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Modern Technologies for the Management of Education Activities

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Introduction

Education has always been a crucial part of a nations' interest since it represents how humanity functions and governs itself. People are trying to find the best methods to teach or learn new subjects, but in the actual context, there is a need for new means and perspectives. School from home has been part of our lives, more or less in the past year, and we don't know for sure what will happen in the future. Because of this, the need for new and modern technologies in the educational system is more fierce than it has been ever before.

The scope of this paper is to analyze the actual state of the educational system management applications and technologies and to come with a practical solution for its current needs. Nowadays, there are a lot of educational solutions offered on the market, from Teams, Zoom, and Google Class to the ones developed internally by each institution. When it comes to choosing one of them it is vital to consider firstly the needs of the users to facilitate the learning process.

The quality of education and the satisfaction of the end-user are in the first place when it comes to the development of new and innovative applications. In this paper, we will see which are the main criteria when it comes to choosing or developing this kind of application, how the users perceive them and what factors can bring the success or failure of an educational application. Furthermore, we will analyze which are the main features of e-learning platforms and the used architectures and technologies to find the best solution for the newly built application.

Of all educational activities, we will focus more on the learning side. The build application should come with a more effective way of communicating between students and teachers, allowing a better interaction between them in regards to the loaded document for study purposes, documents such as courses, projects, or other learning materials. We shouldn't neglect the evaluation part, so each student will be able to see its progress for each course based on the projects or quizzes they completed. Last but not least, the application will have a section dedicated to the management of the final study papers such as bachelors' thesis and dissertation.

Chapter 1. The current stage of e-learning systems

This chapter will describe the actual state of the educational system towards the used technologies for the development of applications. The main goal is to specify the most important criteria taken into account when developing or choosing a suitable application. We will also see how user satisfaction influences the success of an application and the costs and the most used architectures. Another point considered is related to the advantages and weaknesses of e-learning applications.

1.1. E-learning – general concepts

Digital technology has a major impact on the educational infrastructure. Thus, it is important to learn from the COVID-19 crisis, when the need for technology was greater than ever, and to make education and training systems fit for the digital age (European Commission, 2021). The speed at which more and more people will use technology in the learning process is greater each day and because of the current crisis, there will be no turning back from this continuous embracing of the new technological trends. Before 2020, more than 60% of the respondents involved in the study conducted by the European Commission did not use online learning (European Commission, 2021). Nowadays, people consider that the learning resources should be interactive and easy to use. Also, the shared information should be relevant and the structure more clear to be followed. Therefore, there is an increased demand for educational applications, but at the same time, the requirements from the end-user are at a new level of complexity, since the number of people who access digital learning is greater.

The digital transformation of the educational system has allowed the incorporation of a new teaching and learning ecosystem called e-learning (Valverde-Berrocoso, Garrido-Arroyo, Burgos-Videla, & Morales-Cevallos, 2020). The various forms of e-learning allow both students and business executives to learn from anywhere and at any time (Kumar, Berhe, & Kamalakannan, 2018). These two areas of e-learning are fundamentally different, while the corporate sector focuses on effectively training the employees, the education sector is focusing on knowledge transfer. E-learning is designed to create an online communication between teacher and student, being used by many academic institutions. This form of learning can be used also in a physical class when the teacher prepares an online quiz for the students. In contrast with e-learning, we need to introduce a new learning concept, distance learning.

Distance learning, unlike e-learning, is more about the distance between the student and the teacher. In this case, the technology is used as a binder between the participants. Many universities from all over the globe offer this learning possibility by providing online courses to students from different regions of the world. The origin of distance learning derived from the opening of so-called “open universities” in England in 1969 and Germany in 1974 (MILIĆEVIĆ, et al., 2021). The coronavirus pandemic has forced universities to physically close down, but to avoid the disruption of the 2019-2020 academic year, many universities adapted to the new conditions with the help of e-learning and distance learning (Acheampong & Agyemang, 2021). Moodle software tool is usually used for distance learning activities, is estimated to be used by more than 30.000 education institutions worldwide (MILIĆEVIĆ, et al., 2021). This tool helps teachers load their materials and make them available to specific groups of study. Also, it allows testing the students' level with quizzes, and the communication with the teacher, in case of any questions, can be done via email.

With all the changes from the past year, the need for easy-to-use applications through which we can access learning materials, communicate with the teachers or receive an evaluation for a specific project has become quite critical lately.

It has always been a necessity to find new ways of interactions between teachers and students to improve the quality of education and, because of this, information technologies are playing a major role in delivering digital content for educational purposes (Alor-Hernández & Álvarez-Rodríguez, 2018). The amount of data to be managed by each educational institution is quite big. The apparition of the Web of Data and the adoption of it in educational-related activities has led to the creation of an embryonic "Web of Educational Data" (Alor-Hernández & Álvarez-Rodríguez, 2018). This includes institutional data from universities but also the data publicly available. This data is available online through a lot of platforms like Massive Open Online Courses (MOOC), web pages, or blog posts, leading to an increasing need of organizing and linking all the educational content.

With the growing importance of Information and communication technologies (ICT) in the educational field, learning management systems (LMS) are widely adopted to store a wide range of data, from students' characteristics to testing scores and grades (A. Conde, Colomo-Palacios, J. García-Peñalvo, & Larrucea, 2018). An LMS can include software applications and web-based technologies used by universities and students to either access, plan, implement, supplement, monitor, or assess learning or to communicate about learning (Elfeky, Masadeh, & Elbyaly, 2020). Therefore, students can access all the learning materials they need, receive grades for their work or the quizzes they completed and interact with other colleagues or teachers.

An LMS provides many benefits for the educational process. Among these the most important is that it discards the physical location, the system can be effectively used by students which are not physically present at the university. Accessibility is another future that becomes vital with the increase of using digital devices. It is important to access the course we are interested in from anywhere, at any time, and from any device. Most of the LMSs increased their accessibility lately by allowing their users to login using various internet browsers from computers or mobile phones or their official application which is usually available on more operating systems such as Windows, Android, or IOS (Aldiab, Chowdhury, Kootsookos, Alam, & Allhibi, 2019). Also, the attractiveness of LMS by using gamification or video games makes them a suitable candidate when the user perspective and easiness of use is put in the first place. The most commonly used LMSs include Moodle, Blackboard, Schoology, Google Classroom, and Canvas (Bouchrika, 2020).

Besides LMS, another type of e-learning platform is the Student Management System (SMS) which is responsible for managing the data about all the students and employees of a university. This kind of application should help to improve communication between students and school functionaries, including parents' interventions in this process as well. On the other hand, we have the Assessment Software which enhances the assessment process for teachers and students by easily creating the lessons and evaluating each students' performance. For the cases when communication face to face is not possible, the students could use Virtual Classrooms or Video Conferencing to help reduce the inconveniences of the distance. The Massive Open Online Courses (MOOC) offer video lessons, reading materials, assessments, and discussion forums for the students who want to achieve a certain level of knowledge in a certain domain. This kind of course is used by universities all around the world, especially in the context of the actual crisis when physical presence is much harder to be achieved (Matviichuk, 2020).

1.2. How to choose an e-learning tool – main criteria and success/failure factors

E-learning applications may appear in different forms from web-based learning systems to virtual classrooms and digital collaboration systems (Shee & Wang, 2008). Furthermore, we will focus on web-based e-learning systems (WELS) which refer to web-based software systems developed to help with the management of e-learning activities. With all this variety of e-learning tools, it is important to keep in mind which are the criteria when choosing to use or develop an application for the educational field. For an e-learning platform to have success, its first concern should be user satisfaction. The four main categories of criteria which should be taken into account from this perspective are presented in the below figure (Figure 1).

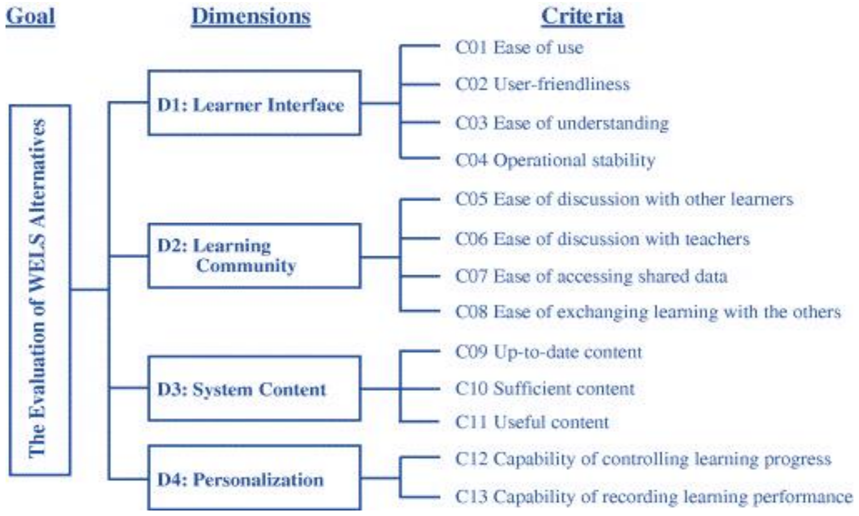

Goal
Dimensions
Criteria
The Evaluation of WELS Alternatives
D1: Learner Interface
D2: Learning Community
D3: System Content
D4: Personalization
C01 Ease of use
C02 User-friendliness
C03 Ease of understanding
C04 Operational stability
C05 Ease of discussion with other learners
C06 Ease of discussion with teachers
C07 Ease of accessing shared data
C08 Ease of exchanging learning with the others
C09 Up-to-date content
C10 Sufficient content
C11 Useful content
C12 Capability of controlling learning progress
C13 Capability of recording learning performance

Figure 1. The criteria used to evaluate WELS systems from the user satisfaction point of view (Shee & Wang, 2008)

The learner interface refers to the actual product with which the student or learner interacts. This interface should be easy to use by the end-user, the design should be friendly and all the important parts of the application should be reachable at a few clicks away, thus the stability of the interface is considered a key criterion. A too sophisticated design could lead to hardness of finding the needed resources and user confusion. Furthermore, all the presented details should be easy to understand from the users' perspective. The learning community is also an important factor to consider. The platforms where the discussion with other learners is encouraged to make the learning process more interactive. From the same category, we have ease of discussion with teachers. The learner should feel at ease with asking questions to the involved teacher about any shared material. The shared documents should be in a place of the application which students can easily access and this place could enable and the sharing of ideas and opinions about a specific document or topic, between teacher and students or between students themselves. Even if the interface and community have a major place in the criteria rank, the shared content is also vital when the focus is on an e-learning platform. The information should be updated periodically, and the content should be sufficient, neither too less nor too much for each specific subject. Also, the content should be targeted and useful for the learner. The last criteria refer to the personalization of the e-learning tool. Learners will appreciate if they can control the learning process as much as it is possible and also record the learning performance by having quizzes available or feedback from the teacher at some point in completing each subject.

Besides user satisfaction, there is a framework called Rubric for E-Learning Tool Evaluation (Western University) which offers criteria of evaluation for any kind of e-learning platform. The classification for each set of criteria is shown in the figure below (Figure 2) Not all the criteria are appliable to any kind of application and if one of the above is not suitable it can be skipped. Also, this rubric is meant to offer insights into the relative strengths and weaknesses of the e-learning tools which are compared by using a set of criteria. The framework contains eight main categories, each having another varying number of criteria. By applying all of them we can obtain a multi-dimensional evaluation from a functional, technical, and pedagogical point of view of the e-learning system.

Unlike other models used to choose, adopt and evaluate technology, like the technology acceptance model (TAM) or SECTIONS model, the created rubric presents existing concepts using an instructor-based lens to create an evaluative, predictive model that lets instructors, designers and developers evaluate technologies to find an appropriate fit for their situation (Anstey & Watson).

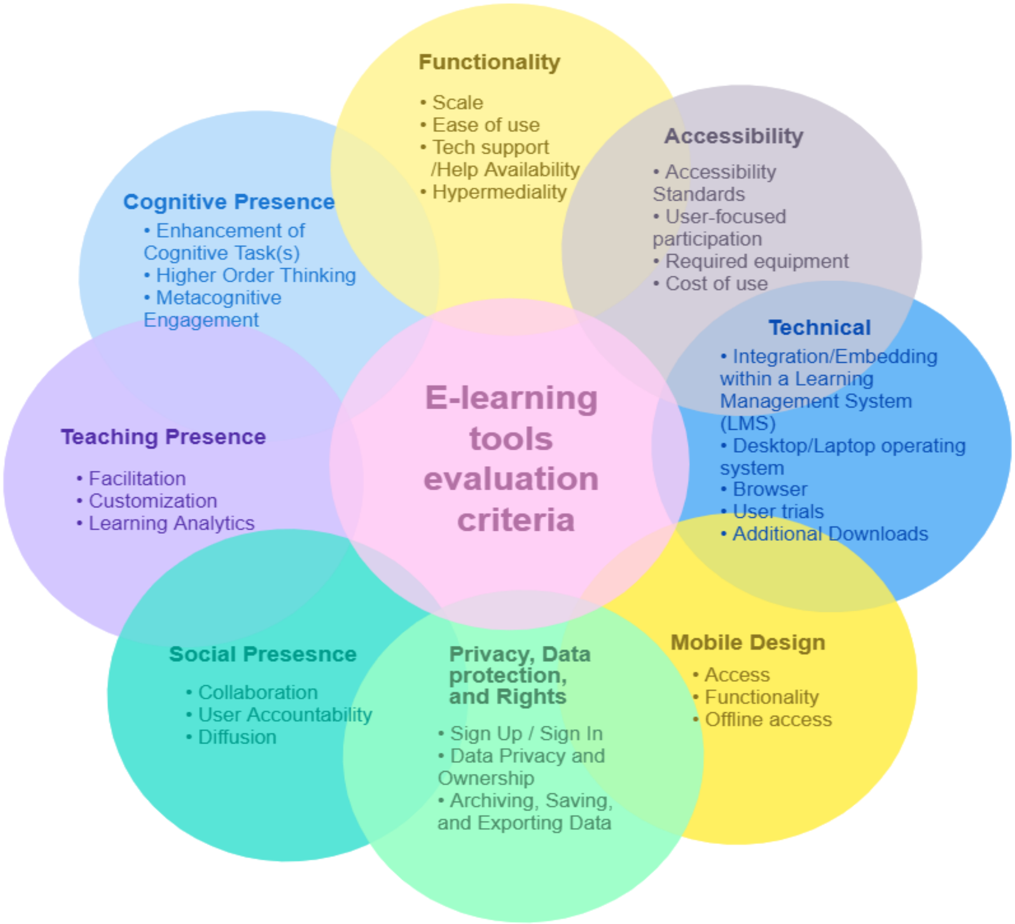


Figure 2. E-learning tools evaluation criteria (Western University)

As shown above, the rubric consists of some major categories of criteria. From the ***functionality*** point of view, an e-learning tool should serve its intended purpose. *Scalability* is an important factor from this criteria group since any e-learning tool should adapt to larger or smaller study groups, thus limiting the number of users cannot be a solution. A tool tends to be more positively perceived and adopted when it is *easy to use*, its design feels intuitive and offers some guidance for the user. The ease of use criteria focuses more on the design of the application because this component contributes to the user-friendliness. Another sub-criteria, from the functionality group, is represented by the *technical support* offered or the *help availability*. When a technical problem occurs or the user doesn't have enough information to find a specific module or component from the application, users must know where to turn for help. Also, the help should come in a time-efficient way, so that the end-user can go on with its learning process. The *hypermediality* refers to the possibility to allow users to communicate through different channels such as audio, visual, or text.

