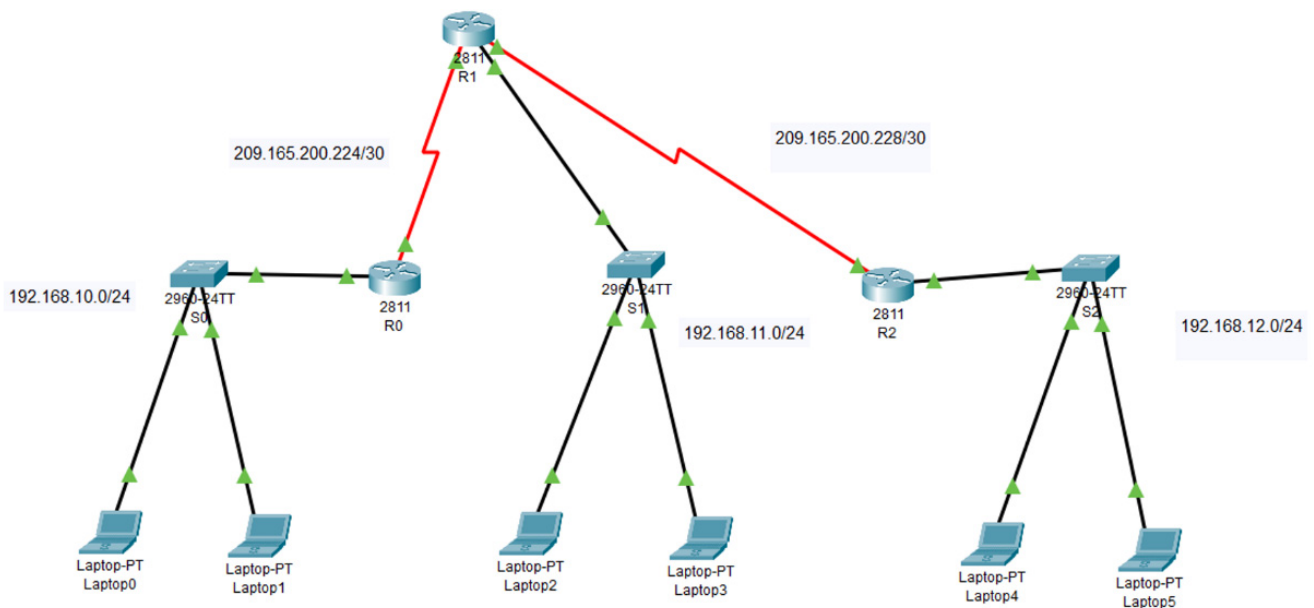


Figure 4. Simulation one.

