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Ph.D. THESIS SUMMARY

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SISTEM COMUNICARE MULTIMEDIA INTERACTIV BAZAT PE SUPORT OFERIT DE PROGRAME TIP MOODLE
INTERACTIVE MULTIMEDIA COMMUNICATION SYSTEM BASED ON SUPPORT PROVIDED BY MOODLE TYPE PROGRAMS

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Chapter 1

Introduction

1.1 Presentation of the field of the doctoral thesis

Moodle is an e-learning platform created to provide learners, teachers and IT administrators with an easy-to-use system, the possibility to create personalized courses [1]. Within the Modular Object Oriented Dynamic Learning Environment (MOODLE) platform, several communication methods are described as resources and activities characteristic for learners [2]. Moodle is a platform designed for universal learning, both to support learning and teaching. In recent years, plugins and communication blocks have been developed to facilitate communication between learners and teachers. With the increase in complexity, the diversification of tasks and information in the educational system, it becomes imperative to continuously improve e-learning resources and platforms. The main concern is to increase learner satisfaction and learning outcomes.

1.2 Purpose of the doctoral thesis

This thesis contributes to the development and optimization of new functions for effective e-learning strategies and for their implementation in an educational setting. The purpose of these solutions described in the paper was to find methods with minimal to free costs, easy to use, secure for information protection and easy to integrate with the e-learning platform without incurring maintenance and administration costs. From market research and analysis, existing programs had licensing costs or needed another client or program to benefit from certain features. The challenges we started with in these implementations were given by the lack of absolutely necessary functions for the present and the near future, within the Moodle platform and the need to introduce these new functionalities with an impact on the learning process that would be beneficial for users and administrators.

1.3   Content of the doctoral thesis

In Chapter I, characteristics and general notions about the Moodle e-leaning platform were described. In chapter II, the following activities were exposed: documentation and installation of Moodle. The minimum and mandatory criteria for installation and a description of the facilities offered were presented. For the implementation of the platform, several aspects were taken into account, namely: the operating system on which the application was installed, the computer configuration, the compatibility of the Moodle plugin package with subsequent updates of the Windows operating system. The installation was designed to be accessed from the intranet in view of information protection and platform security. Also in this chapter, an optimization of the management of lessons for learners and the maintenance of the Moodle platform was addressed. Course management in Moodle is an area to which resources and activities for learners have been added. The steps for creating and modifying a course page to which documents in different formats were added were presented, customizing the course structure by adding addresses to internet pages and forums, rights and roles were given to the students depending on what information they should have access to the course, tests were created in several variants such as multiple choice question and true or false question and the way in which the students are Note. Types of authentication, different methods of adding users, account management, data recovery services, courses, updating version from the manufacturer were presented; verification of efficiency and optimal operation. In Chapter III, the following activities were exposed: creating a course backup and restoring it. To back up a single Moodle course or move a course from one Moodle platform to another, the method in the Moodle e-learning platform settings was used. The restoration of the Moodle e-learning platform was done by creating a checkpoint in Hyper-V Manager. The checkpoint is a Hyper-V checkpoint that captures the state of the virtual machine at a specific point in time, allowing it to later revert to that state of the virtual machine when necessary. Other topics touched on in Chapter III were the creation of a Windows Server 2019 for the backup of the Moodle e-learning platform and the storage of the e-learning platform backups. In Chapter IV, 3 new functionalities for the Moodle e-learning platform were presented. The first described the creation of a new two-factor authentication scheme for increased security in accessing the platform. The second functionality addressed uploading files to a course via the command line executed from outside the platform, and the third referred to a new method of sending different types of files through the communication window. For both the first and second functionalities, a case study was carried out on how users perceive the use of new methods. In chapter V, an analysis of the management of the e-learning platform regarding the provision of chatbot-based support services in the educational system was presented. Aspects of the benefits of AI chatbot technology, streamlining operations for learners' suggestions and observations were addressed. Another description in this chapter is about using a file conversion interface for adding some materials. The steps for creating an audio-video conversion interface for the e-

learning platform with Microsoft Visual Basic Express Edition were presented. The result is a program with the .exe extension that runs on Windows operating systems.

Chapter 2

Installation, configuration and administration of the Moodle e-learning platform

2.1 System requirements

Minimum and mandatory system requirements for the Windows operating system are: (i) minimum memory required 512 MB RAM but allocation of 1 GB RAM is recommended; (ii) minimum hard disk of 200 MB but for optimal operation it is advisable to allocate 1 GB; (iii) the processor must operate at 1 GHz. Moodle versions 3.1 and above can be installed on Windows operating systems from model 8 onwards.

2.2 Installing the Moodle program

The installation of the Moodle program was done in 3 stages. In the first stage, the installation package was downloaded and extracted in zip format from the manufacturer's internet address. The second stage consisted of starting the web server through an executable file. The last stage was the one in which the e-learning platform was configured using an internet browser, in this case being Microsoft Edge. The installation package contains an Apache web server, a MySQL database, and PHP scripting language [7].

2.3 Create your user account and customize your workspace

Moodle offers different access rights depending on the role assigned in the platform. The most complex rights are assigned to teachers. Such an account can create an online class, add assignments to learners, enter resources, grade assignments, and communicate with learners. The learner account is activated by the teacher who assigns it permissions based on what they are allowed to view. The editing was done from the work panel / preferences / learner account / edit profile. Here data such as name, surname, e-mail address, city, country and a brief description of the teacher have been entered to which the profile picture can also be added [8].

2.4 Administration of the e-learning platform

At a certain period of time, a higher version appears on the internet address of the Moodle platform that comes with improvements or solves certain security problems found in the previous version [16]. In this situation, it is necessary to update the platform. Before the upgrade, check that the server meets all the requirements for upgrading to the latest version in the site/server/environment administration path. It is possible to update to the latest version released by the manufacturer if Moodle 3.2 or later is installed.

Chapter 3

Backup and restore methods for the Moodle e-learning platform and increasing security by accessing the Moodle e-learning platform

3.1 Backup and restore a course from the Moodle e-learning platform

From time to time a situation arises where the information created on an e-learning site gets lost, corrupted or deleted. To prevent these problems, it is advisable to make a

backup of the course. Moodle has three backup options: automatic, manual and site course backup [19].

3.1.1 Manual course backup

Once a course has been created to make sure that nothing is lost or happens to the platform, it is advisable to make a backup. To back up the mentioned course or wanted to move another course from one Moodle site to another, then a course backup was the simplest method. In the description below, a manual backup was used for the course created. This operation was done from the settings of the Moodle e-learning platform from where the backup command was selected. Several decisions were made here. The first option was to save the course in a format that is compatible with other e-learning systems, and IMS Common Cartridge 1.1 was selected, but by this selection some customizations were lost because not all features are compatible in another learning management system [20]. In the second option, the function that retains all the features was selected and went to the next step where a settings scheme was found with the preservation of resources and course sections. Immediately afterwards, the backup file was selected and given a name, but not before another check was done. The result was a file with the .mbz extension. The resulting file has been saved on the station in case it will be necessary to restore the course for various reasons such as operating system corruption, viruses or hard disk errors. Figure 3.1 shows the manual course backup.
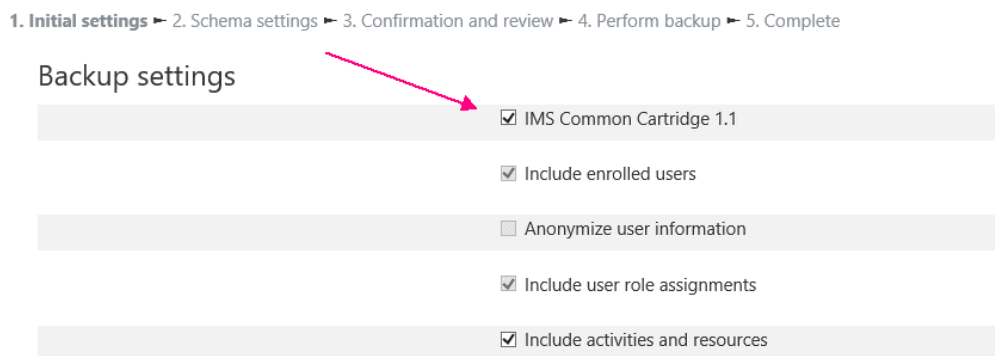
Figure 3.1. Configure manual course backup settings.

3.1.2 Automatic course backup

To set up an automatic backup of the course the following steps were taken: accessed site administration / courses / backups / automatic backup configuration as can be seen in figure 3.5.