The second criteria group, ***accessibility***, can be broadly seen as the ability to make the e-learning platform usable by as many people as possible. To do this, any e-learning tool should have some specific *accessibility standards*, including legislative accessibility standards and the guidelines from the World Wide Web Consortium (W3C). The end-user is the one who has the final word in choosing or rejecting a specific e-learning tool, thus *user-focused participation* is a must. The application should be designed to address the needs of diverse users and their various capabilities. The *required equipment* should also be taken into account, elements like hardware, technology, or services needed for the user to engage with an e-learning tool play a vital role. In addition to tuition costs, students usually face significant expenses for course resources. The *cost of use* for an e-learning tool should be free for the students and covered by the tuition or subsidized by the institution.

From the **technical** point of view, in a review of e-learning readiness models, researchers found that a user's technology, which includes internet access, hardware, software, and computer availability, was integral to successful e-learning implementation (Anstey & Watson). The tool should have to possibility *of integration with an LMS* while maintaining its full functionality. Also, the platform should be accessible to any user from *desktop/laptop operating system and browser*, the most operating systems (OS) or browsers a tool supports, the better. A very limited list of supported OS or browsers is a cause of concern. The *additional downloads* needed for the e-learning application to function are seen as a downside. The user expects to not need any additional software or browser extensions to use the tool.

With the large growth of mobile devices in the last years, an e-learning platform should take into account the ***mobile design*** part also. The e-learning tool can be *accessed* through downloading a mobile application or even using a mobile browser. The mobile version of the application should have few to no differences from the desktop application and the design should be responsive, adapting to a smaller screen and different dimensions of the devices. *Offline access* is also a nice feature to be offered, any e-learning tool that accesses the internet should offer an offline mode to expand access to those users who have limited internet access.

While e-learning tools offer numerous benefits to learners, they can also entail risks. To avoid this, subjects such as ***privacy, data protection, and rights*** should be properly addressed. All institutions have the responsibility to protect students' personal information such as name, student ID, photos, or videos of the student. Therefore, the e-learning tool shouldn't require the creating of an external account or additional login. Through the *sign-up/ sign-in* mechanism, no personal information is collected or shared. Regarding *data protection and ownership*, these tools should offer users the right to choose what happens to their intellectual property, either they want to make it public or keep it private. Users decide how their data is shared and keep ownership and copyright of the data. An e-learning platform should also let the user archive, save, or import, and export the created content in various formats.

The last three criteria focus on creating a sense of community between learners. ***Social presence*** is meant to establish a trusting environment that fosters collaboration and teamwork in the created community. *Collaboration* is a key factor that sustains this community. It is important to provide synchronous and asynchronous channels for knowledge sharing and asking questions when needed. Thus, each user should be *accountable* for its activities and instructors should be able to identify students in any situation, even if they are using pseudonyms. The *diffusion* criteria sustain that commonly used tools are more easily to be adopted than the ones which are less known.

The ***teaching presence*** refers to enabling instructors to establish and maintain their teaching presence using the communication means provided by the e-learning tool. *Facilitation* of these creating this kind of bond between teachers and students is up to the chosen platform. The ability of the instructor to be present with learners is improved by active management, monitoring, engagement, and feedback from all the involved parts. Also, teachers should be able to *customize* the interaction of each student with the e-learning tool and monitor the students' progress by using the *learning analytics* provided by the tool.

The last criteria described by the framework is the ***cognitive presence*** which is a tools' ability to support students' cognitive engagement in learning tasks. Ideally, an e-learning tool transforms the learning process. An e-learning tool should engage students in different tasks either by redesigning the activity or by establishing new approaches previously inconceivable or unachievable through other means (Anstey & Watson). The tool should also facilitate *higher-order thinking* tasks such as critical thinking, problem-solving, or reasoning, and *metacognitive engagement* by regularly giving feedback to students.

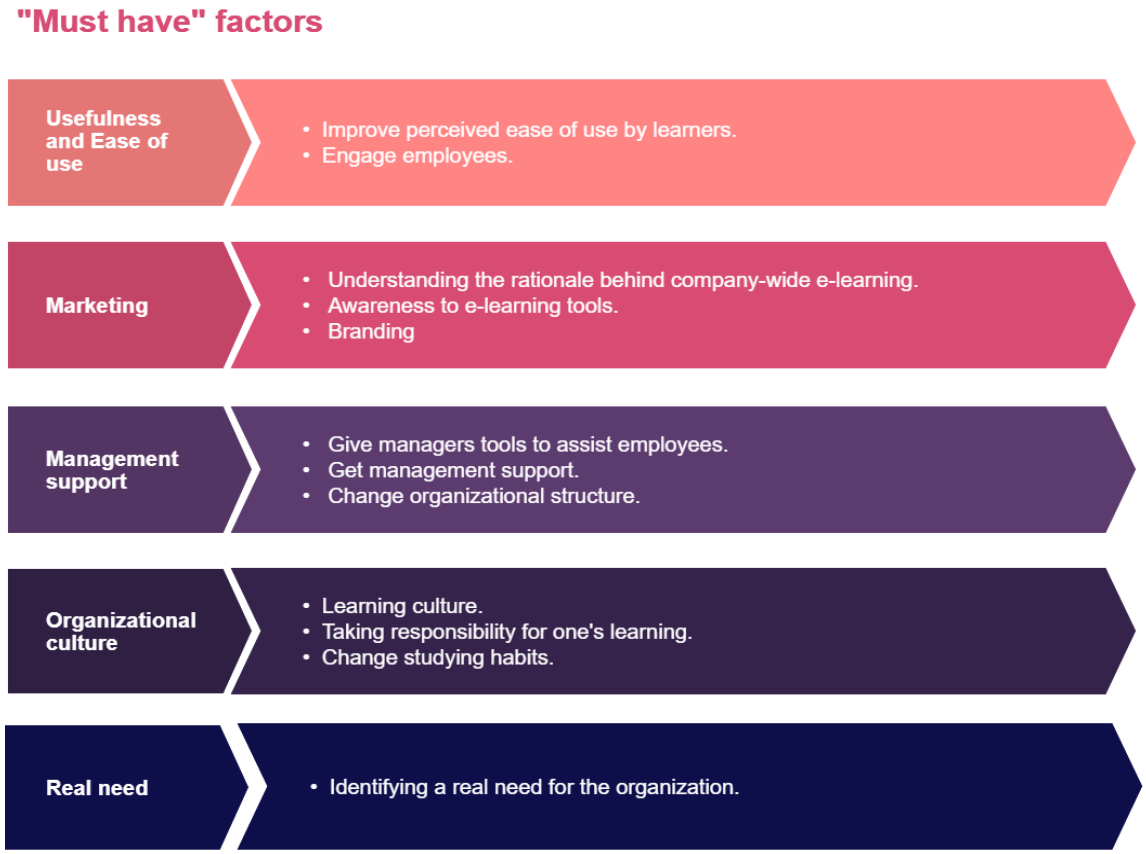
Keeping in mind all the criteria presented above can be a success factor for an e-learning tool. Opposite, if any of the elements are not incorporated into the platform it can lead to failure. History has a lot of attempts to revolutionize the learning process by using innovative technology, but all this struggle comes with a great lesson: in order for a technology to improve learning, it must fit into students' lives and not the other way around (Romiszowski, 2004).

The success factors of an e-learning platform have been mentioned in a variety of literature, but the critical factors which lead to the success of the tool are (Alhomod & Shafi, 2013):

- *Institutional support*, emphasizing the available technological infrastructure.
- *Course Development*, which benchmarks the development of courses by each faculty.
- *Teaching/Learning.*
- *Course Support*, materialized by the technical support, and, also, the teachers' support when inconveniences arise.
- *Student Support,* which refers to all the information needed by the students, including admission, tuition, books, and other student support services.
- *Faculty Support,* which includes the basis of technical support of the faculty to transition from classroom teaching to online teaching.
- *Evaluation and assessment*, which is intended to review students' progress to ensure the utility of the e-learning platform.

Besides these factors, it is vital that the users of the chosen e-learning tool have been using previous any kind of technology. Le blanc and wands (2001) classified the success factors of an e-learning system as follows (Alhomod & Shafi, 2013): *organizational factors*, which include the technical infrastructure of each university and the support of the management team, *general factors*, including learning principles, and *cognitive factors*, including access to help, user control, user interface and the presence of complex and complete information.

For a more in-depth analysis, Sela and Sivan (2009) divided the success factors into two main categories, “must-have” factors and “nice to have” factors, which will be shown in the figures below (Figure 3, Figure 4).



"Must have" factors

Usefulness and Ease of use
- Improve perceived ease of use by learners.
- Engage employees.

Marketing
- Understanding the rationale behind company-wide e-learning.
- Awareness to e-learning tools.
- Branding

Management support
- Give managers tools to assist employees.
- Get management support.
- Change organizational structure.

Organizational culture
- Learning culture.
- Taking responsibility for one's learning.
- Change studying habits.

Real need
- Identifying a real need for the organization.

Figure 3. Must-have factors for the success of an e-learning tool (Sela & Sivan, 2009)

Although these factors are a little more general, including all e-learning tools, not just the ones for the educational field, they apply very well to the e-learning platforms developed for educational purposes only. Firstly, the e-learning platforms interface must be user-centered, and the shared materials should be complete and related to real-life experiences. From the marketing point of view, it should exist an awareness campaign so that everyone will be aware of the benefits of adopting a new e-learning application. Since management support is also important, the managers of universities should be among the first persons who see the benefits of adopting such a platform. Also, the learning culture of the university should be analyzed, and the platform principles should be similar to the ones already existing in the institution. Lastly, the chosen platform must cover the real need of the organization, so the development process of an e-learning tool, as well as the adoption one, should be closely supervised.

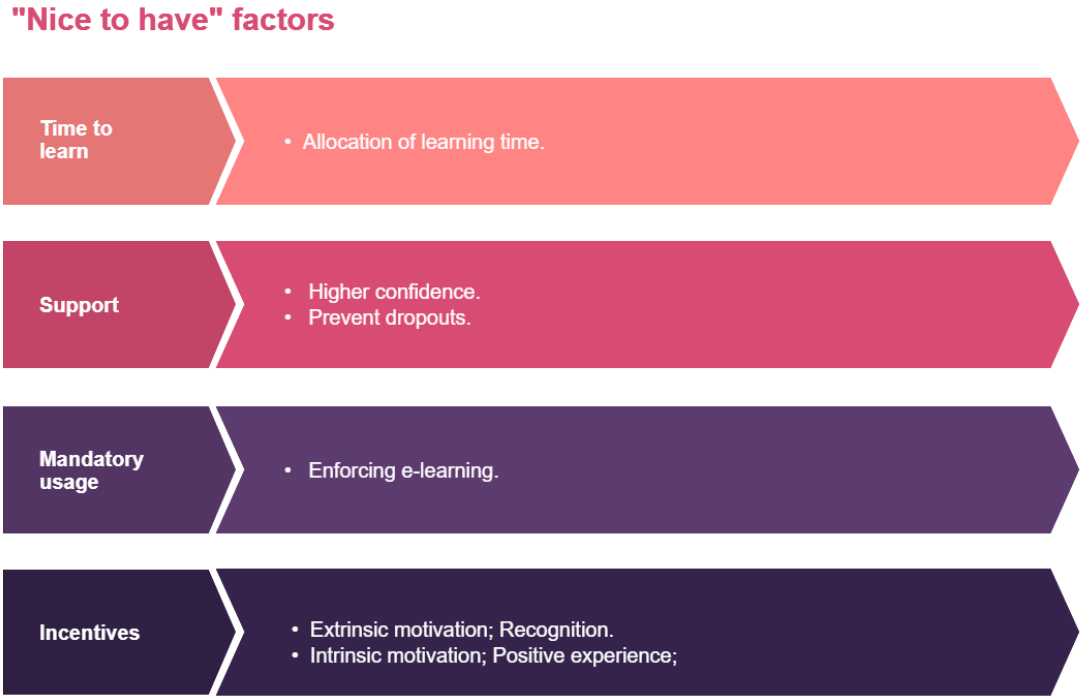


Figure 4. Nice to have factors for the success of an e-learning tool (Sela & Sivan, 2009)

The nice-to-have factors include four main categories. The first one refers to the allowed time to learn. Here it is important that each student can choose when they want to learn and to schedule their own learning time. Also, technical support can be a nice feature that will be appreciated by beginners in the use of the e-learning platform. The usage of the tool should be mandatory, not voluntary because this will increase the e-learning effectiveness. The last point refers to the fact that provided materials should be unique, and unavailable on other platforms so that students will find them useful to use.

On the other hand, the failure factors can appear as well in the development process of an e-learning tool. The main reasons why the failure appears for the e-learning tools, especially in the actual context are (Almaiah, Al-Khasawneh, & Althunibat, 2020):

- *Technological challenges:* This is maybe the most critical factor that can lead to the failure of an e-learning platform because when students are facing technical difficulties they can’t use the platform.
- *Lack of technical support:* The unavailability of technical staff and lack of support can also be a downside.
- *Lack of awareness:* The students lacking awareness of internet skills may be a problematic thing also.
- *Universities readiness:* Students processing inconsistent readiness over the years.

- *Quality course content:* If the available content is less interactive it leads to a decrease in its quality.
- *Localization of content:* Lack of customization of the content according to each students' needs.
- *Course content:* Lack of relevant, accurate, and aligned with students' needs content.
- *IT skills of faculty members:* Weak IT skills.
- *Faculty members' acceptance of e*-learning systems: Teachers and students lacking technology acceptance.
- *Low level of knowledge of faculty members:* Instructors lacking knowledge of the course content while delivering an e-learning session.
- *Faculty member effort.*
- *Lack of security and privacy concerns*.
- *Lack of technological infrastructure*: Lack of needed hardware, software, facilities, and network capabilities within the university.

1.3. Architectures and technologies used by e-learning applications

In order to build an e-learning application, there are some standards that should be included. Learning standards and specifications can be organized into five categories (Liu, El Saddik, & Georganas, 2003):

- *Metadata:* All the learning content should be labeled in a consistent way to support the storage and easy find of the information.
- *Content packaging:* This standard allows courses to be transparent along with learning systems.
- *Learner profile:* Each learner profile can include personal data, learning plans, performance information, certifications, and degrees obtained.
- *Learner registration:* This component allows the administrators to know what kind of content to deliver for each learner.
- *Content communication:* After content is distributed. There is a need to communicate user data and previous activity to the content.

One of the suitable architectures for e-learning systems is the Service Oriented Architecture (SOA). Service-Oriented Computing is a shift from a vision of web-based on the presentation of information to a vision of the web as a computational infrastructure, where systems and services interact to fulfill users' request programmatic view (Papazoglou & Jan van den Heuvel, 2007). The advantages of using SOA are that it is reusable and the implementation is flexible. Also, the cost of development is lower, and the speed of development is higher (Armenski & Gusev, 2008).