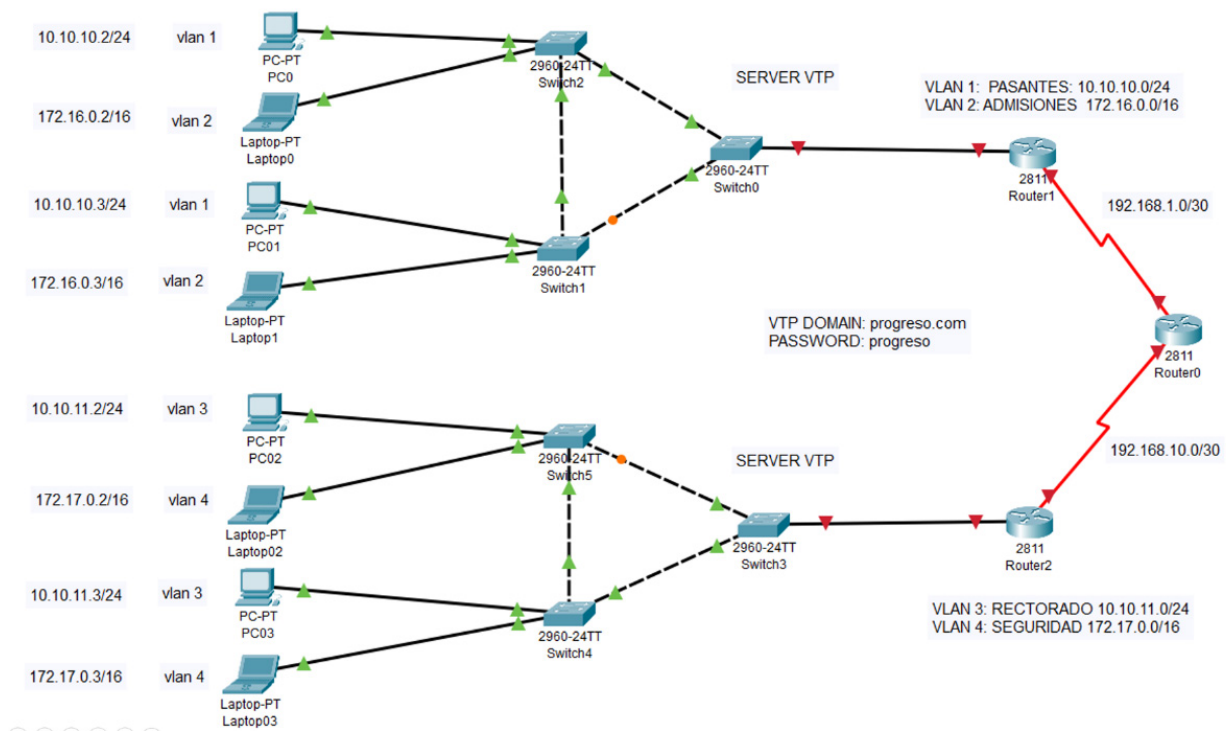


Figure 5. Simulation two.

### 5.3. Results

#### 5.3.1. Usability Results

Table 3 shows the mean ( $\mu$ ), median (M), and standard deviation ( $\sigma$ ) measures of the four categories of the IBM CSUQ [63]. The results show that the overall satisfaction of the participants has a positive trend, with a mean result of  $\mu = 5.92$  out of a maximum of 7 and a standard deviation of  $\sigma = 1.19$ . Table 3 shows the question with the lowest score is question 9 ( $\mu = 5.3$ ;  $M = 6$ ;  $\sigma = 1.37$ ). This indicates that consideration should be given to improving how the system displays the Mensa scores when an error has been made in the handling of the interface. On the other hand, the best-rated question is number 15 ( $\mu = 6.1$ ;  $M = 6$ ;  $\sigma = 0.93$ ), which indicates that the application provides ease of use because the information provided is clear and displayed in an orderly manner on the screen. In addition, questions 6 ( $\mu = 6.04$ ;  $M = 6$ ;  $\sigma = 1.21$ ) and 7 ( $\mu = 6.04$ ;  $M = 6$ ;  $\sigma = 1.09$ ) are the third best rated, indicating that the students felt comfortable with the use of the application and in a short time were able to learn to use it correctly. It can also be observed that SYSUSE and INTER-QUIAL have the highest scores, which means that the overall satisfaction is related to the quality of the interface design and usability of the system.