Figure 3.5 *Automatic course backup setup.*

On the next page, changes have been made to the settings: On active, this has been set to "enabled" to enable automatic backups. When scheduling, the days on which the backup was to be run were selected.

3.2 Restoring the Moodle e-learning platform by creating a checkpoint in Hyper-V Manager

One of the great advantages of virtualizing the machine where the Moodle platform is installed is the possibility of easily saving the state of a machine at a given time. In Hyper-V, this is achieved by using the virtual machine's control points. Hyper-V is a hardware virtualization component of Microsoft that can be used to create and run a software version of a computer, called a virtual machine. It is found on Windows operating systems, which are for a fee. Each virtual machine acts as a complete computer, running an operating system and programs. This is beneficial when you wanted to create a virtual machine checkpoint before making software configuration changes, applying a software update, or installing new software [23]. If a system change causes a problem such as hard disk failure, operating system corruption, or virus, then the virtual machine can be brought back to its original state.

3.3   Creating a Windows Server for Moodle e-learning platform backup

3.3.1   Configure and manage the Windows backup server

After a period of time to manage the server, there will most likely be a risk of losing data due to one of the following situations: hardware error, software error, human error, computer virus, theft, natural disaster, fire, etc [29]. When data is lost, the impact has repercussions on teachers' activities, as they have to restore their data or wait for it to be restored. In this scenario, there are periods of inactivity that result from restoring or rebuilding the data. Unfortunately, data loss is inevitable, it will happen sooner or later, and a backup method must be prepared and executed when the time comes. In addition to data protection, the roles played by network servers, the role assigned to a server, domain applications, DNS (domain name of the server), files and storage, DHCP (equipment internet protocol address), etc. must also be taken into account. The ability to keep critical applications running should also be considered. Windows Server uses the Volume Copy Service (VSS) to create snapshots at a certain time, which helps keep the e-learning platform downtime to a minimum, Figure 3.11. To protect the data on the server, it is recommended to configure it in RAID format (redundant array of independent disks) or cluster (a group of servers working as a single system) [30].
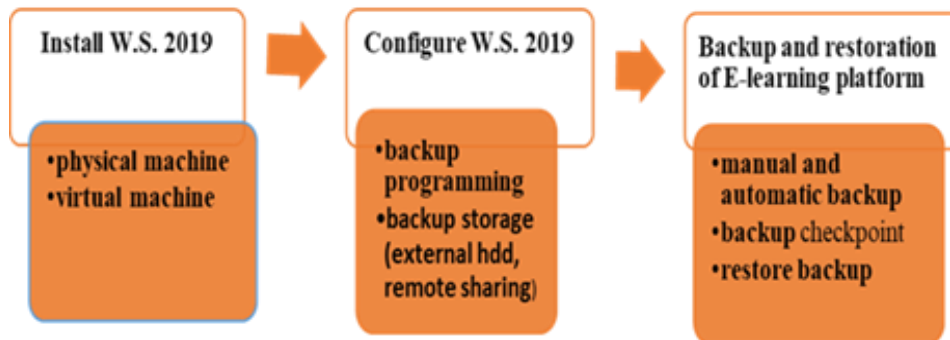
Figure 3.11 *E-learning platform restoration procedure.*

3.3.2   Configure the backup server online

Services included: unlimited transfer data, data security, centralized management and monitoring, multiple storage options, automatic storage management, and documents kept for short and long time.

Azure backup service			
Recovery data management	Storage management	Monitoring and statistics	Management of storage policies

Table 3.1 *Windows Azure Online Backup Services.*

Storing backups in the cloud allows us to retrieve from any location where we have access to the internet, gives the possibility to store files outside the area where the e-learning platform is located to be protected against disasters. Windows Azure Online Backup is a feature available with Windows Server 2019 that allows you to back up your e-learning site files and folders to the Windows Azure Online Backup Service [36]. Windows Azure is a cloud-based storage service managed by Microsoft, Table 3.1. Backups are compressed, which means that a backup is smaller and reduces bandwidth requirements. Backups are also encrypted to protect data where it's stored. Cloud data storage allows it to be accessed and retrieved from any location that has internet access.

Chapter 4

New functionalities for the Moodle e-learning platform

4.1   A new two-factor authentication scheme for increased security when accessing the platform

Authentication allows users to log in to a Moodle site with a username and password. Moodle offers various authentication plugins for managing user authentication, including external databases, Shibboleth, email-based self-registration, OAuth 2, and manual accounts, with additional plugins available in the Moodle plugin directory [38]. In the literature, the use of digital certificates as a means of authentication was relatively uncommon until 2020-2021. This innovative authentication method has replaced the previously prominent use of holographic signatures and the encryption of official documents. The implemented solution led to the improvement of the way of accessing the electronic services offered by the Moodle platform by implementing within this

platform a new authentication method based on the username, the user's password and the digital certificate issued by a certification authority [39,40]. This ensures a unique and secure electronic identity for each user who uses the electronic services offered by this platform, with unified and secure access.

4.1.1 The evolution of the digital certificate

A p12 file contains a digital certificate that uses PKCS#12 (Public Key Cryptography Standard #12) encryption. The p12 file builds on PKCS #8 by adding essential information and improving security through the privacy and integrity modes of public keys [48]. It is a portable format for transferring personal private keys and other sensitive information. Various security and encryption programs use P12 files. P12 keys store a private key that encrypts information in such a way that decryption requires the use of the appropriate public key. In addition, data encrypted with the public key needs the private key for decryption [49]. A P12 file may also contain a certificate revocation list, information about the chain of trust, and information about its holders, such as their first name, last name, the name of the company they work for, a position held, and other personal data.

4.1.2 Benefits of two-factor authentication

IT departments in various industries are engaged in a continuous fight against fraud and hackers. To strengthen infrastructure security, companies should prioritize the adoption of two-factor authentication. This approach offers several benefits, including increased security through the use of alphanumeric passwords and special characters for both the certificate and the Moodle account. By activating a digital certificate, fraudulent attacks require greater resources and efforts. Even if hackers manage to obtain the password from the platform account, they cannot access the account unless they have the user's certificate and password to gain access to the platform [56]. Implementing these dual layers of authentication substantially improves data security and significantly decreases the likelihood of unauthorized access to information. Two-factor authentication is a useful and unique tool for adding an essential layer of extra security. Not only does it increase safety, but it also increases employee productivity, helping the company's bottom line. Many institutions use two-factor authentication for users who want to introduce additional security. From the research carried out compared to current connection methods, this new method brings extra security and confidence [63].

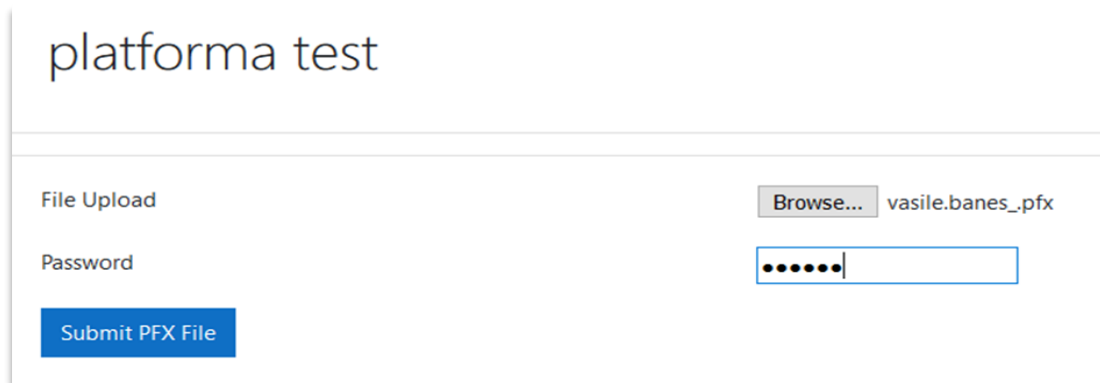### 4.1.3 The threats that two-factor authentication addresses

The need for two-factor authentication has increased as institutions, governments, and individuals realize that passwords alone are not secure enough to protect user accounts in the current technical format. The average cost of data breaches increases annually,

with financial losses of billions of dollars annually. 2FA protects against a multitude of threats. The most common threats include: stolen passwords – a traditional password can be used by anyone who gets hold of it. For example, if a user writes down their password on a paper medium, that password can be stolen to gain access to an account. After entering a password, 2FA validates the user with a second device [64,65]. Phishing attempts – hackers often send emails that include links to malicious websites designed to infect a user's computer or convince them to enter their passwords. Once obtained, a password can be used by anyone handling the hacking attempt. 2FA combats phishing by adding a second layer of validation after entering the password [66].