SOA leads us to understand it as an architecture that is oriented around services (Palanivel & Kuppuswami, 2014). A service is a piece of software implemented using well-defined standards. After implementation, the service will be added to a service directory and will be available to all developers. A typical SOA will look like in Figure 5.

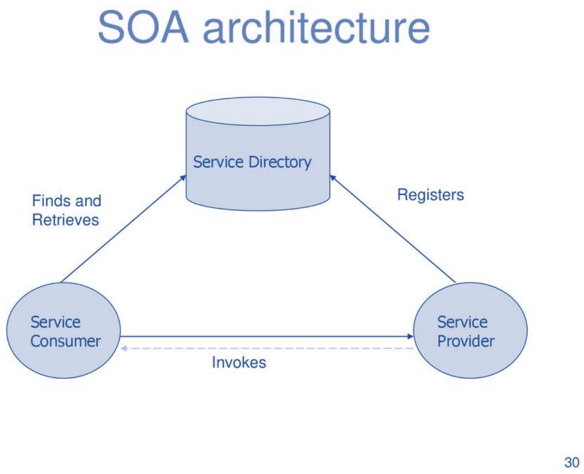


Figure 5. SOA

SOA provides enterprises better flexibility when it comes to building new applications in an agile manner by using the existing application infrastructure to create new services. The reasons to apply SOA to an e-learning system are the following (Palanivel & Kuppuswami, 2014):

- Achieve better collaboration among related LMSs.
- Provide consistent service-level agreement across various related LMSs.
- Provide better adaptive learning.
- Provide a learner-centric single portal for learners, which will be able to incorporate all the learning materials needed by the user.
- Facilitate life-long learning, where a learner will need to access multiple LMSs during his/her learning journey.

However, a disadvantage of SOA is that it doesn't deal with the service deployment and leaves it in the hands of each service provider which can lead to failure of the application. To address this issue, e-learning developers turn their attention to Cloud computing, which is a more flexible delivery model and also complements the service orientation of the SOA paradigm. This lead to the appearance o the Cloud Computing Architecture for an e-learning system. Among the advantages of such kind of architecture we can find (A Cloud Computing Architecture for E-learning, 2013): raw computing power and increased storage capacity, continuous availability, higher security for the e-learning tools, it increases the efficiency of traditional e-learning platforms. A cloud computing architecture for an e-learning system can be seen in the figure below.

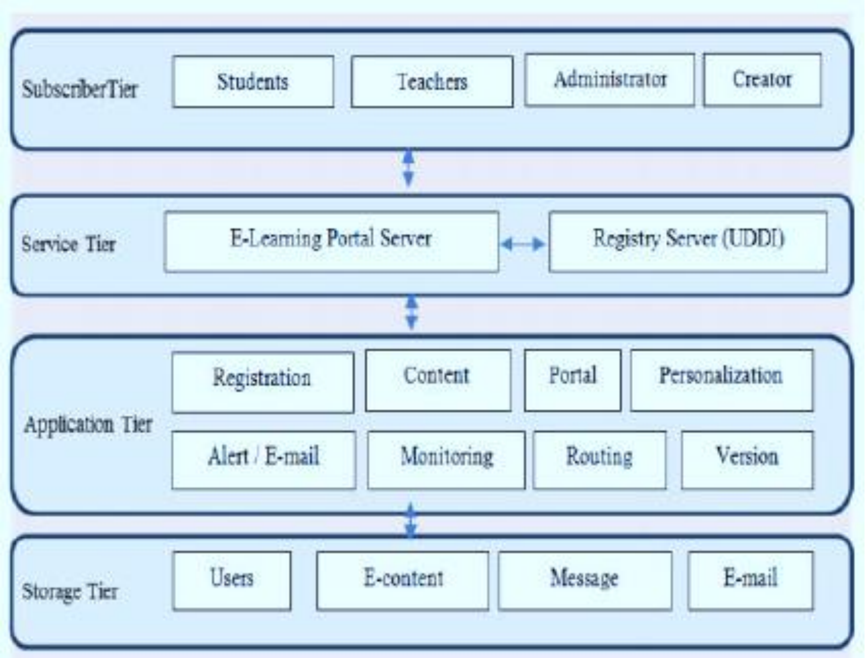


Figure 6. Cloud Computing architecture for an e-learning system (Palanivel & Kuppuswami, 2014)

This architecture contains four layers. The first one, the storage layer, is used, as its name says, to store all the data regarding users, courses, messages, and other data needed for the educational process. On the second layer, we find the application itself, with all the features available for different categories of users. The service layer is the one that comes with the help of the deployment process. The subscriber tier is represented by the end-user of the e-learning system, such as students, teachers, administrators of the tools, and creators of the application.

If we move forward, taking all the benefits from the two architectures presented previously, we encounter the Service-Oriented Cloud Computing Architecture (SOCCA), a theoretical architecture proposed by researchers. It also contains four layers represented by (Palanivel & Kuppuswami, 2014):

- *Cloud provider layer*: this is the layer at which each cloud provider has its hardware and software.
- *Cloud ontology mapping layer*: this layer wants to mask the differences between separate clouds by helping with the data transfer from one cloud to another.
- *Cloud broker layer*: the layer which deals with information such as pricing, hardware, software, and services provided for each cloud provider.

- *Application layer*: the specific application that integrates specific teaching resources in the cloud computing model, including courses and shared resources.

When it comes to the used programming languages behind e-learning tools, on the backend side the most common are PHP, C#. For the frontend side it is used HTML with CSS, and JavaScript and for the storage of the data MySQL, Oracle, usually a relational database (Bhuiyan, Yousuf, Urmi, & Nahar, 2013).

1.4. *Features, advantages, and disadvantages of an e-learning system*

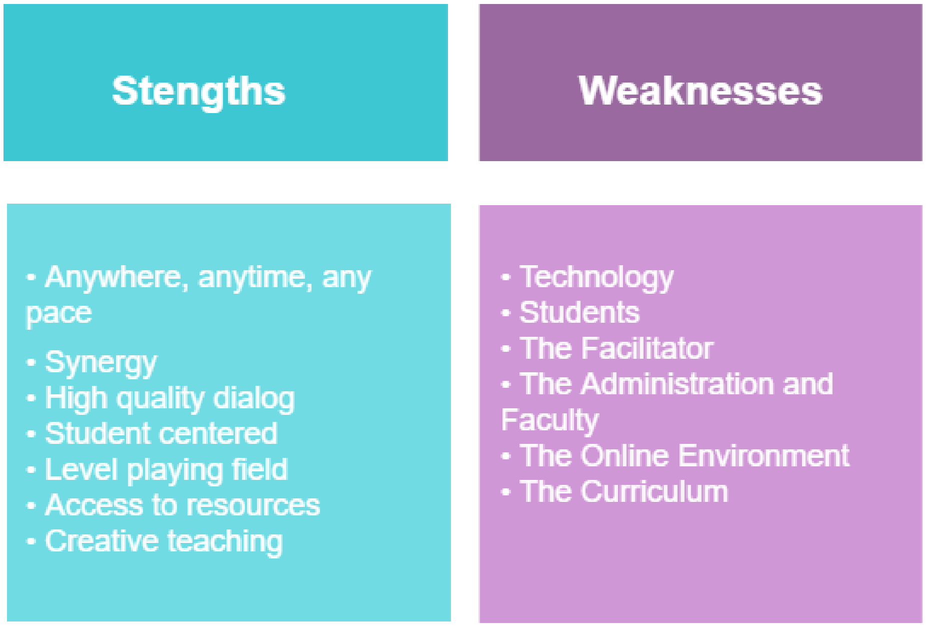
When it comes to the features that an e-learning platform should provide, there is a large variety of elements that could be provided. In general terms, an e-learning platform should address *connectivity*, allowing students to communicate and connect with instructors over a large distance. Also, *flexibility* becomes an important ally, more and more students want to access the platform when they want and not by a specific schedule. The learning platform should encourage *interactivity* and *collaboration* between the users, either students or teachers, and a *Virtual Learning Environment* (VLE) will be helpful to find easier the needed resources (Bhatia, 2011).

Since user satisfaction and collaboration is an important success factor, we will also revise the main factors which help in a successful conversation and collaboration when using e-learning platforms. The most important ones include (Roche, 2020):

- *Online admission/Signing up for a course.*
- *Reporting and Data Analysis.*
- *Assessment Management and Live Feedback.*
- *Student Information Management.*
- *Quality Content.*
- *Quick User Integration.*
- *Easy Payment Methods.*
- *Motivational Triggers.*
- *Going Mobile.*
- *Online Communities and Social Engagement.*

Besides the features mentioned before, which help with the students' integration and far better-improved collaboration between users, some extra features could be taken into account. A live chat is a nice option for when students have unclear things and want to ask their questions. Also, if they have to fill any forms, the number of fields should be minimum. The application could provide a way to gather reviews from previous or current users, in this way the credibility in that specific system will increase.

Like any other system, e-learning tools have both advantages and disadvantages, as shown in the figure below.



Stengths

- Anywhere, anytime, any pace
- Synergy
- High quality dialog
- Student centered
- Level playing field
- Access to resources
- Creative teaching

Weaknesses

- Technology
- Students
- The Facilitator
- The Administration and Faculty
- The Online Environment
- The Curriculum

Figure 7. E-learning systems Advantages & Disadvantages (University of Illinois, 2020)

The most important advantage of an e-learning tool is its accessibility, anyone being able to use it from anywhere and at any time. Also, it facilitates the interaction between learners, and the sharing of new resources and information is done more easily. The high-quality dialog is encouraged with the use of comments and the whole platform is student-centered, so each student would obtain the most advantages from the learning session. The anonymity users receive in the online environment is greater, so the learners are not discriminated against based on age, race, or other criteria and they can focus on the most important goal, the learning process. Likewise, access to any kind of resources comes in the help of students alongside the new creative methods teachers can use.

The disadvantages from the figure above are structured in six main classes, but we will analyze each other separately. Among the weaknesses of e-learning platforms, the most important one is related to technology. Not any student has access to technology or at least not equally. Furthermore, if the students cannot afford the technology proposed by the university, they are lost as customers. Also, all the users may possess a minimum level of computer knowledge to obtain some visible results from the e-learning process. Besides these, there could appear also some other limitations of technology such as server unavailability, internet connection failure. Also, while e-learning can be a very efficient way of studying for mature, self-disciplined students, it can be inappropriate for dependent learners. If we go to the other side of the learning process, not all teachers who are very successful on-ground instructors will become as successful in the online environment. In addition, the administration of the institution can interfere with the adoption of the platform by thinking that it won't offer quality education. Even if most of the subjects can be taught online, the ones that require hands-on experience are very difficult to be assimilated in this way. Furthermore, the curriculum of the institution must be modified accordingly to the online learning process as well, for the learning process to be successful.

Although there are a lot of e-learning tools available all around the world, the global e-learning market is still growing, as we can see in the figure below (Figure 8). A massive growth can be seen in the sector of online e-learning and mobile e-learning.

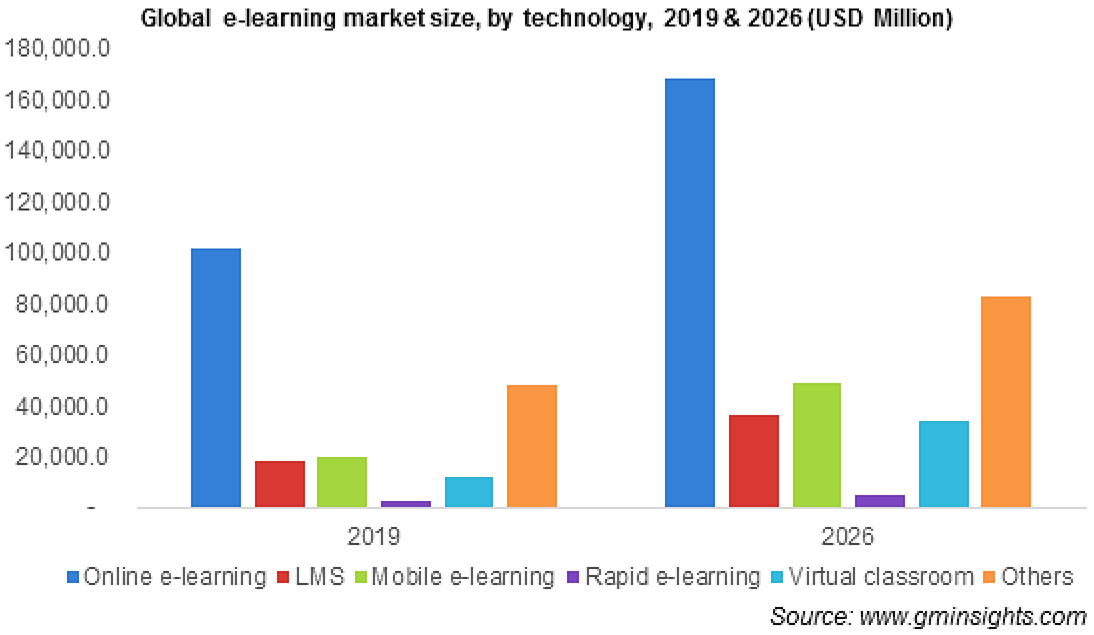


Figure 8. Global e-learning market growth by technology (2019 - 2026) (Wadhwani & Gankar, 2020)

With all the features offered by the e-learning tools, we might think that this is all that it can be offered, but there are some elements that are not used to their full potential. One of them is live feedback, which can be covered by implementing a live chat in the application or by allowing comments for each part of the students' assessment. Another thing is represented by the online visualization of the loaded documents, projects, or courses. This feature could be improved by adding a comments section to allow easier communication between learners. These two things will provide a starting point for the application I want to develop and present in the following pages.

Chapter 2. General architecture and technologies of the e-learning application

Chapter 2 will contain an overview of the main used technologies in order to build the e-learning application. Also, we will have some diagrams with the architecture for the application as a whole, and some specific ones, for the backend and frontend side. There will be presented other UML diagrams as well, such as use case, class, or sequence diagrams.

2.1. Technologies used in the development phase

The developed application will be a web application developed with Spring Boot, Angular, and MySQL. In this process, the used tools will be IntelliJ, Visual Studio Code, and MySQL Workbench.

For the backend side, we used Spring Boot, an open-source, microservice-based Java web framework because it creates a production-ready environment that is easily configurable (Bos, 2020). This framework is suitable for web development, having a spring-boot-starter-web module that helps with the quick start and run of the application. The main advantages offered by Spring Boot are (Priya , 2020):

- ✓ it offers an effortless way to create a spring-based application using Java.
- ✓ minimizes the time spent in developing the applications and increases productivity.
- ✓ helps in reducing manual work of writing annotations.
- ✓ has boilerplates and XML configurations.
- ✓ developers can easily test the applications by using the embedded HTTP servers such as Jetty or Tomcat.