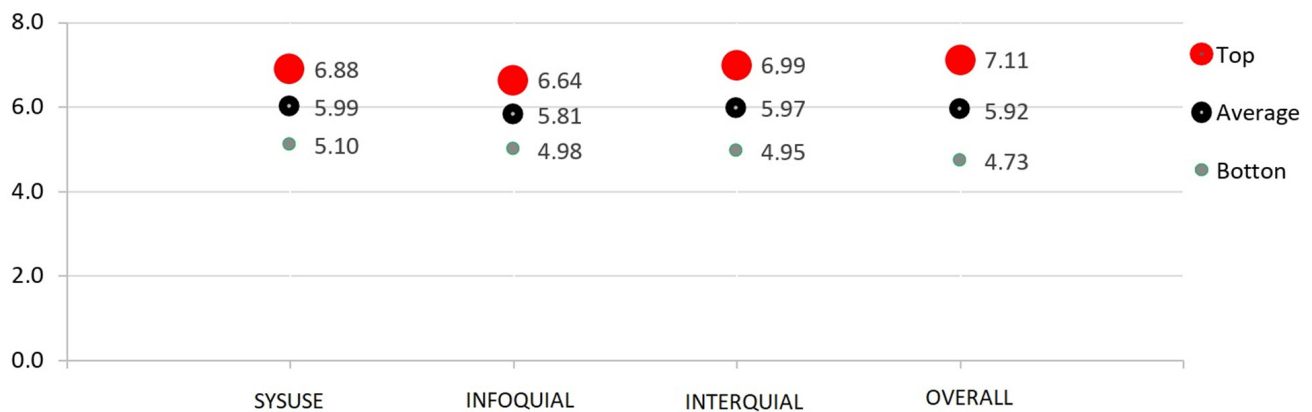
On the other hand, Figure 6 shows the usability values of the system (SYSUSE), which has a positive trend with a mean value ( $\mu = 5.99$ ) higher than the other analysis factors, which shows that usability is satisfactory for users. Information quality (INFOQUAL) presents the lowest results, with a mean value ( $\mu = 5.81$ ); this means that the application should improve the way it presents information to users. Finally, the interface quality (INTERQUAL) shows a mean value ( $\mu = 5.97$ ), which indicates that users perceive that the web application has adequate quality in its graphical interface.

The participants also chose a word that defines the web application from a group of words presented in task number five. Figure 7 shows that the students consider the web application as attractive, useful, organized, sophisticated, efficient, and that its use allows them to save time in the work to be completed. This result shows only the most relevant words chosen by the students.

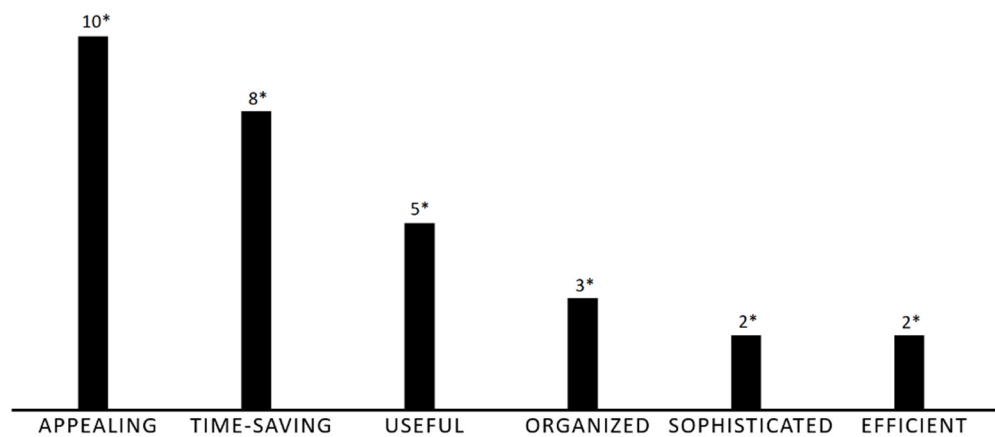
**Table 3.** Results of the average, median, and standard deviation measures of the IBM CSUQ tool.