4.1.4 Development of the 2FA method

This new method, developed by introducing another authentication factor with a digital certificate and logging in with a username and password, increases the degree of security in the Moodle platform. The correlation of the attributes related to the information in the digital certificate with the data of the account created in the platform is necessary for unique identification. Unique identification consists of reading common attributes in the certificate and Moodle account, such as the certificate's serial number and email address. The site administrator and the certificate authority enter this data when creating the Moodle account and generating the certificate. We made the attribute correlation functionality possible by writing parameters into the newly developed plugin, the plugin being the software component. Connecting a user to the site using the new 2FA solution is done by presenting the certificate and entering the related password, the first factor of authentication. If the unique identification has been correctly associated, move on to the second authentication factor, where the user must enter the account and password on the platform in a new window. Validation occurs when the data is verified and correct, and the user lands on the main page of the site. Check passphrases and pfx, and then read pfx to get the user's data and signatures. The pfx plugin overrides the login method and configurator to run the pfx upload page. Once the user has successfully uploaded and validated the password, the script will retrieve the data from the database to verify the specific users associated with the pfx file. This plugin reads the pfx file, which combines a certificate and a private file with a password. The Open SSL program has been installed on Windows to generate the certificate and the private file. A local host was created to run Moodle: XAMPP (suite of programs and databases) installed, Apache distribution containing MariaDB, PHP and SQL Server. Installed Moodle locally: Windows version of Moodle 311 has been installed on your local system. A script has been created to validate the pfx file. Created a script to read the pfx file using open SSL: created the function name readpfxfile. Script created to read the certificate file. A function has been created to extract the data from the certificate file. Script created to upload the pfx certificate and enter the password. A script has been created to read the uploaded file without moving to any location. A

function has been created to read the pfx file. A script has been created to get the certificate data from pfx. A script has been created to extract the data from the certificate. Finished creating a script to read the pfx file and get the data usage password. Extended Moodle Basic Authentication Class. A function has been created to display the custom page. This line of code is used to redirect to the custom login page. The authentication plugin has been created with the pfx form load, as seen in Figure 4.3.

Figure 4.3 *Uploading the Pfx File.*

4.1.5 Simulation results, laboratory studies on five two-factor authentication methods on configuration, use and evaluation by users

Many widely used 2FA methods have insufficient or inappropriate use of user usage and behavior analysis. Another aspect is that previous research on the use of 2FA is difficult to compare due to the wide variety of work environments. Below are some references for these studies. Reese K. et al. [68] conducted a two-week study of five common 2FA methods for collecting quantitative and qualitative data. Das S. et al. [69] conducted two studies that measured the use and acceptability of using YubiKey (a type of hardware token compatible with FIDO U2F) as the second factor in securing a Google account. Using a thought-aloud protocol, participants encountered difficulties in using them and proposed certain design changes. After repeating the study with a new group of users, they found that ease of use increased, but acceptability did not. Acemyan C. and collaborators [70] studied the configuration and authentication of four of Google's 2FA methods. They found that participants had many failures, found Google's 2FA system difficult to use, and needed improvement. They found little difference between the four different methods of 2FA when comparing efficiency, effectiveness, and measures of satisfaction — illustrating that one method is not necessarily more or less useful than another. Lang J. et al. [71] report on Google's internal implementation of security keys for their employees. They report a long-term

reduction in authentication-related support calls after hardware keys are deployed. Reynolds et al. [72] describe two studies on the use of YubiKeys. The study found many usability issues with YubiKey's setup process and workflow, but found that day-to-day usage was significantly higher. Platform administrators ran simulation parameters in the test environment on a Windows Server 2019 operating system while accessing the client from workstations configured with Windows 8, 8.1, and Windows 10 operating systems.

4.1.6 Analyzing the impact of the developed method

The study presented in this paper was carried out on 74 users divided into two groups of 37 people. The data and users have been collected from the current workplace, I have the consent to use this data and some details are confidential. The first group in the sample logged in with only the username and password from their Moodle account. The second group in the sample authenticated using the proposed two-factor authentication scheme. The number of password reset requests for both schemes is shown in Figure 4.4.
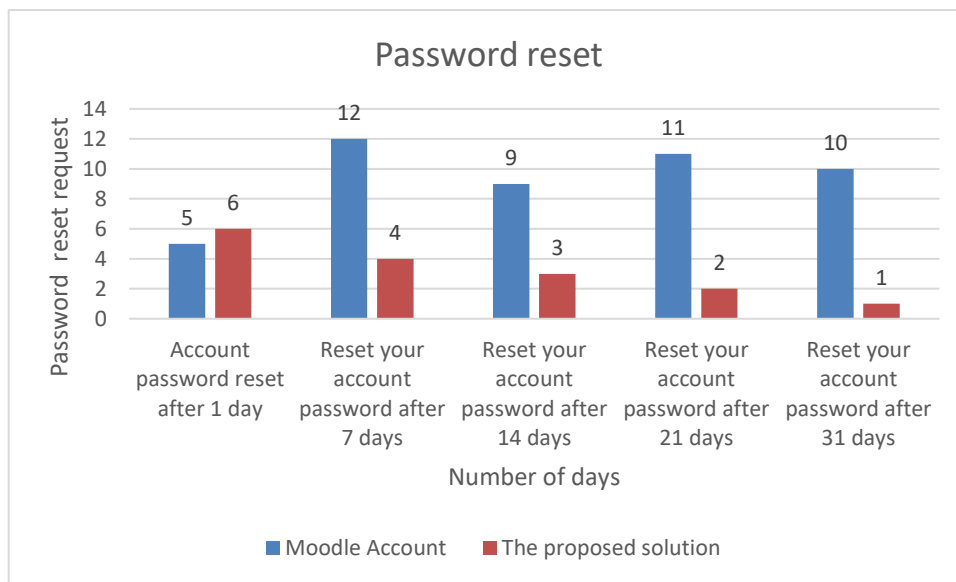
Figure 4.4 *Comparison between Moodle and the proposed solution regarding account password reset.*

Thus, it is observed that using the implemented authentication, the number of users who forgot their password decreased with the use of the new solution, having a visible and favorable decrease trend compared to the solution related to authentication with the username and password. From the analysis of the results obtained from the graph below, the following can be identified: On the first day using simple authentication with username and password, there was an equal number of external attack attempts, 3 for each solution, Figure 4.7. On the seventh day, using simple authentication with a

username and password, there were five external attack attempts, and with the solution implemented, there were six external attack attempts. The same thing happens in the intervals of 14, 21 and 31 days; only the number of attacks varies.
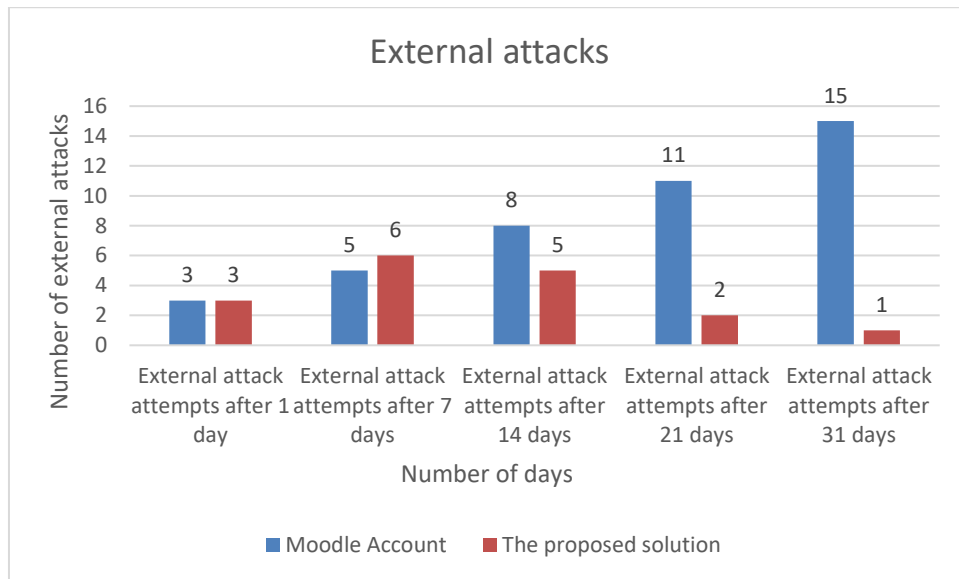
Figure 4.7 *Comparison between Moodle and the proposed solution regarding external attacks.*

Thus, it is observed that using the implemented authentication, the number of external attack attempts had a slight increase, after which it decreased; while the number of external attack attempts using simple username and password authentication has increased, which demonstrates that external attack attempts have decreased with the proposed solution, which proves its security.