From the frontend perspective, the chosen framework is Angular, an application design framework used to build sophisticated single-page applications (Angular, 2020). This development platform was built on Typescript, which is a superset of JavaScript, and consists of (Angular, 2020):

- ✓ a component-based framework for building scalable web applications.
- ✓ a collection of well-integrated libraries that cover a wide variety of features, including routing, forms, and client-server communication.
- ✓ a suite of developer tools meant to help with the developing, building, testing, and updating the code.

Another reason for choosing Angular over other frameworks for the frontend application is that the platform was developed by Google and comes with significant releases every year. Also, the community of developers that use it is pretty significant and it will be easier to find answers to any questions. If we look at the features offered by Angular, there are enough advantages that place the framework in a winner position for our application, such as (Franciszek , 2020):

- The functionality out of the box it offers, such as taking care of the routing or the environment pre-configuration.
- The use of Typescript, a strongly typed language that helps with keeping the code clean and easy to understand by other developers. Also, it makes it easy to debug and maintain larger applications.
- In comparison with React, Angular is a fully-fledged responsive web design framework that considers consistency a key feature. Because of this, there is one suggested way to create a component, service, or module.
- Angular offers support for code maintainability in several ways. The first one is related to the automatic update of the packages when moving up from one major version to another. Then, the update of the other packages can be done by using one command: ng update. And the last one is that the components can be easily decoupled and replaced with improved implementations.
- The modular nature of Angular allows developers to divide code into modules which helps with the easy organization of the application functionality and the creation of reusable chunks of code.
- In help of making the development process even quicker comes Angular Material, a collection of ready-to-use UI components that follow Google's Material Design principles.

For data storage, the used technology is MySQL, a relational database management system based on SQL. The main reason why it was used is that it increases the performance of the application. It is also fast and more secure than other databases.

2.2. Application architecture and layers

The interaction between the client, web or mobile browser, the Angular application, the Spring Boot side, and the database can be seen in the figure below. The client will interact with the Angular application through a browser. Each request made by the client will be fulfilled by calling a REST API build with Spring Boot. Each API will return the requested information and the connection with the persistence layer is done on the backend side.

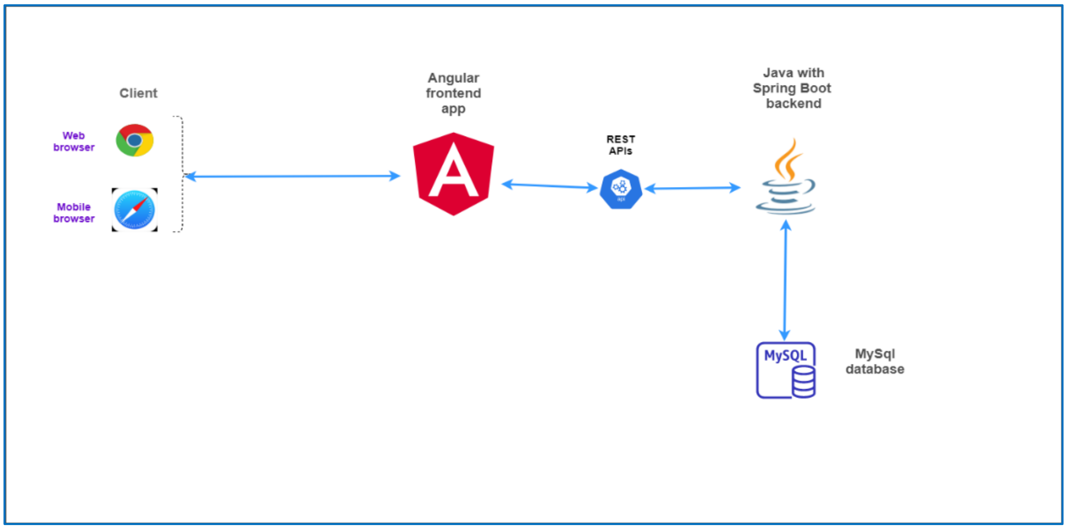


Figure 9. General architecture

The general architecture of the application is presented as a multi-tier architecture, a software architecture in which different software components are organized in tiers (layers) and provide dedicated functionality (Heiko, 2009). The most common occurrence of multi-tier architecture is a three-tier architecture that consists of a presentation tier, an application tier, and a data tier. The ***presentation tier*** is the frontend side of the application, the Angular application, in our case, that containing templates, components, and services. The presentation tier displays the data it retrieves using the HTTP Client service. The ***application tier*** represents the middleware of the application or the backend side. In our specific case, it is the Spring Boot application that connects the presentation and data layers through the REST Controller and the classes from the dao package. The ***data tier*** contains the database or storage system, MySQL database for this specific case. All the tiers and the communication between them are presented in the figure below.

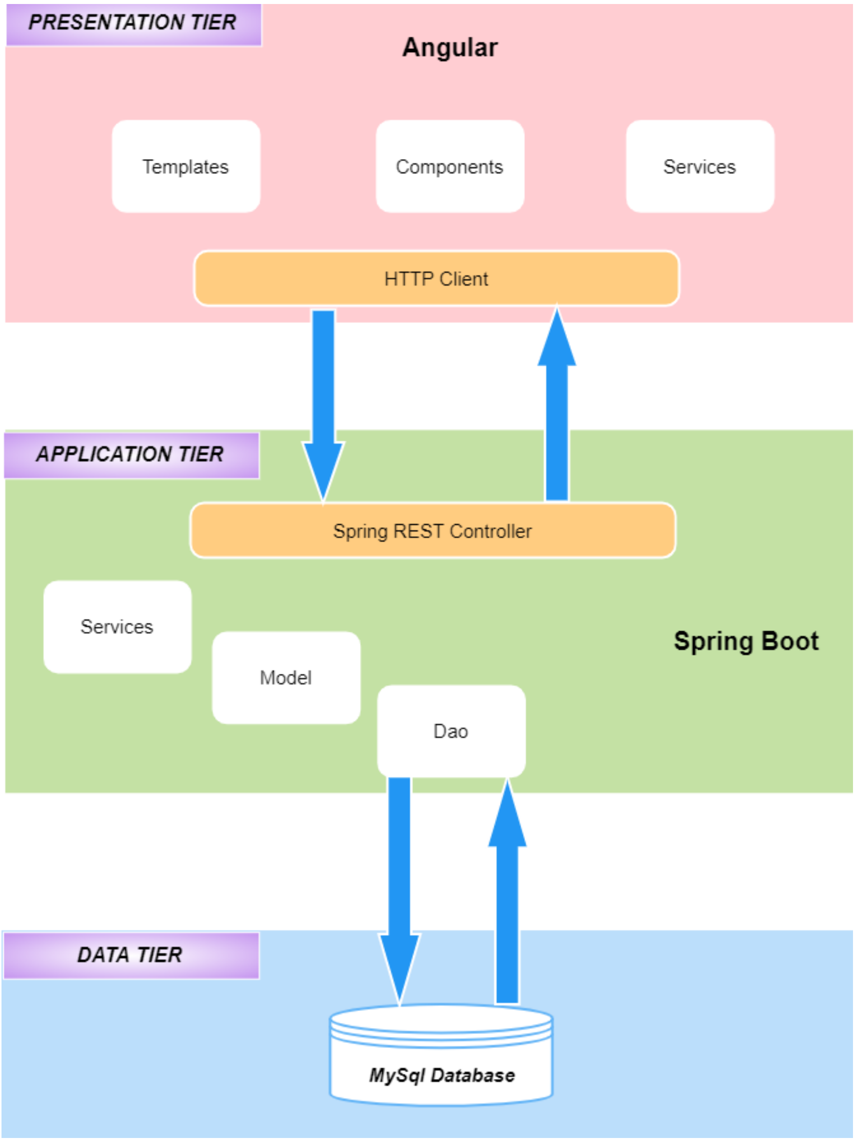


Figure 10. Three-tier architecture of the e-learning application

The application is created as a Single-Page Application (SPA) that works inside a browser and does not require a page reload during its use. This approach was used because SPA is quite fast, resources being loaded only once, through the lifespan of the application, the development and debugging are straightforward and much easier, and the application can work even offline because it can retrieve the data with one request and the keep it in the local storage (Neoteric, 2016). Regarding the layers of our application, they follow the general architecture of SPA applications and will be presented in the figure below.

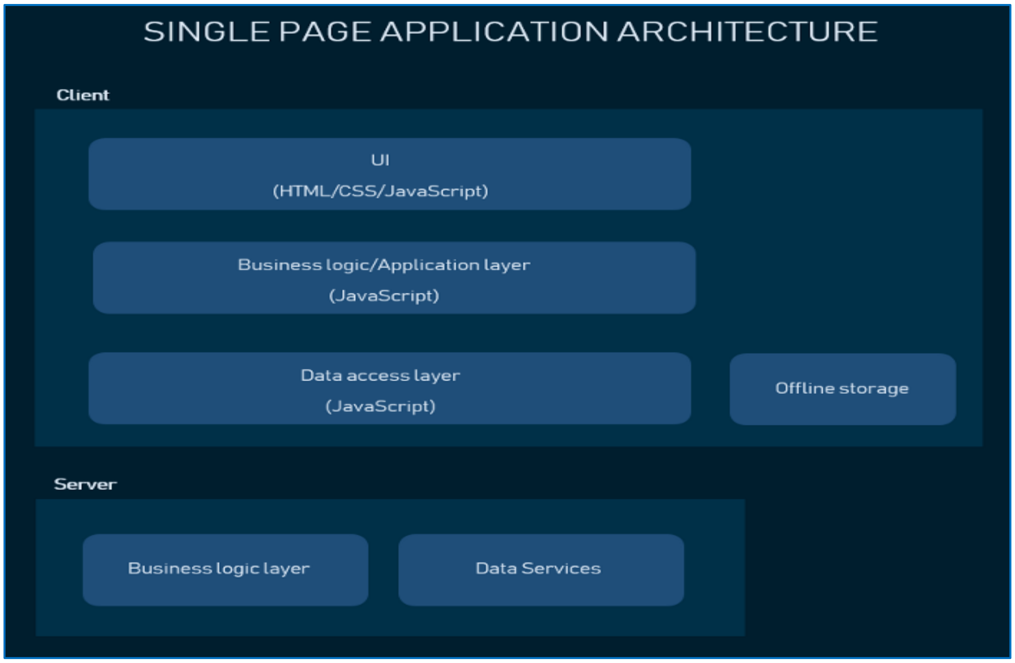


Figure 11. General architecture layers (AltexSoft Inc., 2019)

As we can observe in the diagram above, the application logic has been moved to the client-side and the server is used only for data storage purposes. The frontend of the application, excepting the static HTML and CSS, was developed using a single framework, Angular in our case. Angular will dynamically generate content and display it to the user. Any changes made to one of the UI elements spread through the whole component. Since the logic is moved to the client-side, we will use client-side scripting technologies. Basically, we will build templates using JavaScript or TypeScript, a superset of the JavaScript language, so that when a user requests specific information, the server will transmit this data to the browser, and it will be rendered accordingly to the built template.

When it comes to the backend side of the application, it communicates to the client through the built APIs. In this case, we will have an ***API layer*** that will handle get, post, put, patch, or delete requests from the client. This layer will communicate with the ***service layer***, that is in charge of handling the existing business login. Besides this, a ***data access layer*** is needed in order to connect to the database and retrieve data from there. The architecture for the backend side is shown in Figure 12.

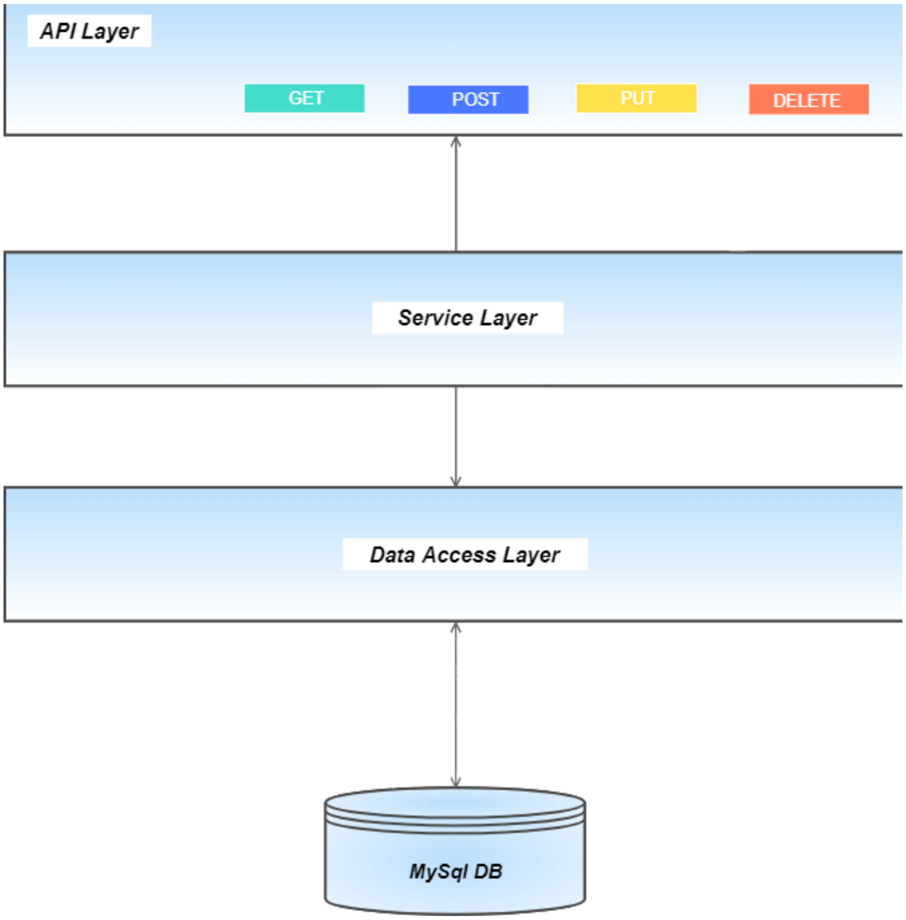
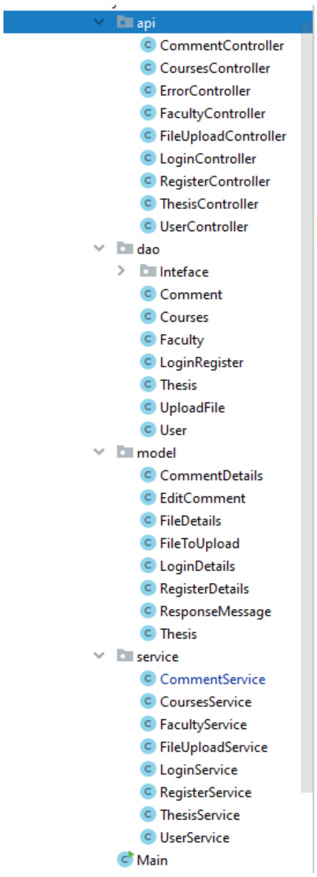


Figure 12. Backend architecture

Accordingly, the structure for the backend project is as follows. We will have an ***api package*** where we will store all the built APIs, having a controller for each of them. Here we will define all the routes from where the APIs will be accessed by the frontend application. Each controller will map the request body to the specific model from the ***model package.*** An API will directly communicate with its service stored in the ***service package***. The service is in charge of all the needed business logic for the specific call and it will use a repository from the ***dao package*** to accomplish the functionality. The repository contains a singleton connection to the database and will process all the steps from executing the query to returning the data. We can see the explained package structure in Figure 13.



```
api
    CommentController
    CoursesController
    ErrorController
    FacultyController
    FileUploadController
    LoginController
    RegisterController
    ThesisController
    UserController
dao
    Inteface
    Comment
    Courses
    Faculty
    LoginRegister
    Thesis
    UploadFile
    User
model
    CommentDetails
    EditComment
    FileDetails
    FileToUpload
    LoginDetails
    RegisterDetails
    ResponseMessage
    Thesis
service
    CommentService
    CoursesService
    FacultyService
    FileUploadService
    LoginService
    RegisterService
    ThesisService
    UserService
Main
```

Figure 13. Backend package structure

Regarding the frontend application, the architecture chosen for the Angular project contains three tiers (Figure 14). The first one is related to the ***services*** existing in the application. Here we will find all the business logic in the application and because of dependency injection, services can be reused in any component they are needed. The second layer is represented by ***container components,*** smart components that contain other presentation or "dumb" components. These components will pass data down to presentation components, data in form of Input or Output. The last layer is represented by the ***presentation components***, components used just to display information.