IBM CSUQ	Question	$\mu$ *	M *	$\sigma$ *
SYSUSE	1. Overall, I am satisfied with how easy it is to use this system.	6.04	6	1.01
	2. It is simple to use this system.	6.08	6	0.99
	3. I can effectively complete my work using this system.	5.9	6	1.13
	4. I am able to complete my work quickly using this system.	6.02	6	0.91
	5. I am able to efficiently complete my work using this system.	5.92	6	1.12
	6. I feel comfortable using this system.	6.04	6	1.21
	7. It was easy to learn to use this system.	6.04	6	1.09
	8. I believe I became productive quickly using this system.	5.9	6	1.18
INFOQUAL	9. The system gives error messages that clearly tell me how to fix problems.	5.3	6	1.37
	10. Whenever I make a mistake using the system, I recover easily and quickly.	5.62	6	1.19
	11. The information (on-screen messages and guidance or other documentation) provided with this system is clear.	5.86	6	0.97
	12. It is easy to find the information I need.	6.08	6	1.07
	13. The information provided with the system is easy to understand.	5.84	6	1.02
	14. The information is effective in helping me complete my work.	5.84	6	1.00
	15. The organization of information on the system screens is clear.	6.1	6	0.93
INTERQUAL	16. The interface of this system is pleasant.	5.98	6	1.13
	17. I like using the interface of this system.	6.04	6	1.14
	18. This system has all the functions and capabilities I expect it to have.	5.88	6	1.06
OVERALL	19. Overall, I am satisfied with this system	5.92	6	1.19

\* average ( $\mu$ ), median (M), and standard deviation ( $\sigma$ ).



**Figure 6.** IBM CSUQ question graph.



**Figure 7.** Most used words to describe the web application. \* Number of students.

### 5.3.2. Results of the Use of the Web Application

The two groups of students performed the configuration of the assigned data network equipment in a connectivity laboratory, which is designed for these practices. Each student was timed on how long they took to perform the configuration in the traditional way (CLI) and with the automation application (Web App). The results are shown in Figures 8 and 9.

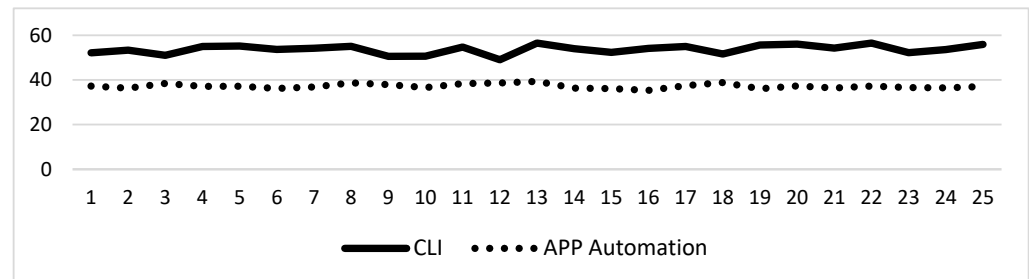


Figure 8. Comparison of setup time using the app and CLI for simulation 1.

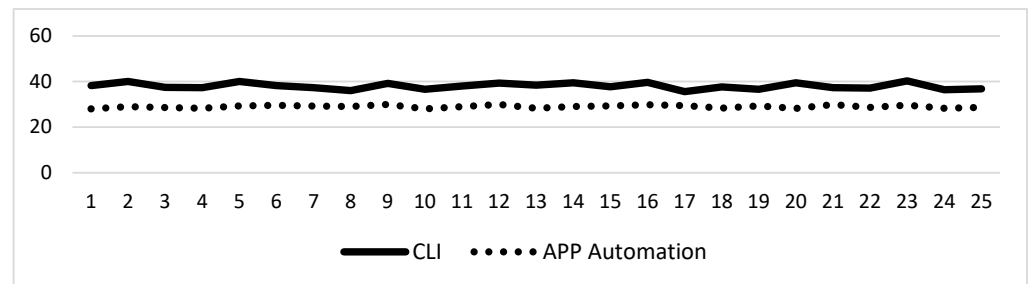


Figure 9. Comparison of setup time using the app and CLI for simulation 2.