4.1.7 Conclusions

The traditional method of authenticating using only the username and password poses an increased security risk to users and their organizations. Most of the time, content changes or feature enhancements are impossible because most e-learning platforms have built-in systems or require access costs, unlike Moodle, a free, open-source platform. Learners can log in using the default methods of the Moodle platform, but also a possibility for the IT administrator when they want to improve the platform or there is a requirement from users to create a new method using the plugin function found in the console's settings menu.

4.2 Uploading files to a course via the command line executed from outside the platform

In addition to the standard methods, the implementation of another way of uploading files using the command line interface was considered. CLI is the acronym used for Command Line Interface, which are conventional interfaces widely used in the 1980s. A command-line interface (CLI) allows users to write commands in a terminal or console window to communicate with an operating system. It is an environment where users respond to a visual prompt by writing a command and receive a response from the system. The new method presented simplifies the process of transferring files to the platform using a computer-level command. In addition to the reduced execution time, compared to other platforms related to the Moodle environment, the steps required to upload files to insert new documents or modify existing ones, are simplified. This removes the steps that were taken for authentication and authorization to access the document submission functionality. No additional or specific technical knowledge is required to use this functionality, it is enough to launch a script, which leads to ease of use.

4.2.1 Advantages of Using the Command Line Interface

The operating system provides a CLI vs GUI user interface for interacting with an electronic device [79]. Some operating systems offer CLI and GUI, while others only offer CLI. GUI stands for a graphical user interface, while CLI stands for command-line interface. There are several benefits of CLI such as: (i) ease of understanding [80]; (ii) low-resolution monitor [81,82]; (iii) requires memory; (iv) speed; (v) appearance.

4.2.2 Approach the solution by implementing the command line interface

The minimum and mandatory requirements for the operation of Moodle are the following: 200 MB hard disk, 512 MB memory, 1 GHz processor [85]. The tests were carried out on the Windows Server 2019 x64 and Windows 11 x64 operating system, the installed Moodle package is version 3.11, which contains all the other programs necessary to run it. The utility will add all available files in the folder as an activity in each valid course passed as an argument [88]. The commands will look like this: C:\users\admin\screen\moodlewindowsinstaller –latest – 311\server\php\php.exe, represents the path to the directory where the php file is located and C:\users\admin\screen\moodlewindowsinstaller-latest-311\server\moodle\admin\tool\task\cli\process.php --user=admin --courses=1 – location=C:\files, represents the path to the course, the path to the folder where the files

are, and the local account information from the platform and the course number are located, as can be seen in Figure 4.9.


```
C:\Users\43896795>E:\MoodleWindowsInstaller-latest-311\server\php\php.exe E:\Moo
dleWindowsInstaller-latest-311\server\moodle\admin\tool\activitypush\cli\process
.php --byuser=vasile.banes --incourses=4 --filelocation=E:\FileTypes
================================================
Following is the Information that will process
By User : Vasile Banes
In Course :
Course [id, shortname, fullname] : [4 , 1234 , Information Technology ]
For Files :
[Filename, Filelocation ]:  [ Test1 , E:\FileTypes/Test1.docx ]
[Filename, Filelocation ]:  [ Test2 , E:\FileTypes/Test2.mp3 ]
To create activity , please pass parameter --process=1
================================================

C:\Users\43896795>E:\MoodleWindowsInstaller-latest-311\server\php\php.exe E:\Moo
dleWindowsInstaller-latest-311\server\moodle\admin\tool\activitypush\cli\process
.php --byuser=vasile.banes --incourses=4 --filelocation=E:\FileTypes --process=1

================================================
Following is the Information that will process
By User : Vasile Banes
In Course :
Course [id, shortname, fullname] : [4 , 1234 , Information Technology ]
For Files :
[Filename, Filelocation ]:  [ Test1 , E:\FileTypes/Test1.docx ]
[Filename, Filelocation ]:  [ Test2 , E:\FileTypes/Test2.mp3 ]
==================== Starting Process ========================
>>>>>>>>>>>>>>>>>
Course : 1234
File : E:\FileTypes/Test1.docx
File added successfully. http://moodle.localhost/mod/resource/view.php?id=23
>>>>>>>>>>>>>>>>>
Course : 1234
File : E:\FileTypes/Test2.mp3
File added successfully. http://moodle.localhost/mod/resource/view.php?id=24
==================== END ========================
```

Figure 4.9 The command line executed with the success message displayed.

4.2.3 Real results

The originality of this functionality is given by the fact that it offers users and system administrators a fast, efficient interface, independent of the operating system interface, through which files can be transmitted to the Moodle platform without using additional authentication or authorization steps and without navigating the platform until the screen of the document transmission service is reached. This provided a useful and fast tool for submitting documents within the Moodle platform, without having to authenticate and authorize using the website's web interface.

4.2.4 Conclusions

For a teacher or administrator, Moodle provides a way to present materials to learners, which can take the form of files. In Moodle you can upload several files at once, only archived in zip format, and for viewing you can see the content only after unzipping it. With this method, a new way of uploading files to courses within the Moodle platform has been created. Traditional upload methods have been based on accessing the platform with the username and password and have the main disadvantage of taking at

least 10 steps to complete the process, while the new method proposed by us is superior in that it no longer has to log in to the platform, as well as simplifying, speeding up and managing the process. While in the current Moodle platform it takes up to 470 seconds to upload 5 files of 20 MB, the method proposed in the current thesis offers a time consumption of only 5 seconds for these files.

4.3 Communicating files through the chat window

In recent years, several plugins or programmable blocks have been developed to support communication between learners or between learners and teacher, most of which have been created to integrate the platform with external programs such as Slack, Telegram or TwinPush [92]. Other software components allow you to display lists, sent notifications, or to create window-like, automatic messages [93,94]. The challenges faced in this implementation of the solution were given by the non-existence of this way of transmitting files within the Moodle platform and by the need to introduce this new method with an impact on the communication process that would be beneficial for users[95]. The aim of this solution was to find a free, easy-to-use and secure method of information protection to integrate with the Moodle e-learning platform without incurring maintenance and administration costs. The importance of integrating the submission function into the existing platform. Rapid exchange of information, interaction between learner, teacher and learner, learner(s) accessing the information sent or received at any time by viewing the links resulting from these operations, real-time transfer.

4.3.1 E-learning platforms and chat programs

Internal Moodle messages do not support message attachments. There is a wide range of offerings on the market for online learning management software, which provide a suitable choice for every educational structure or company. The criteria for choosing the platform are mostly based on the price and the facilities offered. There are several advantages of using chat, and these are:
- Chat has an advantage over a forum in that it takes place in real-time;
- Este deosebit de benefic atunci când cursanții nu au ocazia să se întâlnească față în față;
- Reading the discussions even if they did not attend the meeting;
- The learner does not need to open a separate window to use this chat, while the Moodle activity chat needs another window to do so;
- The learner can use it to collaborate with their peers to ask questions to teachers;
- The teacher can communicate individually with the students;

- Learners can navigate between pages, and their open conversations will always be there.
  Chat features include:
- Sending text messages;
- Internet addresses typed in the chat window are turned directly into links;
- Emoticons;
- A warning to one or more students in the form of beeps or sounds.

4.3.2   Purpose of sending files through the chat window

This solution aimed to develop a functionality that allows sending files of different types (extensions) between users of the Moodle e-learning platform through the chat window. It is an option to upload files, but this is only valid for courses and, in no case, for chat, and only if they have been given a role in this regard by the teacher or administrator. The solution is integrated into Moodle, and the chat window appears with a button with the "clip" icon from which files are selected from the computer and can be sent to another user to be viewed and downloaded from the user profile account.

4.3.3 Threats addressed by sending files through the chat window

Document control: the e-learning platform is accessed in a closed environment, and without an internet connection, file transfer is done only through the intranet. Document security: by sending documents only through the platform accessed, their confidentiality is preserved. There is no longer a risk of attachments being transmitted through different channels and content being read or monitored. Protects the computer against viruses: in this way, phishing attacks (monitoring or forwarding messages), spam (multiple unsolicited messages) or viruses that encrypt documents have been avoided.