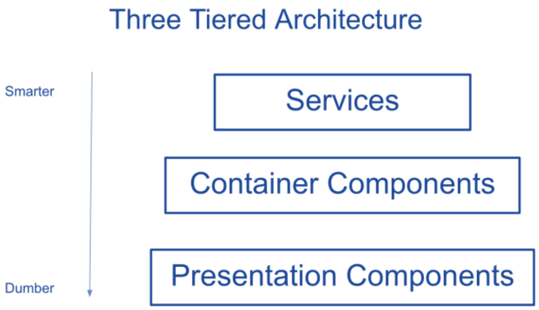
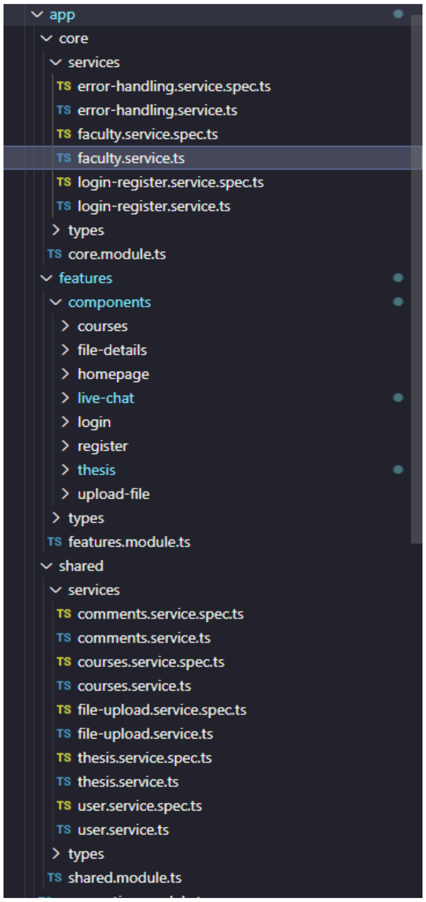


Figure 14. Frontend architecture (Cavezza, 2019)

In the built application the components, either container or presentation ones, will be placed in the ***features module***. The services will be distributed in two separated modules, depending on when they are rendered in the application. The services needed at the beginning of the application will be placed in the ***core module*** and the ones used by the components through the other phases of the application are found in the ***shared module***. There will also be defined models for the data that comes from each API and it will be placed in the types folder from each module. The described structure for the modules can be seen in the figure below.



```
v app
  v core
    v services
      TS error-handling.service.spec.ts
      TS error-handling.service.ts
      TS faculty.service.spec.ts
      TS faculty.service.ts
      TS login-register.service.spec.ts
      TS login-register.service.ts
    > types
    TS core.module.ts
  v features
    v components
      > courses
      > file-details
      > homepage
      > live-chat
      > login
      > register
      > thesis
      > upload-file
    > types
    TS features.module.ts
  v shared
    v services
      TS comments.service.spec.ts
      TS comments.service.ts
      TS courses.service.spec.ts
      TS courses.service.ts
      TS file-upload.service.spec.ts
      TS file-upload.service.ts
      TS thesis.service.spec.ts
      TS thesis.service.ts
      TS user.service.spec.ts
      TS user.service.ts
    > types
    TS shared.module.ts
```

Figure 15. Frontend module structure

2.3. UML Diagrams

In order to exemplify the way in which the backend packages interact with each other, we have created a class diagram for a course. The diagram is similar to the other classes in the application, but we will attach just one example. Below we will see that the CoursesController interacts with the CoursesService. The service is created based on the CoursesInterface which will be implemented by the Courses class from the dao package.

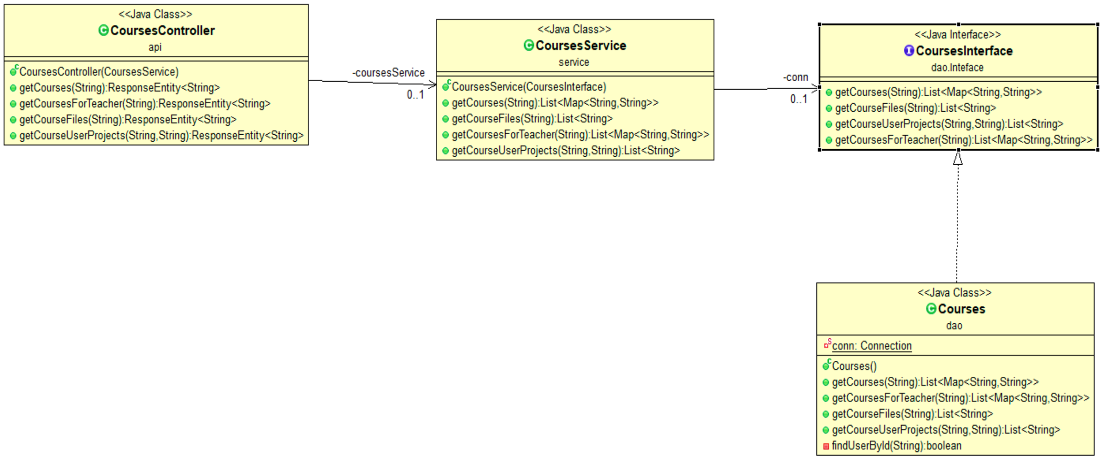

<<Java Class>>
CoursesController
api
CoursesController(CoursesService)
getCourses(String):ResponseEntity<String>
getCoursesForTeacher(String):ResponseEntity<String>
getCourseFiles(String):ResponseEntity<String>
getCourseUserProjects(String,String):ResponseEntity<String>
-coursesService
0..1
<<Java Class>>
CoursesService
service
CoursesService(CoursesInterface)
getCourses(String):List<Map<String,String>>
getCourseFiles(String):List<String>
getCoursesForTeacher(String):List<Map<String,String>>
getCourseUserProjects(String,String):List<String>
-conn
0..1
<<Java Interface>>
CoursesInterface
dao.Inteface
getCourses(String):List<Map<String,String>>
getCourseFiles(String):List<String>
getCourseUserProjects(String,String):List<String>
getCoursesForTeacher(String):List<Map<String,String>>
<<Java Class>>
Courses
dao
conn: Connection
Courses()
getCourses(String):List<Map<String,String>>
getCoursesForTeacher(String):List<Map<String,String>>
getCourseFiles(String):List<String>
getCourseUserProjects(String,String):List<String>
findUserById(String):boolean

Figure 16. Class diagram for courses

For the persistence layer, we already mentioned that we will use a MySQL database. The corresponding diagram for the application is presented in Figure 17.

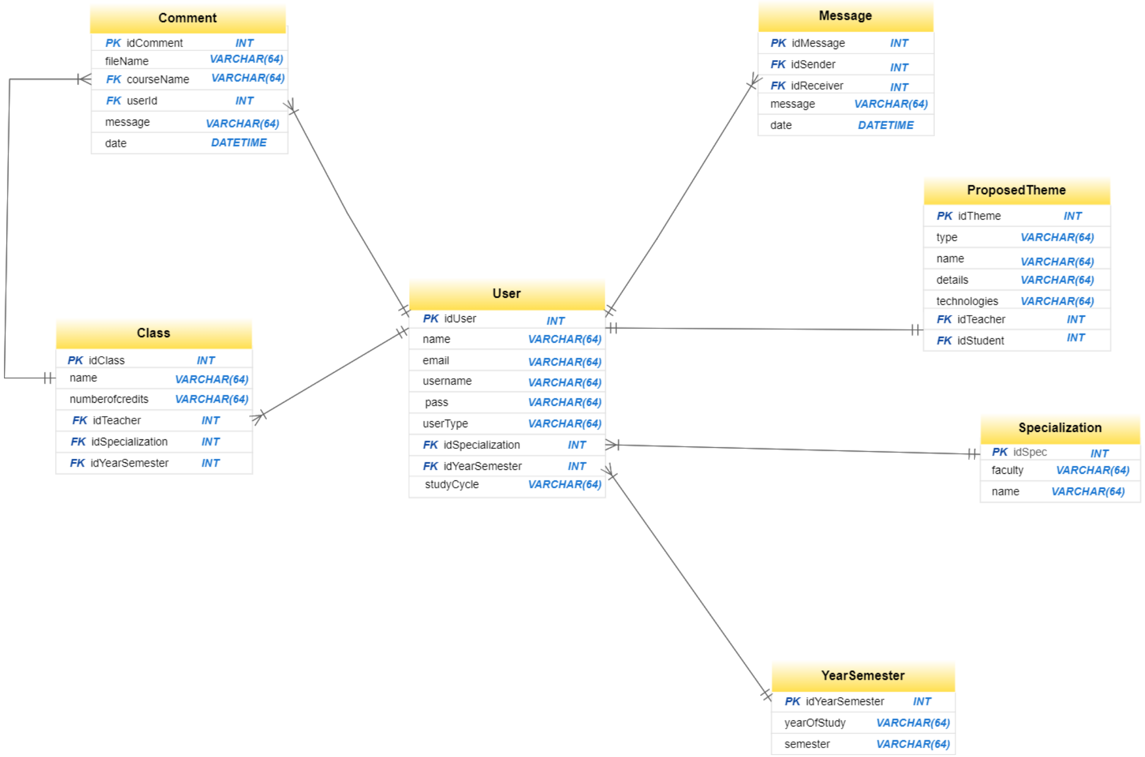


Figure 17. Entity Relationship diagram

The users that will use the applications can be separated into two types of users, students, and teachers. Furthermore, we can observe the use case diagrams for each of them. They have similar actions they can do, but some of the actions are specific for each category. From the common actions we have the login, register, logout, see courses, add comments, or send message action. The specific actions for a student are to upload a project or to choose a thesis theme. In contrast to a student, a teacher will have access to the upload resource for a course option or visualize assigned students for thesis one. The two diagrams are shown in the figures below.