Table 4 shows the average time obtained in the configuration of the communication equipment using the CLI and the automation application. As can be seen, in simulation 1 (Figure 4) the average time it takes a student to configure the equipment of the proposed network using the CLI is 38 min versus the 29 min it takes to do the same job using the web application. Similarly, the configuration time with CLI is 53.7 min versus 37.2 min with the application in simulation 2 (Figure 5). The use of the automation application saves 11 and 16.5 min in the configuration of equipment in simulations 1 and 2, respectively.

Table 4. Average equipment setup time.

	CLI	APP	% Efficiency
Simulation 1	38.0	29.0	23.7%
Simulation 2	53.7	37.2	30.7%

Based on the results, it can be stated that teaching the configuration of networking equipment using automation can make the time required for this work more efficient.

## 6. Discussion

The web application was well received by the students as most of them considered it attractive, useful, organized, sophisticated, and efficient. They also mentioned that the use of the application allows them to save time in the work to be completed. This is an important aspect since one of the main advantages of web applications is that they can automate tasks and processes to make work more efficient and productive. The positive opinion of the students about the web application is a good indicator that the application fulfills its purpose and is useful for their work.

Nevertheless, the IBM SCUQ tool gave positive results regarding the usability and quality of the graphical interface. This means that using the application by the students is

extremely simple, and, at the same time, the information provided by the GUI guides the users in an adequate way for a correct configuration of the network equipment. Usability is essential for any application, as it allows users to use it effectively and efficiently to achieve their goals. The design of the graphical interface, on the other hand, is critical to user satisfaction, as this feature is the users' perception of how the application looks and feels to use. If the graphical interface is attractive and easy to use, users are more likely to enjoy using the application and recommend it to others. However, it is important to keep in mind that usability and GUI design are not the only things that matter. It is also important that the application meets users' needs and expectations, and that it is effective in achieving its objectives.

The results obtained in the case study contrast with the majority of initiatives that use process automation to improve the time efficiency of work that was previously completed manually [42,44,46,51]. In the work presented by Mazin et al. [51], a comparison between the use of the automation application versus the CLI is shown, and although their results are positive, they were not analyzed in an educational environment and did not involve students. Therefore, an automation web application can be very well designed for the industry and perform adequately. However, the objective of this research was to analyze if the use of a web application, as a support in the educational model, can make students better understand the subjects on the network infrastructure and be more efficient when configuring equipment in a data network. This is in order to contribute to the fourth objective of the DSO, which focuses on ensuring access to quality education [18].

The use of this emerging tool can help students acquire technological skills more quickly. This application allows them to focus on the most important tasks of configuration, while the manual process can be more time-consuming and error-prone. In addition, students can learn about automation itself and how it is used to improve efficiency in the IT industry. It is for this reason that these tools should ensure ease of use in automation compared to manual configuration. Moreover, the use of technology can increase the motivation and engagement of students. Introducing a modern technological tool into the learning process can increase students' interest and make them feel more involved in the subject matter. This research leaves open other concerns that can be addressed in future work; for example, how could schools and universities use technology to improve the teaching and learning process? What other tools and technologies could be useful in the classroom? Discussion of these issues may be useful in understanding how emerging technologies can be used to improve education in general.

It is important to mention that the use of technology in the educational model can prepare students to work in a work environment that is increasingly dependent on technology and automation. The automation of processes can be a great benefit for companies looking to save time and resources, which in turn allows them to be more efficient and productive. It is important to develop technological skills in students and prepare them for their future, as the adoption of new technologies can be a challenge for some companies, especially if users are not familiar with the tools. Their potential use in the industry would open possibilities to help reduce human error and increase the accuracy and consistency of setups. In addition, it could affect the quality of work and customer satisfaction in the long run.

The use of automation application in education can have a number of benefits for students, including the improved acquisition of technological skills, increased motivation and engagement, and better preparation for working in a technology- and automation-dependent work environment. Discussion of these issues may help better understand how emerging technologies can be used to improve education.