4.3.4 Analyzing the impact of the developed method

Following the implementation of the proposed solution, the following aspects were discovered: the speed of communication of information between students; minimizing the transmission of attachments through other methods, such as email or online file transfer sites; removing viruses from computers without using the internet. The study of the 45 learners aimed to identify the method they prefer to use to send attachments, which seems to be the most efficient and user-friendly, as can be seen in Figure 4.11.
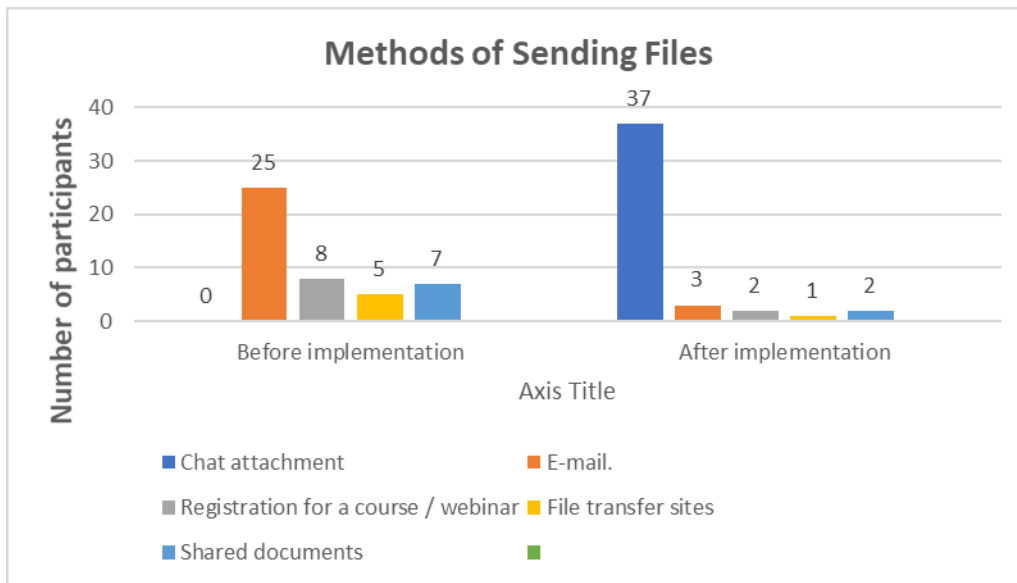
Figure 4.11 *Comparison of the method implemented before and after sending the files.*

Thus, there has been a decrease in interest and in the number of those who use the old solutions in favor of the newly implemented solution. The simulations were carried out over a period of 30 days, and the logs were checked every 24 hours. Logs reported several phishing attacks, and antivirus programs were able to block these attempts, leaving the platform and workstations unaffected.

4.3.5 Study methodology, statistical analysis of results and scientific discussion

Laboratory studies on configuration, use and evaluation by users. With questions such as platforms used after implementation, separate or integrated customer preference, usability, complexity of use, transmission of files after implementation, and retention of this solution. As a conclusion of this study, it results in the opening of the surveyed users to the use of the new solution, given its advantages. Thus, the transmission of files through the chat window, in the opinion of users, is useful, easy to use, does not require complex knowledgeși rămâne în preferința lor pentru utilizare ulterioară, chiar și după încheierea testului.

4.3.6 Case study on how users perceive using the new file submission method

From the analysis of the information obtained from the study carried out on a sample of 60 people for 30 days, it can be seen that the trend was increasing, so that at the end of the 30 days, all users participating in the study declared that the solution was an easy means of communication. The evaluation carried out followed what was the intention of the users when they chose to use the new method of sending files and what was the

experience, the degree of satisfaction and the results obtained as a result of using it within the established sample.

4.3.7 Approach the solution by implementing the newly developed plugin

The working method to add new features to Moodle is to create a new standard plugin (software component). The working method used to create and edit the plugin was PHP (Hypertext Preprocessor, Web Scripting Language) technology and the WAMP server (Windows, Apache, MySQL, PHP) on Windows systems. WAMP was used as a secure space to work on the platform without having to host it online. When the clip icon is clicked, basic file upload options are available. Once a file is uploaded, the link to the file will be shared as a message to another user. The user who receives the message will click on that link and view the attachment. The installation was done like any other plugin; He logged in to the platform with the administrator account, after which he selected the platform administration, plugin, and plugin installation. The plugin files created in zip format to be imported into the site administration contain the codes that execute this functionality.

4.3.8 Real results

This project aimed to increase the degree of communication, the rapid exchange of information, better account management, the protection of information uploaded to the website and the easy access and identification of people connected to the platform. All these aspects have been achieved with the help of the newly created plugin. Another important point of file transfer is that it can return to the original form of the chat at any time and vice versa without affecting the database or configuration of the learner profile.

4.3.9 Conclusions

Moodle has the option to communicate between learners through the chat window, where you can only send text messages and emoticons. There is also the possibility that the IT administrator, when he wants to improve the platform or there is a requirement from the users, to create a new method using the plugin function found in the site administration. This plugin is used for a new solution that contributes to the possibility of transmitting files through the chat window with various extensions and sizes.

Chapter 5

Research study for the management of Moodle-type platforms; Discussions and comparisons with literature

5.1 An analysis of the management of the e-learning platform regarding the provision of chatbot-based support services in the educational system

A chatbot is a communication interface that simulates human conversation that supports organizations and users in solving problems of different aspects, finding out information or as personal assistants. While not all chatbots are equipped with artificial intelligence (AI), modern chatbots are increasingly using AI conversational techniques such as natural language processing (NLP) to understand user questions and automate responses to them.

5.1.1   Chatbot, the architectural structure

The first chatbot created was configured as an interactive program of common questions, programmed to answer a package of common questions with indicated answers. Thus, users had to choose between keywords and simple phrases to advance the conversation, as the chatbot was unable to process complex questions or answer simple questions that were not anticipated by the developers. Modern AI chatbots now use natural language understanding (NLU) to understand the user's open-ended questions, being able to spot grammar, translation, and typo issues.

5.1.2 Chatbot security

The chatbot is a new solution and technology, with enormous potential for growth and implementation for customer support services. The chatbot is becoming more and more

intelligent, and it can develop new capabilities such as the ability to process information. In order to avoid security breaches or database compromise, it is imperative that the chatbot solution is encrypted. This important aspect must be taken into account by organizations and institutions that collect and manage personal data. In this way, information leaks can be avoided. Being a new technology, it needs time to be learned and adopted by people, which puts users in risk situations such as phishing attacks or data viruses and ransom demands.

5.1.3 E-learning platform comparisons

Comparison between e-learning platforms on the existing support provided to learners by course teachers and IT administrators for technical issues. From the analysis of the information obtained from the comparison made at the level of e-learning platforms regarding the existing support offered to learners by teachers at courses and by IT administrators for technical issues, it is observed that none of the platforms under study offer Chatbot AI IT support and none of the platforms under study offer Chatbot AI for courses.

5.1.4 Experiment

The study was conducted for 30 days on a sample of 60 users on the analysis of how they perceive the use of a chatbot, the efficiency of use, ease of use and intention to use in the future.

5.1.5 Results of the experiment

From the analysis of the information obtained from the study conducted on a sample of 60 people for 30 days, the following results can be observed: it improves their ability to execute learning tasks, increases performance, provides access to information, the execution of the chatbot is efficient and simple, reduces study time and they are satisfied with the response time to the questions/problems submitted.

5.1.6 Conclusions

Chatbots play an important role in reducing costs, optimizing resources, and automating services. Nearly 40% of internet users worldwide prefer to interact with chatbots over virtual agents, and major industries, including retail and healthcare, turning to digital technology, chatbots are likely to grow in popularity in the future. The conclusion of this study results from the openness of the surveyed users to the chatbot platform declared efficient, easy, easy to exploit, which brings added value both in terms of use and time and diversity of the topics that can be debated within it. All these have made

this platform to be declared useful, easy to use, efficient, covering a wide range of topics, offering fast, correct and efficient answers offering a high degree of satisfaction to the people who use it, thus being a new trend and an accessible way of using such problems.