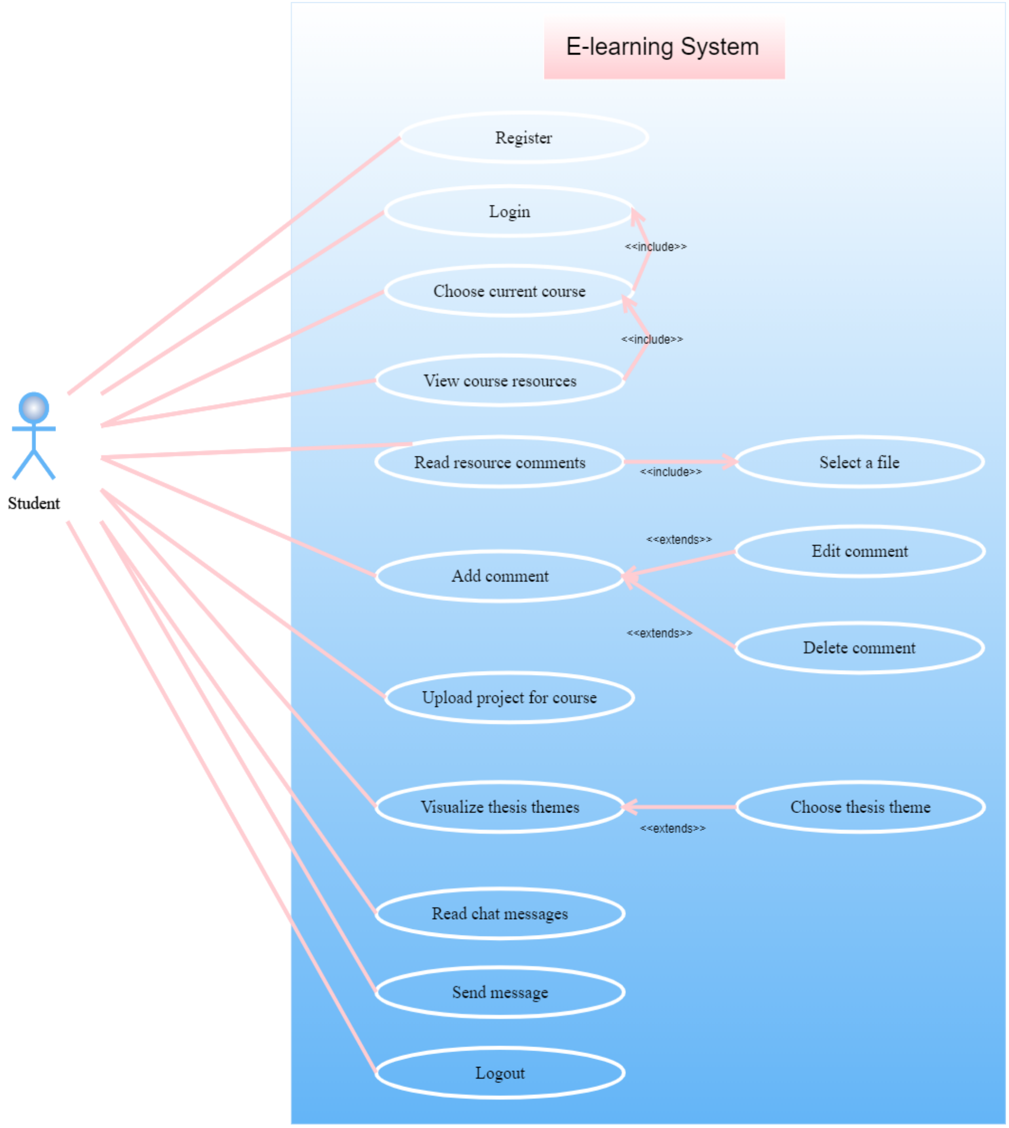


Figure 18. Use case diagram for Student

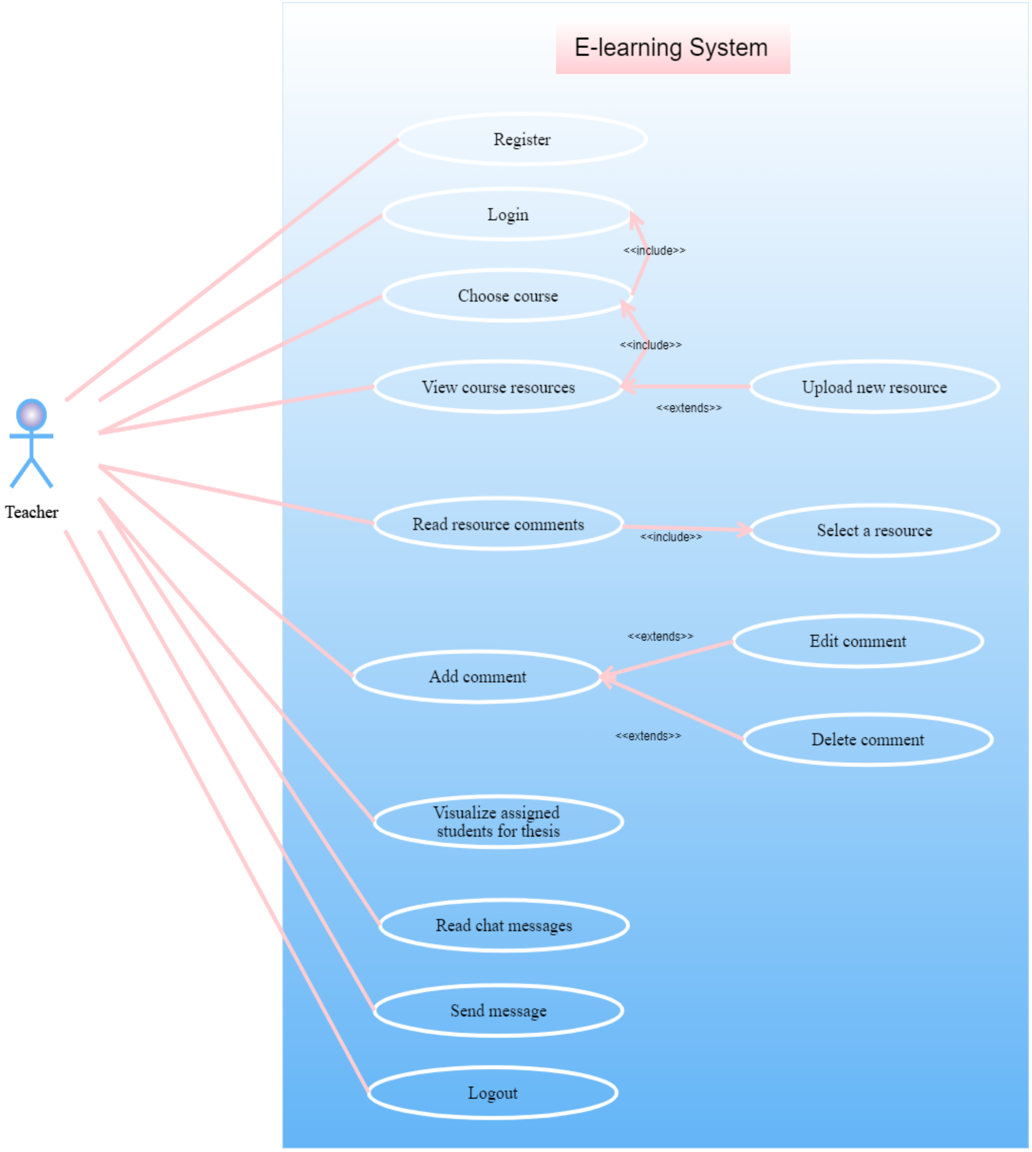


Figure 19. Use case diagram for Teacher

After the login process, the users of the e-learning application have available various activities as shown in the activity diagram below.

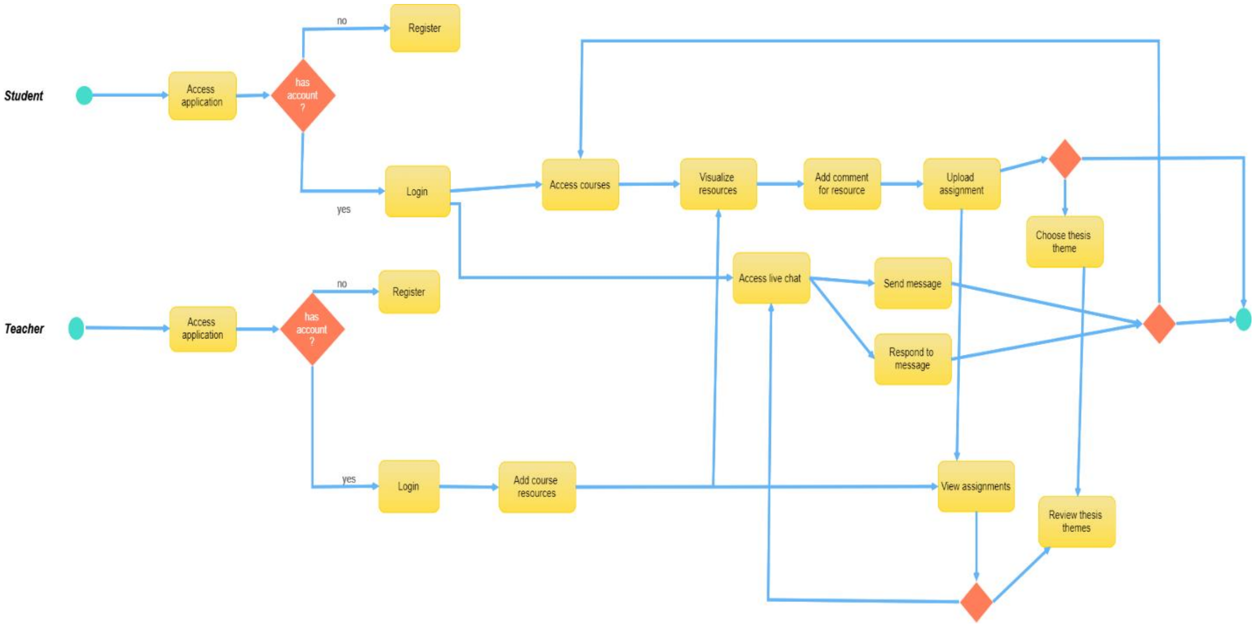


Figure 20. Activity diagram

The sequence diagram shows us the interaction between the application and the two types of users, student, and teacher. A student can upload a project, write comments on course resources, or send messages to the coordinator. In contrast to this, a teacher can visualize the added projects for each course, respond to added comments or review the chosen themes.

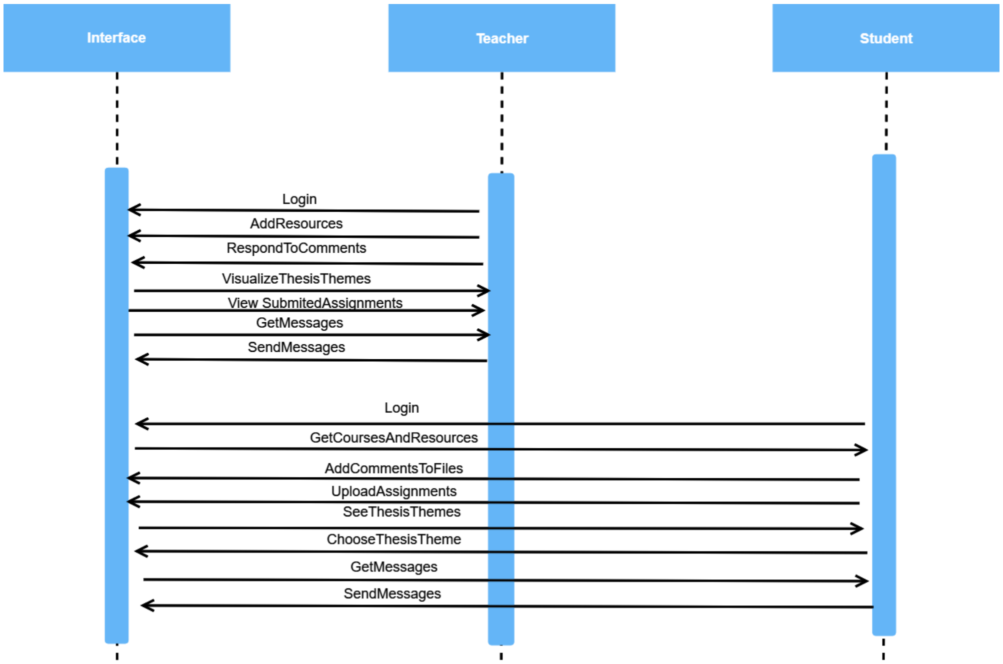


Figure 21. Sequence diagram

Chapter 3. A model of e-learning web application

This chapter will present the main functionalities of the proposed model for the e-learning application. Also, there will be included examples with possible use cases from the interface of the application. Since for now, we have just two types of users, teacher or student, we will divide the functionalities based on this and we will exemplify the common and specific ones. In the end, there will be explained some of the most relevant code sequences.

3.1. The main functionalities of the application

As we mentioned several times before, in our application we have two types of users, teachers, and students. For each of them, we will have some specific functionalities. Still, some of them will be shared between the two types of users.

Firstly, we will start to present the features that are common between teachers and students. These features are:

- Ability to log in and register into the application.
- Ability to see the available courses.
- Visualize the added resources for a course.
- Preview each resource file.
- Add comments for a file and visualize the comments added by other users.
- Edit or delete the comment added.
- Search for users to start chatting with.
- Access the live chat and communicate with the other users.

Furthermore, a user of type student has some more specific functionalities, as follows:

- Upload project for a specific course.
- Visualize a list with all available thesis themes.
- Choose a theme for the final thesis.

If the user is a teacher, the following functionalities will also be available:

- Upload resources for a specific course.
- View all the submitted assignments for a course.
- Visualize all the assigned students for the final thesis.

3.2. The interface of the proposed application

When it comes to developing a web application, an important step is to choose the color scheme. For this e-learning application, we will use a triadic color scheme, obtained by drawing a triangle on the color wheel and choosing the three colors from the points of the triangle (O'Grandy, 2020). By using this approach, we ensure a diverse, yet balanced scheme which contains warm colors as well as cool ones. The used colors are shown in the scheme below.

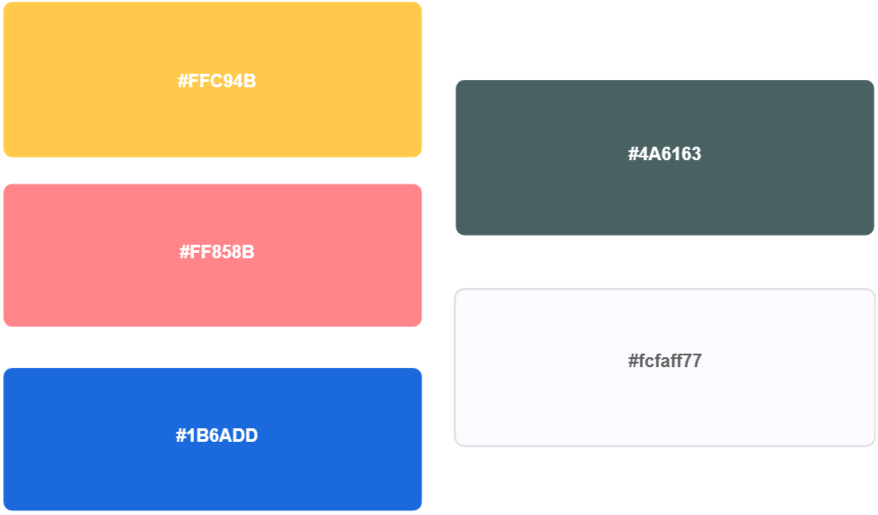
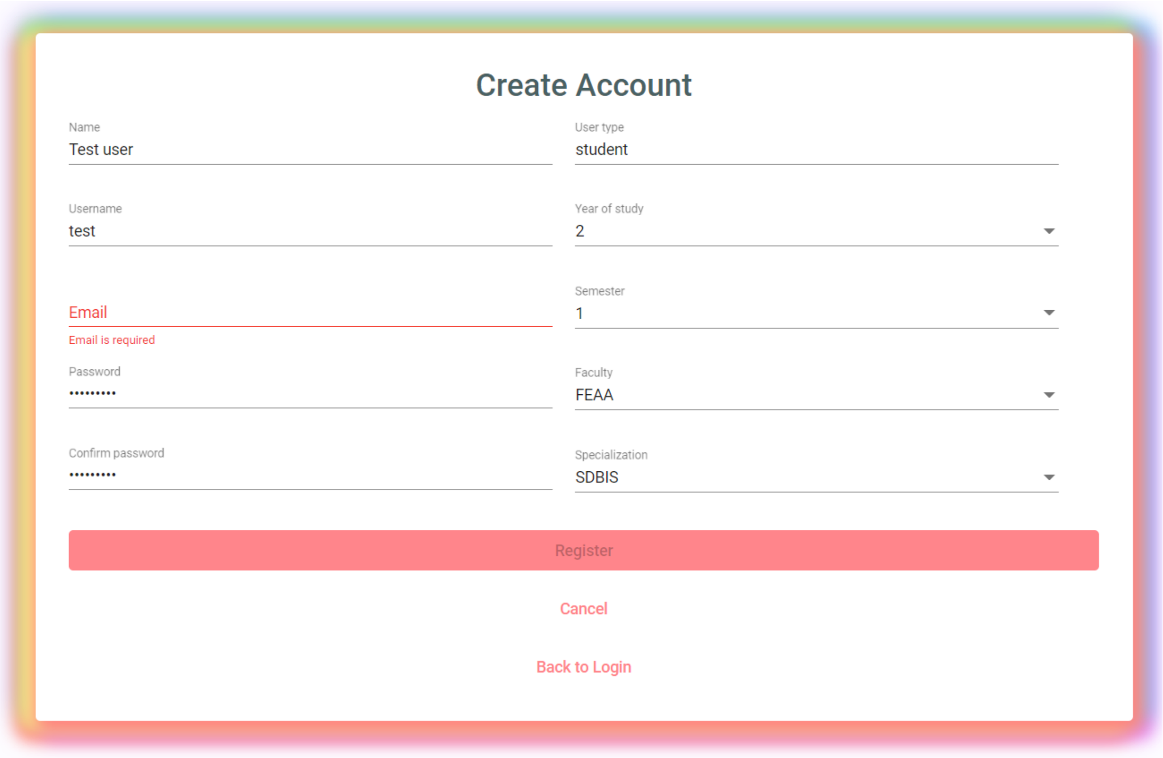


Figure 22. Application color scheme

When a user first opens the application, he will be redirected to the login page. Here, a username and a password are required in order to access the other functionalities of our application. The login button will be disabled if the two fields are not filled and becomes enabled after the user adds its credentials. Also, a success or error popup is shown after the button is pressed, depending on if the login is successful or not.