## 7. Future Work

This work opens new lines of research, which could include the use of the automation application and how it could be adapted to different types of networks and configurations of more equipment. In addition, different network environments could be analyzed, and the resources needed for its implementation could be identified.

Furthermore, it should be investigated how digital technologies based on self-mapping processes can be used in education to improve the educational experience of students. More in-depth case studies could also be carried out, in which it would be analyzed whether students are not only efficient in the configuration of equipment but also whether digital technologies allow them to better understand the concepts acquired. In other words, to check whether the use of digital technology as a support in the educational model can improve the way in which students learn.

In the IBM CSUQ questionnaire, the students rated the usability and design of the application's graphical interface positively, but the lowest rating was for the presentation of information in the graphical interface. Future work could be to improve the graphical interface, for example, by simplifying the layout of on-screen elements, increasing the size of text or images, including additional clear instructions, or using visual elements to highlight important information.

## 8. Conclusions

The web application can be used in teaching networking in technical and university training programs to demonstrate how configurations are performed in real-time, which would help students better understand the concepts. From the positive results obtained in the research, it can be concluded that the communication equipment configuration automation application can be a valuable tool for saving time and improving efficiency both in the IT industry and in education.

The time savings of between 11 and 16.5 min in the configuration process is a significant result, which can be very valuable for companies seeking to be more efficient and productive.

Furthermore, it can be concluded that the use of emerging technologies in education can be beneficial to students, as it can help them acquire technology skills more quickly, increase their motivation and engagement, and prepare them to work in a work environment that is increasingly dependent on technology and automation.

While it is true that the use of technology has many advantages, there are also certain disadvantages and problems associated with the use of technology in education. Technology should not be used in education without an adequate methodology, because instead of supporting learning, it can cause distractions, dispersion of attention, stress, development of minimal effort strategies, virtual fatigue, non-personalized teaching, etc. In addition, there may be cybersecurity issues to which we are all exposed due to Internet access [64]. Unsupervised and unsupported use of technology in learning methodologies and strategies can be very detrimental to students and learning.

**Author Contributions:** Conceptualization, S.C.-C. and A.G.-A.; Methodology, S.C.-C., A.G.-A. and S.L.-M.; Software, J.G., W.J. and J.P.; Validation, S.C.-C., J.G., W.J., A.G.-A., Á.J.-A. and S.L.-M.; Formal analysis, S.C.-C., J.P. and S.L.-M.; Investigation, A.G.-A., S.C.-C., J.G., W.J. and J.P.; Resources, S.C.-C.; Data curation, S.C.-C., A.G.-A. and S.L.-M.; Writing—original draft, S.C.-C., J.G., W.J., J.P. and A.G.-A.; Writing—review & editing, S.C.-C., J.G., W.J., J.P. and A.G.-A.; Visualization, S.C.-C. and S.L.-M.; Supervision, S.C.-C. and S.L.-M.; Funding acquisition, S.C.-C. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was financed by the Universidad de Las Américas through project code: TIC.LCC.22.01.

**Institutional Review Board Statement:** This study does not require ethical approval by UDLA.

**Informed Consent Statement:** Informed consent was obtained from all students who participated in this research work.

**Data Availability Statement:** The data is hosted in the OneDrive cloud in a folder shared to the general public. The link is as follows: [https://udlaec-my.sharepoint.com/:f:/g/personal/luis\\_criollo\\_udla\\_edu\\_ec/EicxdBFFedBEv2nlNko\\_CHgBWvOwubH8XYl2k7P-dAonTw?e=9OV1rZ](https://udlaec-my.sharepoint.com/:f:/g/personal/luis_criollo_udla_edu_ec/EicxdBFFedBEv2nlNko_CHgBWvOwubH8XYl2k7P-dAonTw?e=9OV1rZ) (accessed on 25 February 2023).

**Conflicts of Interest:** The authors declare no conflict of interest.

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