5.2 Conversion tool for audio-video file compatibility in the Moodle e-learning platform

Moodle provides a simple way for a teacher to present materials to learners. These materials can take the form of files such as doc, xls, pdf, zip, ppt, audio, and video. Most file types can be uploaded and accessed through Moodle, but when the tutor is editing in formats other than Moodle support, they must have the necessary software to convert them. At this stage, there is a wide range of audio-video formats, but only some of them can be supported by the e-learning platform. Below is the customization of a user interface for a conversion tool capable of achieving audio-video file compatibility for the e-learning platform through which files can be imported. Therefore, the purpose of this work was to create a conversion tool interface for audio-video file compatibility using Microsoft Visual Studio Express Edition. The application is independent and will be integrated into the Moodle platform. The interface has been developed for Romanian users here and from the menu that appears in this format, figure 5.4.
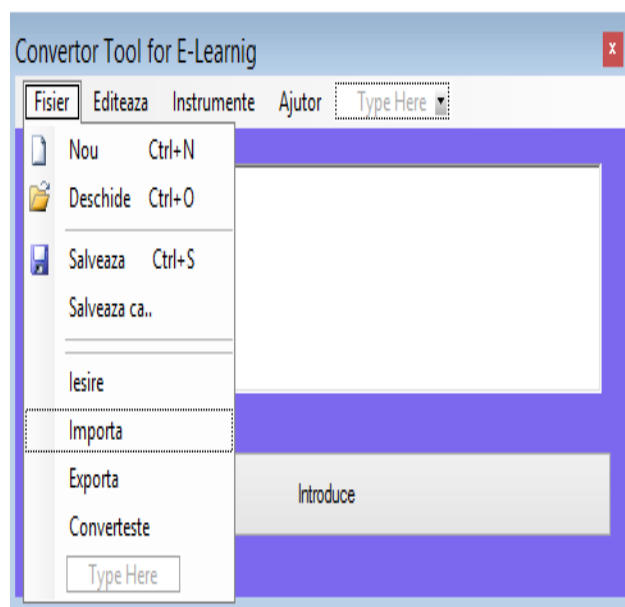

Figure 5.4 *Creating the menu bar.*

5.2.1 System requirements

To create a UI conversion tool considering the compatibility of audio-video files in the Moodle e-learning platform, Microsoft Visual Studio Express Editions was used. The minimum hardware requirements are a 1.6 GHz processor, 256 MB RAM, and a 1024x768 video display. Computers with 2.4 GHz or higher processors, 1024 MB or more of RAM and a 1280 x 1024 display, and a hard drive of 7200 RPM or higher. Additional internet access facilities may be required.

5.2.2 Creating the user interface

- The Start button is created - Basic codes and form settings, form settings - forms, properties, with their help, the size of the interface is changed so that it can position and adjust the start button.
- Edited variables, "if and otherwise" commands, and anchor form.
- The menu bar has been inserted into the form. From the Toolbox-menu and toolbox, the Strip menu and the drag & drop function have been selected. At this stage, the bar is white without any command.
- Save, open files, and resolve save errors. When a save command was opened, a window for this configuration appeared, the savefiledialog function was selected from the application toolbar.
- Written the commands for Undo, Redo, Crop, Copy, Paste, and Select All. Editing form commands for Undo, Redo, Crop, Copy, Paste, Insert From Edit, the Undo function was used in text that is written to be undone.
- Another task in creating the interface was customizing the background color of the shape. This step consisted of adding two buttons (called edit and apply), a label, and a text box.

5.2.3 User interface control display

After completing the form with the Microsoft Visual Basic program, the project was generated with the .exe extension created to run on Microsoft Windows operating systems. When "Help" and "About" were selected in the menu bar of the interface, a window with information about the project appeared, namely: title, description, company, product, brand, assembly version, file version, program language and other information, as shown in figure 5.7. The editing of these data was done by selecting in the form of the Project and Project Properties function where a window appeared with the spaces that were filled in above. After entering this information, the project was completed with the "Build" command and after a few seconds, on the workstation in the "achieve" directory of the program, Visual Basic was saved with the name Conversion Tool for eLearning and the extension .exe. The design of an app's user

interface can influence its usefulness and user experience. When the design of a user interface is too complex or has not been tailored to the target personas, the user may not be able to find the information or service they are looking for. The structure of the user interface has been clearly designed for users so that the elements can be found in a logical position by the user.
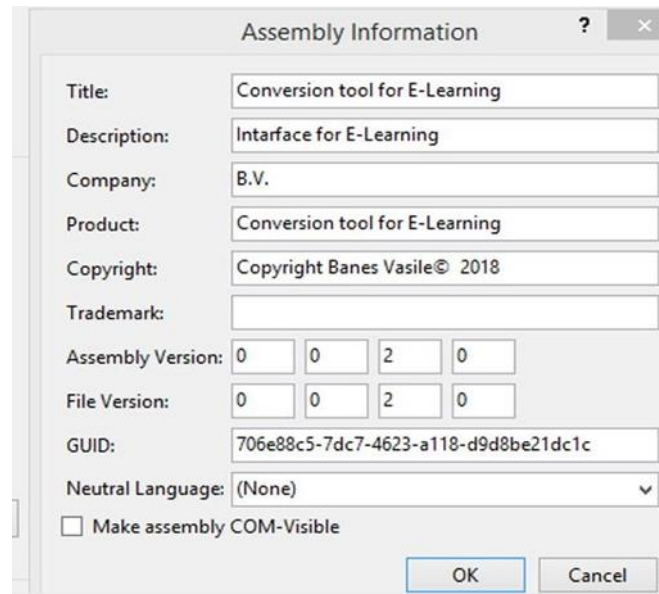
Figure 5.7 Assembly information.

Therefore, the design of the user interface has been optimized so that the user can operate the app as quickly and easily as possible. With a more intuitive UI design, learners can easily navigate the UI, quickly finding the desired commands [109]. This is a paper that has presented the steps for creating an audio-video conversion interface for the e-learning platform with Microsoft Visual Basic Express Edition. The result was a program with the .exe extension that runs on Windows operating systems. Sometimes there is a file in a format that does not support any program on your personal computer. When this happens, there are usually two options: purchasing the program that opens the file, or using free software to convert the file to a format that certain programs support on your personal computer. It's a common problem, especially in film, music, and image. To actually change the file type, it must be converted using a program that supports both file types and a dedicated tool to convert the file from its format to the format you want to format. An important point is when the workstation is in an institution or organization that has an internal network without Internet access and having the program installed, it can be used every time.

Chapter 6

6. Conclusions

6.1. General conclusions of the thesis

In this work, contributions were presented to improve the management and maintenance of the platform, to make courses more efficient, to add new facilities such as resources and activities.

Another improvement was the virtualization of the platform to create a snapshot at a point in time. This virtualization for creating an image is useful when testing with a new platform version update, configuration changes, or maintenance operations without having to move or copy existing data.

Another improvement achieved was the creation of a backup of the Moodle e-learning platform installed on a server with the Windows 2019 operating system and storing the backups on an independent storage device. This solution helps to restore the Moodle E-leaning platform following accidents or data loss in the shortest possible time.

The first important achievement was the 2-step authentication, which was achieved by creating a plugin. The plugin is a software component that adds functionality specific to an existing computer program or internet browsing program. The script/lines of program code in Cross-Platform, Apache, MYSQL and PHP were original and are also at the end of the thesis in Annex A.1. Verification or comparison of the developed method with other already existing methods can be found in tables 4.1, 4.2 and paragraph 4.1.6. The analysis results in an increase in user confidence in the new method and an improvement in data security protection.

The second achievement concerned uploading files into a course via the command line executed from outside the platform. The solution came by creating a software component called a plugin. The script part/lines of program code in CLI, Apache, MYSQL and PHP were original and are also at the end of the thesis in Annex A.2. The verification or comparison of the developed method with other already existing methods can be found in Figures 4.8, 4.9, 4.10, 4.11 and Table 4.3. From the analysis made, it can be concluded that the method proposed in the current thesis improves the processing time from 450 seconds in traditional Moodle to 5 sec in the method proposed here.

The third achievement consisted of transmitting files through the chat window. The method and the most difficult part consisted in writing the parameters. Overcoming the elements of difficulty consisted of writing a software component called plugin, which we implemented in the Moodle platform which are described in detail in Appendix A.3. From the analysis made, it can be said that the proposed method increases the speed of information communication, the elimination of viruses from computers by up to 90% and the reduction of file transmission methods to a single one. Verification or testing of the solution with other existing methods can be found in Tables 4.4 to 4.9 and in Figures 4.12, 4.13, 4.14, 4.15, 4.16 and 4.17. The challenges we started with in this implementation of the solution were given by the non-existence of this way of transmitting files within the Moodle platform.

At the final analysis, an experiment was carried out in which the intention of the users at the time they chose to use the chatbot was followed, what was the experience, the degree of satisfaction and the results obtained as a result of using it within the established sample. It has emerged that it plays an important role in reducing costs, optimizing resources and automating services.