On the login page we have a register button, in case the user didn't use our application before and doesn't have an account created. When pressing the register button, the user is redirected to the register page. Here, we have a form that needs to be filled in to create a new account. The user has to specify the usual register fields such as name, username, or password, but also if he is a student or teacher. He has to choose the current year of study, as well as the semester, faculty, and specialization. After pressing the register button, if all the filled data is correct, the new user is created and a success popup is displayed, the user being redirected to the login page. If there are any errors on the frontend side, such as required fields being left blank, an inline error is shown, and the register button is disabled. For more specific errors, related to the business logic, a popup error will be shown after pressing the register button. Furthermore, the user can press the cancel button if he changes his mind, and all the fields will be emptied. Also, there is a specific button to go back to the login page. Below, we can visualize the register screen, alongside an inline error for the email field.



Create Account

Name: Test user

User type: student

Username: test

Year of study: 2

Email

Email is required

Semester: 1

Password: •••••••••

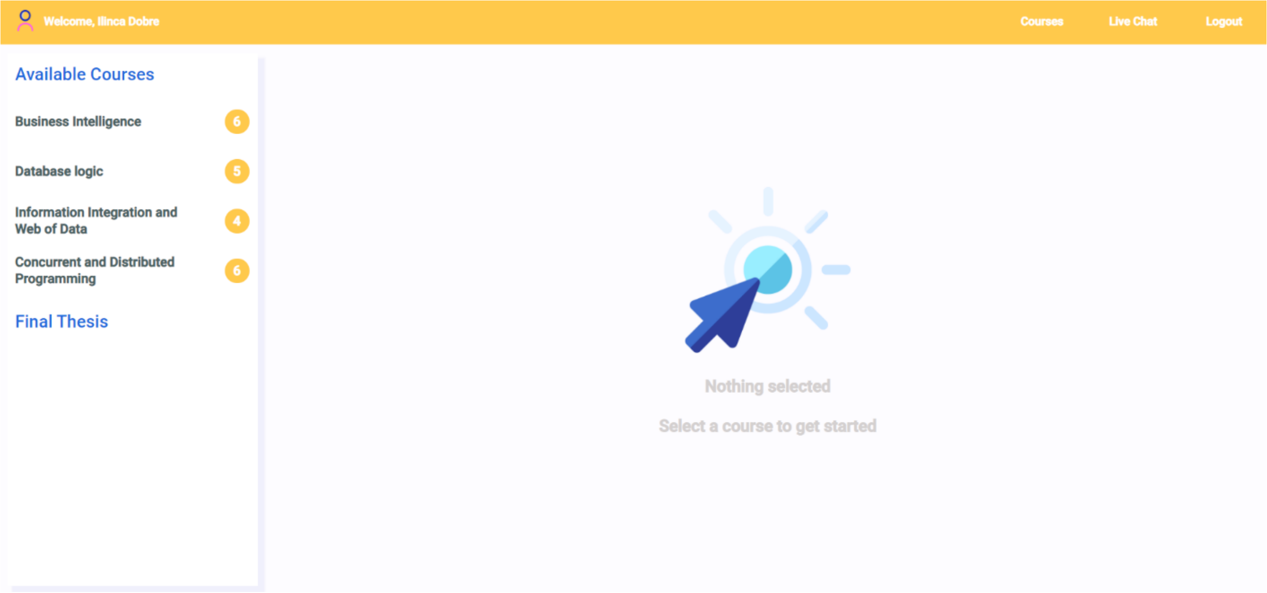
Faculty: FEAA

Confirm password: •••••••••

Specialization: SDBIS

Figure 23. Register screen

After the user creates its account and logs in to the application, the homepage is displayed. Immediately after login, a header will be displayed on the page, containing the name of the user on the left side and a group of other three options on the right side. The options will help the user navigate to the courses page, the live chat one, or log out from the account. Also, a menu will be shown, containing a list of available courses and the option to go to the final thesis page. Firstly, an icon and a message to select a course or the thesis option will be shown so that the user can choose a specific course to see details about or choose a specific thesis theme. The first interaction of the user after login is shown below.

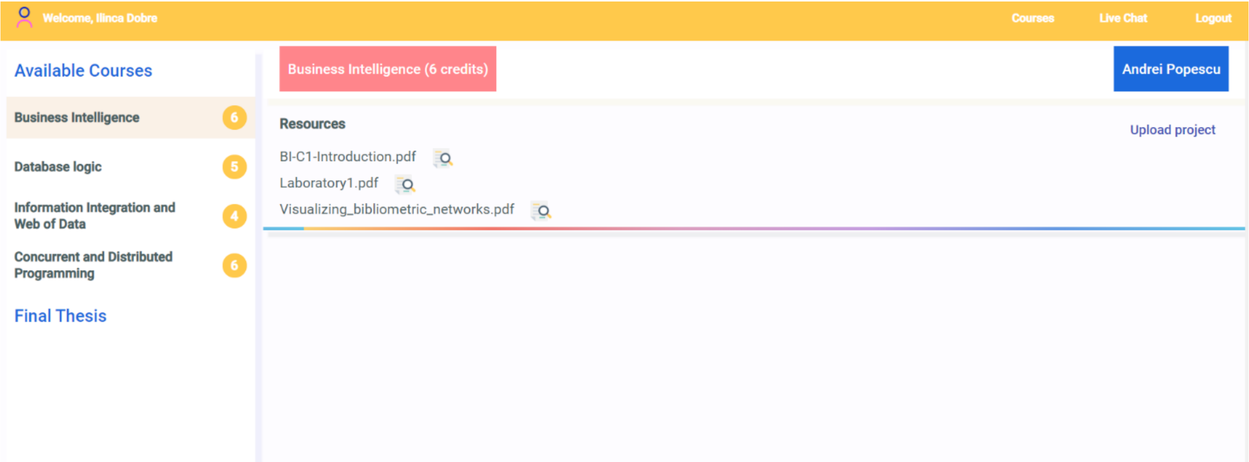


Nothing selected

Select a course to get started

Figure 24. Homepage screen

Either of the user types, student, or teacher, can access the courses that are available on the left menu. They can get specific details about a course by clicking on its name. When we click on a course, we will be redirected to the course page and, at the top of the screen, we will see the course name, the number of credits, and the assigned teacher. Furthermore, we will get a list of resources loaded for that course. On the right side, if the user is a student, a button with the label upload project is displayed. If the user is a teacher, he has two available functionalities, a button to upload new resources for the course and a button to see the uploaded projects. Below, we will see how the course details screen looks like.



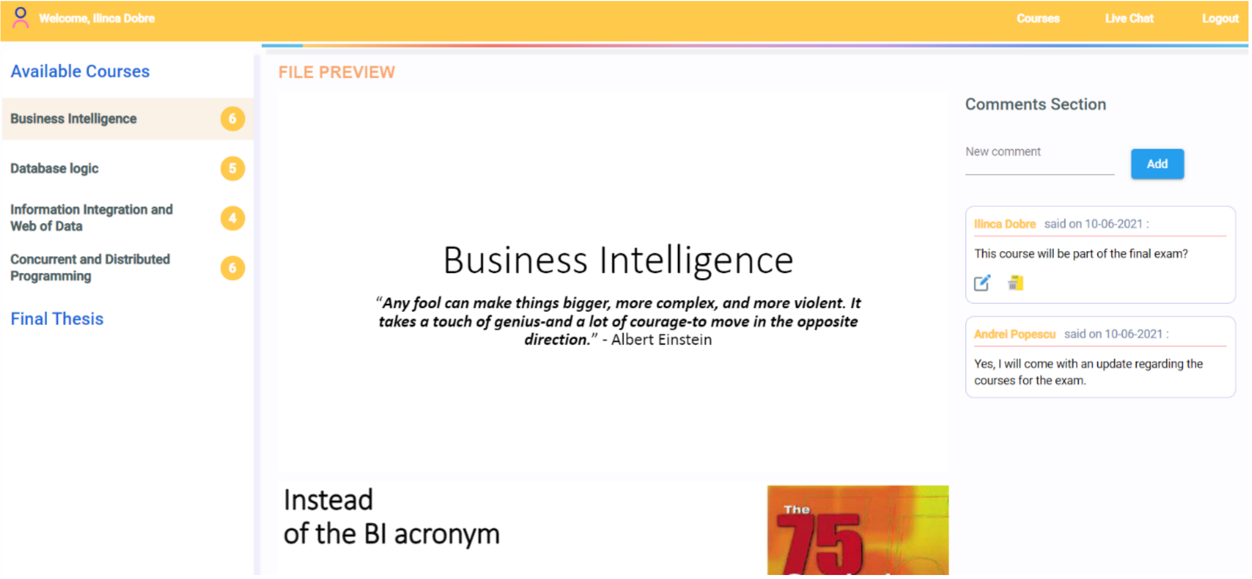
BI-C1-Introduction.pdf

Laboratory1.pdf

Visualizing_bibliometric_networks.pdf

Figure 25. Course details screen

Each file from the resources section has an icon that, when pressed, will open a pdf preview of the document. This will be done using the ng2-pdf-viewer library which will receive the file in the blob format from the Spring Boot application and will display it in the frontend. Also, a comments section is available, in case there are any questions. Each user can add comments for the files from the resources. All the previous comments will appear when the file is first accessed. The user can read the other comments, ask other questions, or respond to them. In the comments list, if the comment belongs to the current user, he will have two more options available. One of them is the edit in place options, when clicking on the edit icon, and the other one is to delete the comment. The file details and comments sections can be seen in the figure below.



Business Intelligence

"Any fool can make things bigger, more complex, and more violent. It takes a touch of genius-and a lot of courage-to move in the opposite direction." - Albert Einstein

Instead
of the BI acronym

Ilinca Dobre said on 10-06-2021 :
This course will be part of the final exam?

Andrei Popescu said on 10-06-2021 :
Yes, I will come with an update regarding the courses for the exam.

Figure 26. File details and comments section

Now, if the user is a student, he can upload a project for the selected course by clicking the upload project button. He will be redirected to the upload file where he can choose the file to be uploaded. The files should be in pdf format in order to be uploaded successfully. This functionality is similar for the teachers, just that they will upload course resources instead of projects.

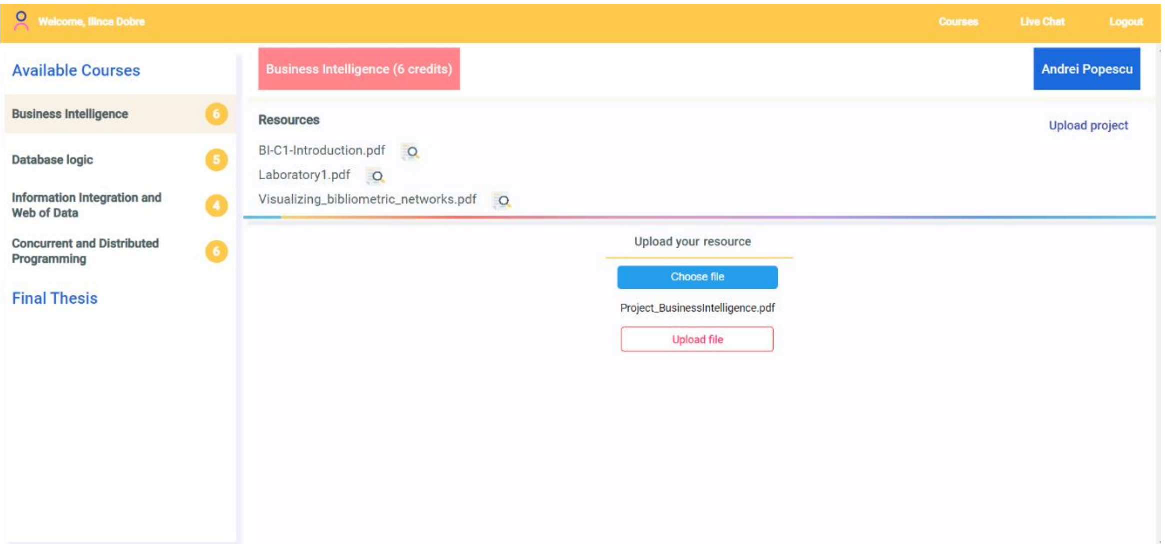
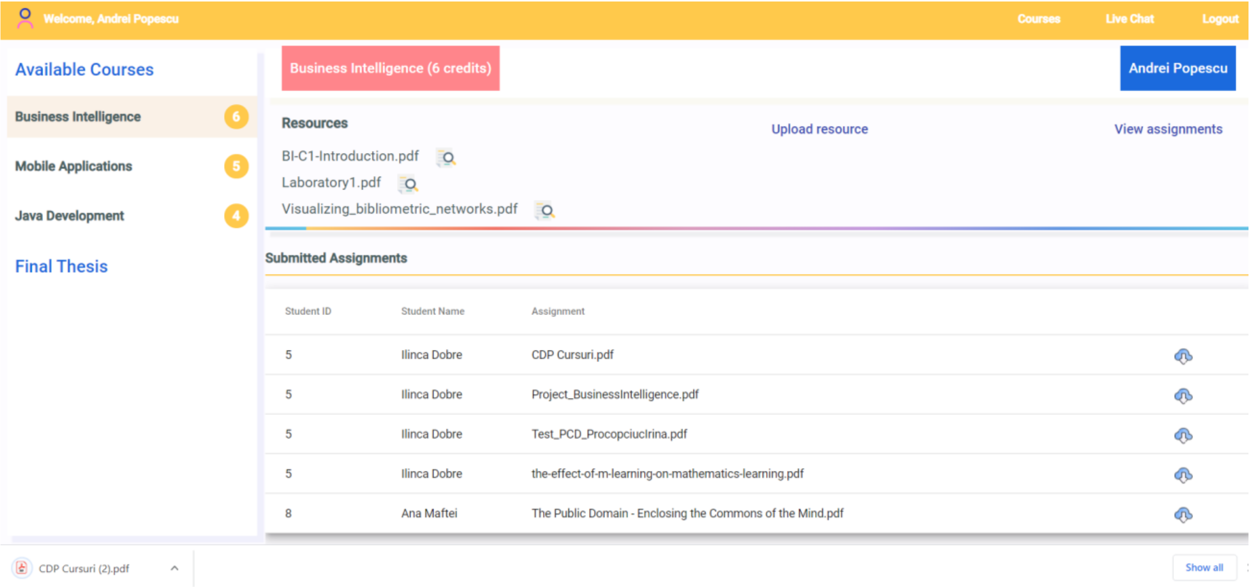


Figure 27. Upload project functionality

Besides the upload functionality, a teacher can also view all the assignments for a course. When clicking on the view assignments button, a table containing all the records for the uploaded projects will be shown. Each row will contain the student id, name, project name, and a column responsible for downloading a specific project. This screen is shown below, with the example of downloading the first file from the table.