6.2 Highlighting personal contributions and publications during the doctoral internship

The general personal contribution of this doctoral thesis was related to the configuration of the platform on the Windows 11 operating system with the customization of the content of tests and dedicated forums for learners and the creation of a Conversion Tool for the compatibility of audio-video files in the Moodle E-learning platform. Below are explicitly listed each of the original contributions of this thesis, developed during the 5 chapters:

1. Configure the e-learning platform on the Windows Server 2019 operating system with the customization of Windows Server Backup functions to make backups to a shared folder on the network on a Windows 11 workstation.

2. Two-factor authentication proposed based on the name and password of the Moodle account and the digital certificate issued by a certificate authority is also not found on the other e-learning platforms. In addition, the proposed solution is the only one based on the username, password of the Moodle account and the digital certificate issued by a certificate authority. The unique contribution of this solution is the use of digital certificates issued by a certification authority and the development of a plugin, which introduces the second authentication factor and additional security.

3. Uploading files to a course via the command line executed from outside the platform. The originality of this functionality is given by the fact that it offers users and system administrators a fast, efficient, easy-to-use interface, independent of the operating system interface, through which files can be transmitted on the Moodle

platform without using steps, authentication for authentication, authorization and without browsing the platform until the screen of the document transmission service is reached.

4. Sending files through the chat window. This project aimed to increase the degree of communication, the rapid exchange of information, better account management, the protection of information uploaded to the website and the easy access and identification of people connected to the platform. All these aspects have been achieved with the help of the newly created plugin.

5. Analysis of the management of the e-learning platform regarding the provision of chatbot-based support services in the educational system. The purpose of this study was to observe the openness of the surveyed users to the chatbot platform declared efficient, easy, easy to exploit, which brings added value both in terms of use and time and the diversity of the topics that can be debated within it. Also, an optimal response time to the posted questions was identified, the easy adaptation of users to the platform, the possibility of using a wide variety of issues, an easy level of understanding of the platform and the efficiency, accuracy of the answers to the questions received.

6. Conversion tool for audio-video file compatibility in the Moodle e-learning platform. The purpose of this paper is to create a conversion tool interface for audio-video file compatibility. Therefore, the design of the user interface has been optimized so that the user can operate the app as quickly and easily as possible. With a more intuitive UI design, learners will be able to easily navigate within it, quickly finding commands.

All these original contributions have been published at International Conferences and in specialized journals, according to the list below.

1. Articles published in ISI Journals

1.1. **Baneş,** V.; Ravariu, C.; Appasani, B.; Srinivasulu, A. *A Novel Two-Factor Authentication Scheme for Increased Security in Accessing the Moodle E-Learning Platform*. Appl. Sci. 2023, 13, 9675. Q2-2023 https://doi.org/10.3390/app13179675. WOS:001062658500001. DOI10.3390/app13179675, IF=2.7.
1.2. Banes, V., Ravariu, C. (2022). *New Functionality for Moodle e-Learning Platform: Files Communication by Chat Window*. Appl. Sci. 2024, 14, 8569. https://doi.org/10.3390/app14188569
1.3. Vasile Baneş, Florin Babarada, Cristian Ravariu, *An analysis of the provision of chatbot-based support services in the education system*, Revue roumaine des sciences techniques, Série Électrotechnique et Énergétique, ISSN: 0035-4066, 2024. submitted in //June 2024, Under review.

2. Articles published in IEEE and International Conference Proceedings

2.1 <u>Vasile Baneş</u>, Florin Babarada, Cristian Ravariu, *Conversion tool for audio-video file compatibility in Moodle E-learning platform*, Proceedings of 11-th IEEE International Conference Electronics, Computers and Artificial Intelligence ECAI2019, 27-29 June 2019, Pitesti, Romania, pp.1-4, Indexare IEEE. 23 April 2020, DOI: 10.1109/ECAI46879.2019.9041975

2.2. **<u>Vasile Baneş</u>**, Florin Babarada, Cristian Ravariu, *Windows Server backup and restore for Moodle E-learning platform*, Proceedings of 12-th IEEE International Conference Electronics, Computers and Artificial Intelligence ECAI2020, 2020, Pitesti, Romania, pp.1-4, Indexare IEEE, 16 October 2020, DOI: 10.1109/ECAI50035.2020.9223252, WOS:000627393500125, ISBN 978-1-7281-6843-2, ISSN2378-7147.

2.3. **<u>Banes, V</u>**., Ravariu, C. (2022). *Authentication Methods with a High Degree of Security in Accessing Moodle E-Learning Platform*. In: Auer, M.E., Tsiatsos, T. (eds) New Realities, Mobile Systems and Applications. International Conference on Interactive Mobile Communication, Technologies and Learning, 2021. Lecture Notes in Networks and Systems, vol 411. Springer, Cham. https://doi.org/10.1007/978-3-030-96296-8_86

2.4. Ravariu, C., **<u>Banes, V</u>**., Enescu, A., Vasile, R. (2022). *Mobile Models for Biosensors with Diffusion Layer Through Enzyme Receptor.* In: Auer, M.E., Tsiatsos, T. (eds) New Realities, Mobile Systems and Applications. International Conference on Interactive Mobile Communication, Technologies and Learning, 2021. Lecture Notes in Networks and Systems, vol 411. Springer, Cham. https://doi.org/10.1007/978-3-030-96296-8_87

2.5. **<u>Banes, V</u>**., Ravariu, C. (2023). *Uploading Files to a Course Through the Command Line Run from Outside the Moodle e-Learning Platform*. In: Auer, M.E., Pachatz, W., Rüütmann, T. (eds) Learning in the Age of Digital and Green Transition. International Conference on Interactive Collaborative Learning, 2022. Lecture Notes in Networks and Systems, vol 634. Springer, pp. 990 - 997, Cham. https://doi.org/10.1007/978-3-031-26190-9_101, Print ISBN 978-3-031-26189-3, published 23 February 2023.

2.6. **<u>Baneş, V</u>**.; Ravariu, C, *Case Study on Providing AI Chabot-Based Support Services in E-Learning Platforms*. International Conference on Interactive Collaborative Learning, Talin, Estonia 25.09.2024. Accepted. To be published in Oct. 2024.

3. Scientific presentations at various Conferences

3.1. **<u>Vasile Banes</u>**, Florin Babarada, Cristian Ravariu, *Conversion tool for audio-video file compatibility in Moodle E-learning platform*, Conferinta Stiintifica INCDIE-ICPE-CA & Siemens Romania, Edition 8-th, Bucharest, Romania, 6.Dec. 2018., Sediul AGIR, Calea Victoriei nr. 118, Prezentare Poster.

3.2.**<u>Vasile Banes</u>**[1], Cristian Ravariu[2], *A New Conversion Interface for File Compatibility in the Moodle e-Learning Platform*, Doctoral Symposium on Electronics,

Telecommunications, & Information Technology Bucharest2023, SD-ETTI, October 4-6, 2023

4. Scientific reports

1. Installation, Configuration and Administration of the Moodle E-learning Platform.
2. Backup Methods for the Moodle e-learning Platform.
3. Increase security by accessing the Moodle e-learning platform using two authentication factors.
4. New functionality for the Moodle e-Learning platform: Communication of files through the chat window.

6.3   Future directions

In this field of study, electronics and information technology, a new direction is a Cloud solution, the cloud being a global network of servers with specific functions, interconnected and working in a single ecosystem, which has the advantage of saving resources and time. The solution has increased security for document protection.

Another area of interest is the integration of artificial intelligence (AI) with the Moodle platform, which can significantly influence teaching activities and course personalization. The exponential growth of artificial intelligence technologies can create learning materials, offer suggestions and opinions and last but not least individual assessments. In the implementation of artificial intelligence, a precautionary approach must be considered, because if it is not introduced correctly, it can bring major risks to education. Therefore, the working method will focus on efficiency, security; I on the relationship between man and artificial intelligence.

A new direction of interest is to improve the communication method within the Moodle e-learning platform by developing an audio and video function or by integrating an existing solution on the market.

Bibliography

[1]. Y. Ghilay, "Effectiveness of Learning Management Systems in Higher Education: Views of Lectures with Different Levels of Activity in LMSs," Journal of Online Higher Education vol.3, no. 2, 2019.

[2] M. Ouadoud, M. Y. Chkouri, A. N. A. Essaadi, "LeaderTICE: A Platforms Recommendation System Based on a Comparative and Evaluative Study of Free E-learning Platforms," iJOE Journal, Vol. 14, No. 1, 2018, pp. 132-150.

[7] D. Miletic, "Moodle Security – Learn how to install and configure Moodle in the most secure way possible," Packt Publishing, Birmingham, UK, 2011.

[8] Moises Riestra-González, Maria del Puerto Paule-Ruíz, Francisco Ortin, Massive LMS log data analysis for the early prediction of course-agnostic student performance, Computers & Education, Volume 163, 2021, 104108, ISSN 0360-1315, https://doi.org/10.1016/j.compedu.2020.104108.J

[16] Asim, J.; Khan, A.S.; Saqib, R.M.; Abdullah, J.; Ahmad, Z.; Honey, S.; Afzal, S.; Alqahtani, M.S.; Abbas, M. Blockchain-based Multifactor Authentication for Future 6G Cellular Networks: A Systematic Review. Appl. Sci. 2022, 12, 3551. https://doi.org/10.3390/app12073551

[19] Nassani, A. A., Grigorescu, A., Yousaf, Z., Trandafir, R. A., Javed, A., & Haffar, M. (2023). Leading Role of E-Learning and Blockchain towards Privacy and Security Management: A Study of Electronics Manufacturing Firms. Electronics, 12(7), 1579.

[20] Shahzad, K.; Aseeri, A.O.; Shah, M.A. A Blockchain-Based Authentication Solution for 6G Communication Security in Tactile Networks. Electronics 2022, 11, 1374. https://doi.org/10.3390/electronics11091374

[23] Mihailescu, M.I., Nita, S.L., Corneliu, P.V., 2020. Applied Cryptography In Designing E-Learning Platforms. Bucharest. https:// doi: 10.12753/2066-026x-20-108.

[29] Nurhaida, I., Ramayanti, D., Riesaputra, R., 2017. Digital signature & encryption implementation for increasing authentication, integrity, security and data non-repudiation. IRJCS International Research Journal of Computer Science. Volume IV. pp. 04-14. http://doi:10.26562/IRJCS.2017.NVCS10080.

[30] Longge Wang, Tao Song, 2016. An Improved Digital Signature Algorithm and Authentication Protocols in Cloud Platform. IEEE International Conference on Smart Cloud (SmartCloud). DOI:10.1109/SmartCloud.2016.46.

[36] Grassi, P., Garcia, M.E., 2017. JL Fenton Digital identity guidelines - NIST Special Publication. https://doi.org/10.6028/NIST.SP.800-63-3.

[38] Ken Reese, Trevor Smith, Jonathan Dutson, Jonathan Armknecht, Jacob Cameron, and Kent Seamons, Brigham Young University, A Usability Study of Five Two-Factor Authentication Methods, Proceedings of the Fifteenth Symposium on Usable Privacy and Security. August 12–13, 2019 • Santa Clara, CA, USA, ISBN 978-1-939133-05-2.

[39] Sanchari Das, Andrew Dingman, and L Jean Camp. Why Johnny Doesn't Use Two Factor: A Two-Phase Usability Study of the FIDO U2F Security Key. In 2018 International Conference on Financial Cryptography and Data Security (FC), 2018.

[40] Claudia Acemyan, Philip Kortum, Jeffrey Xiong, and Dan Wallach. 2fa might be secure, but it's not usable: A summative usability assessment of google's two-factor authentication (2fa) methods, 2018.

[48] Moodle Homepage. https://docs.moodle.org/dev/CLI_scripts#Location, last accessed 2022/04/29.

[49] Robin Olofsson, Sebastian Hultstrand, Git - CLI or GUI, Computer Science, 08, 2015, pp. 1-55.

[56] Chandrasekara, Chaminda, and Pushpa Herath. "REST API, Command Line, and Extension Development." Hands-on Azure Pipelines. Apress, Berkeley, CA, (2020). 179-192.

[63] Kerimbayev, N., Nurym, N., Akramova, A. *Virtual educational environment: interactive communication using LMS Moodle*. Educ Inf Technol 25, 1965–1982 (2020). https://doi.org/10.1007/s10639-019-10067-5.

[64] Kerimbayev, N., & Tatnall, A. (2019). *Formats of virtual learning*. Encyclopedia of Education and Information Technologies.–2019. Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-60013-0_201-1.

[65] I. Esnaola-Arribillaga and M. J. Bezanilla, *"Levels of Moodle Use to Support University Face-to-Face Teaching,"* in IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, vol. 15, no. 3, pp. 129-137, Aug. 2020, doi: 10.1109/RITA.2020.3008376.

[66] Nababan, E. B., Sitompul, O. S., & Arisandi, D. (2021). *Implementation of face-to-face online learning system based on audio video, presentation and chat using the moodle e-learning platform.* ABDIMAS TALENTA: Jurnal Pengabdian Kepada Masyarakat, 6(1), 110-118.

[68] Dewi, A., Ramadhan, M. W., & Purbohadi, D. (2018, November). *Chatting facility development on computer aided instruction* (CAI). In Proceedings of the 2018 2nd international conference on education and E-learning (pp. 11-15).

[69] *https://docs.moodle.org/311/en/File:Moodle_features_students*.pdf.

[70] Jawdhari, Hayder A., and Alharith A. Abdullah. *"A New Environment of Blockchain based Multi Encryption Data Transferring."* Webology 18.2 (2021).

[70] R B, Madhumala & Chhetri, Sujan & KC, Akshatha & Jain, Hitesh. (2021). *Secure File Storage & Sharing on Cloud Using Cryptography*. International Journal of Computer Science and Mobile Computing. 10. 49-59. 10.47760/ijcsmc.2021.v10i05.005.

[71] Maru, Mister Gidion, et al. "*Teachers' perception toward the impact of platform used in online learning communication in the eastern Indonesia."* ijcs 4 (2022): 321.

[72] Broadbent, Jaclyn, and Jason Lodge. *"Use of live chat in higher education to support self-regulated help seeking behaviours: a comparison of online and blended learner perspectives."* International journal of educational technology in higher education 18.1 (2021): 17.

[79] Essel, H. B., Vlachopoulos, D., Tachie-Menson, A., Johnson, E. E., & Baah, P. K. The impact of a virtual teaching assistant (chatbot) on students' learning in Ghanaian higher education. International Journal of Educational Technology in Higher Education, 19(1), 57 (2022).

[80] Liu, L., Subbareddy, R., & Raghavendra, C. G. *Ai intelligence chatbot to improve students learning in the higher education platform*. Journal of Interconnection Networks, 22(Supp02), 2143032 (2022).

[81] Sophia, J. J., & Jacob, T. P. *Edubot-a chatbot for education in covid-19 pandemic and vqabot comparison.* In 2021 Second International Conference on Electronics and Sustainable Communication Systems (ICESC) (pp. 1707-1714). IEEE (2021).

[82] Bilquise, G., Ibrahim, S., & Salhieh, S. E. M. *Investigating student acceptance of an academic advising chatbot in higher education institutions.* Education and Information Technologies, 29(5), 6357-6382 (2024).

[85] Baneş, S., & Ravariu, C. *Uploading Files to a Course Through the Command Line Run From Outside the Moodle e-Learning Platform*, in Book: Learning in the Age of Digital and Green Transition, Proceedings of the 25th International Conference on Interactive Collaborative Learning (ICL2022), Vol 2, pp. 990-997, Editors: Michael E. Auer, Wolfgang Pachatz, Tiia Rüütmann (2022).

[88] Opranescu, V., Ionita, A.D *Towards a recommendation system for an educational profile in systems engineering,* U.P.B. Sci. Bull., Series C, 86(1), (pp. 19-30) (2024).

[92] Birenbaum, M. *The Chatbots' Challenge to Education: Disruption or Destruction?.* Education Sciences, 13(7), 711 (2023).

[93] Wollny, S., Schneider, J., Di Mitri, D., Weidlich, J., Rittberger, M., & Drachsler, H. *Are we there yet?-a systematic literature review on chatbots in education.* Frontiers in artificial intelligence, 4, 654924 (2021).

[94] Le Hoanh Su, T. D. H., Thi-Yen-Linh, T., Thi-Duyen-Ngoc, N., Bao-Tuyen, L., & Ha-Phuong-Truc, N. *Development of an AI Chatbot to support admissions and career guidance for universities.* International Journal of Emerging Multidisciplinary Research, 4(2), 11-17 (2020).

[95] Chen, Y., Jensen, S., Albert, L. J., Gupta, S., & Lee, T. *Artificial intelligence (AI) student assistants in the classroom: Designing chatbots to support student success.* Information Systems Frontiers, 25(1), 161-182 (2023).

[109] Dermawan, O., S. M. Ayu, and M. J. Muhtari. *"Microsoft visual basic 6.0 software to develop mathematics teaching materials."* Journal of Physics: Conference Series. Vol. 1155. No. 1. IOP Publishing, 2019.