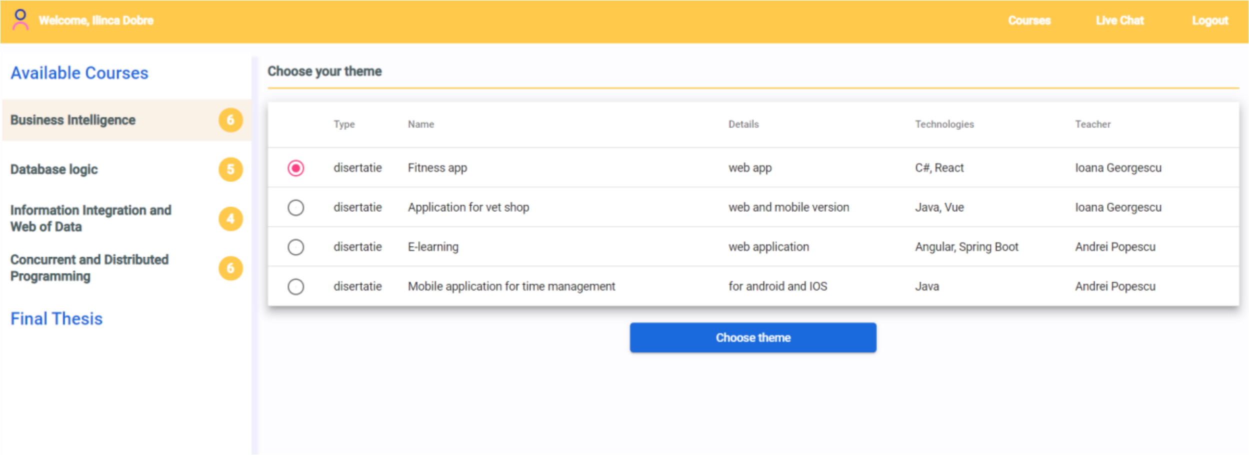


Submitted Assignments

Student ID	Student Name	Assignment
5	Ilinca Dobre	CDP Cursuri.pdf
5	Ilinca Dobre	Project_BusinessIntelligence.pdf
5	Ilinca Dobre	Test_PCD_ProcopciucIrina.pdf
5	Ilinca Dobre	the-effect-of-m-learning-on-mathematics-learning.pdf
8	Ana Maftei	The Public Domain - Enclosing the Commons of the Mind.pdf

Figure 28. View assignments screen

If we move on, the final thesis option from the menu helps us with handling the paper for the study's completion. From the student's point of view, if he didn't choose any theme yet, a table with all the possible options for his specific study cycle will be displayed. The table contains details about each theme, such as the name of the theme, the used technologies, the assigned teacher, or other specific details.

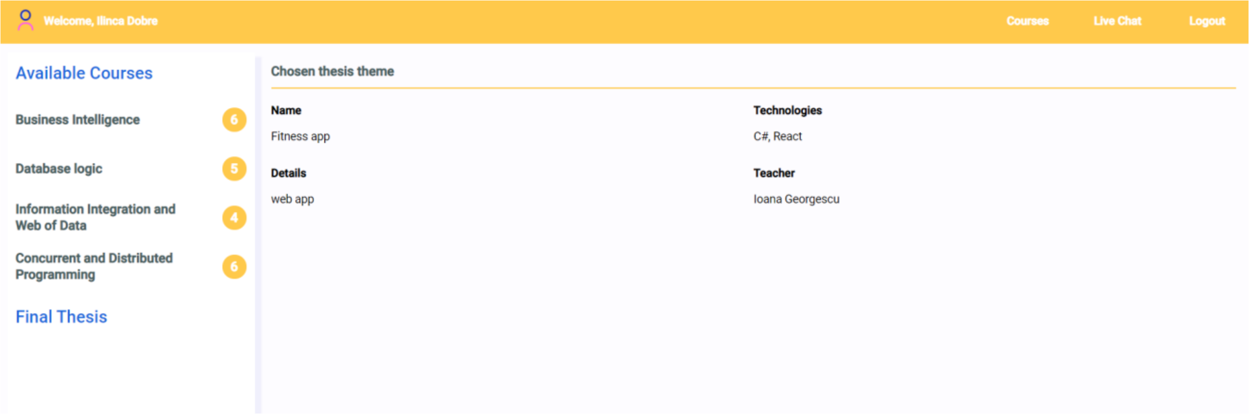


Choose your theme

	Type	Name	Details	Technologies	Teacher
●	disertatie	Fitness app	web app	C#, React	Ioana Georgescu
○	disertatie	Application for vet shop	web and mobile version	Java, Vue	Ioana Georgescu
○	disertatie	E-learning	web application	Angular, Spring Boot	Andrei Popescu
○	disertatie	Mobile application for time management	for android and IOS	Java	Andrei Popescu

Figure 29. Choose thesis theme for student

After selecting a specific theme and pressing the choose theme button, the student receives a success popup, and the chosen theme is shown. If there are any errors during the process, an error is shown. If a student chooses a theme, the next time he clicks on the final thesis option from the menu, he will be shown a page with details about the specific theme and the table with options won't be displayed because he already has a valid option (Figure 30).



Chosen thesis theme

Name
Fitness app

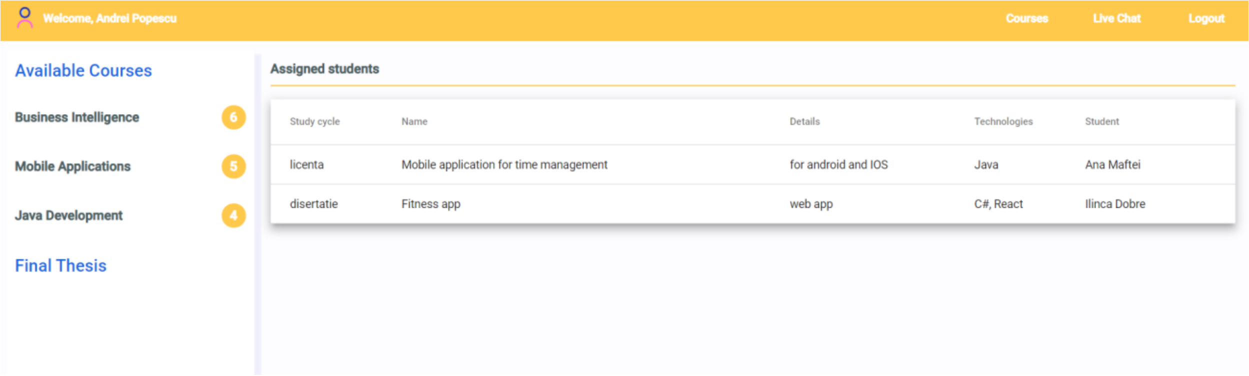
Technologies
C#, React

Details
web app

Teacher
Ioana Georgescu

Figure 30. Visualize chosen theme screen

In contrast, a teacher will get a table with all the assigned students for the proposed themes. He can visualize the study cycle, the name of the theme that was chosen, the involved technologies, and the name of the assigned student, as shown below.

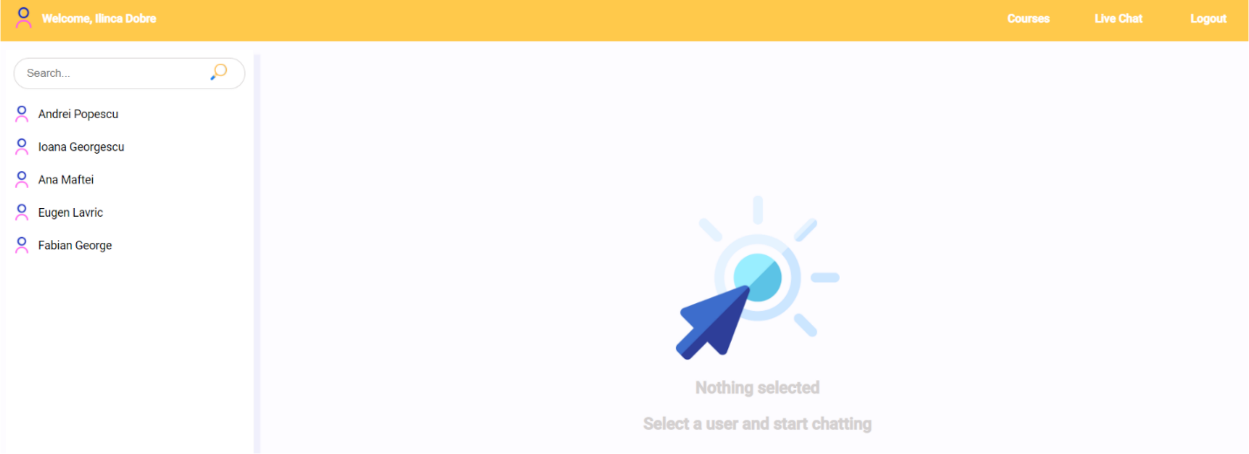


Assigned students

Study cycle	Name	Details	Technologies	Student
licenta	Mobile application for time management	for android and IOS	Java	Ana Maftei
disertatie	Fitness app	web app	C#, React	Ilinca Dobre

Figure 31. Visualize assigned students page

Furthermore, the live chat can be accessed by clicking the Live Chat option from the header. The user will be redirected to the chat page and, on the left side, there will be displayed a list with all the available users from the database. Also, a search bar will be available, in case the user wants to find a specific user to send a message. Firstly, if no user is selected, the page will contain a message to lead the user to select a name from the list (Figure 32).

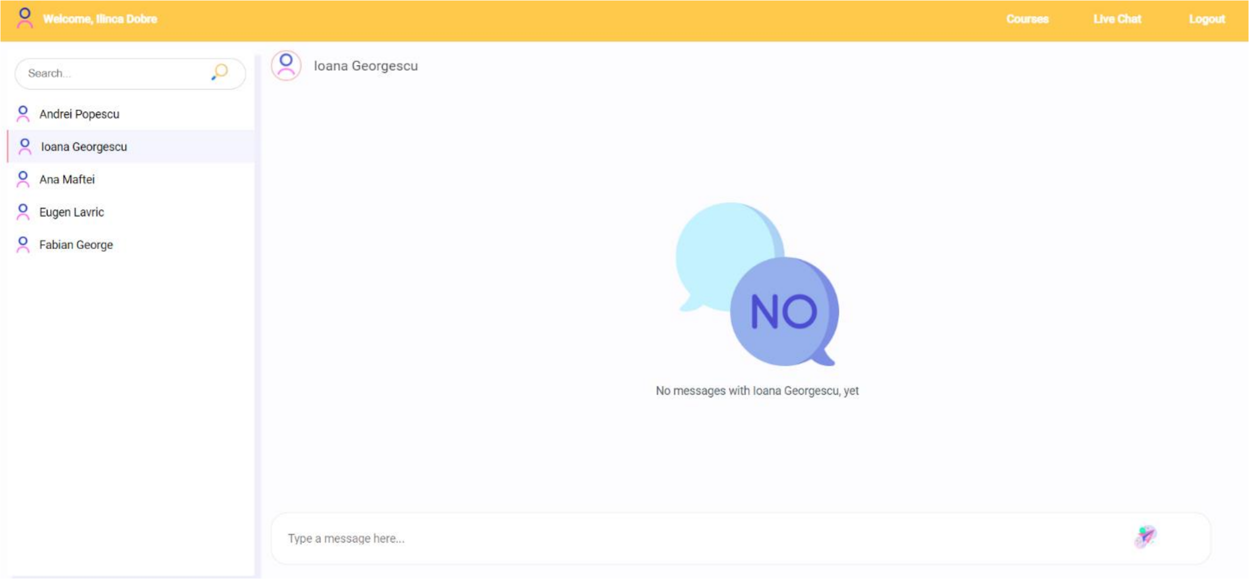


Nothing selected

Select a user and start chatting

Figure 32. Live chat page with no user selected

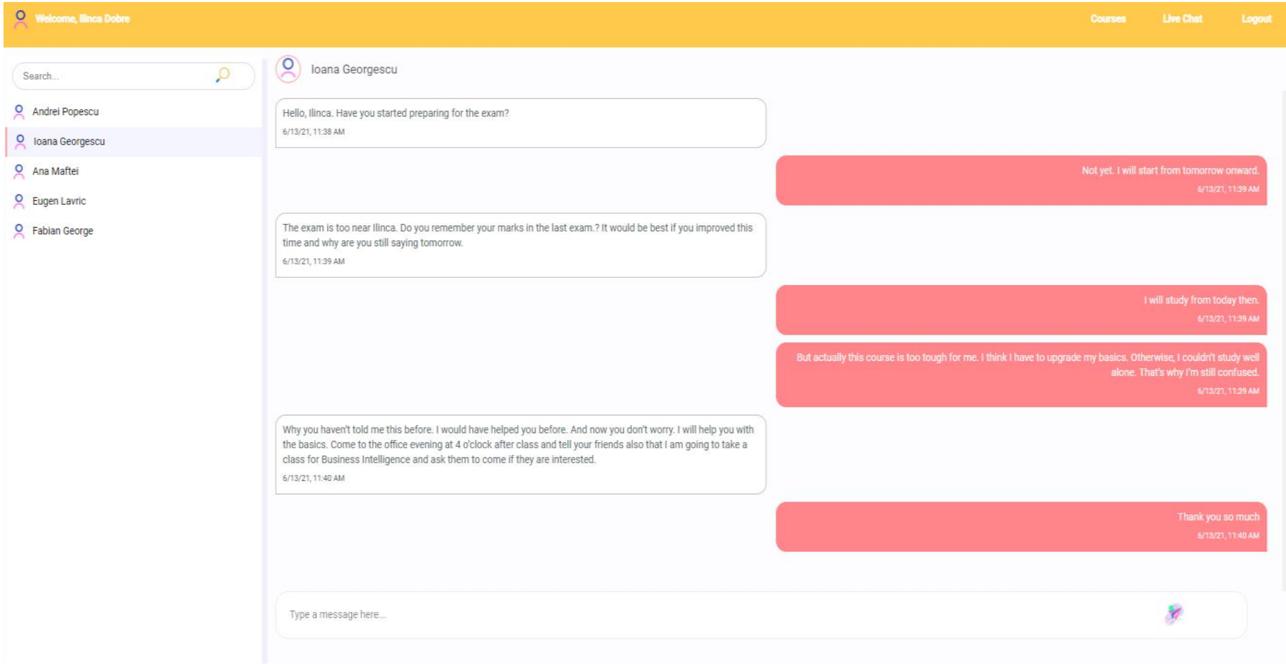
When the user decides to select a new user, he can press a name from the menu list and the chat section will be displayed. If the user hasn't sent any messages to the selected contact, then an icon will be displayed instead of the messages, in order to emphasize this. At the bottom of the page, there will be shown an input where the user can type the messages and an icon to help them send it to the selected user. This specific situation can be seen below.



No messages with Ioana Georgescu, yet

Figure 33. Live chat selected user with no messages screen

Now, if the user has been chatting to the selected user or if he sends messages after selecting it, all the messages will be displayed. If the user is not online, he will not receive the messages in real-time, but he will be able to see them when he opens the chat with the person that sent them. The sent messages will be shown on the right side and the received ones on the left side. Each message will also display the date and time when it was sent. An example of a screen with a conversation is shown below.



Hello, Ilinca. Have you started preparing for the exam?
6/13/21, 11:38 AM

Not yet. I will start from tomorrow onward.
6/13/21, 11:39 AM

The exam is too near Ilinca. Do you remember your marks in the last exam.? It would be best if you improved this time and why are you still saying tomorrow.
6/13/21, 11:39 AM

I will study from today then.
6/13/21, 11:39 AM

But actually this course is too tough for me. I think I have to upgrade my basics. Otherwise, I couldn't study well alone. That's why I'm still confused.
6/13/21, 11:39 AM

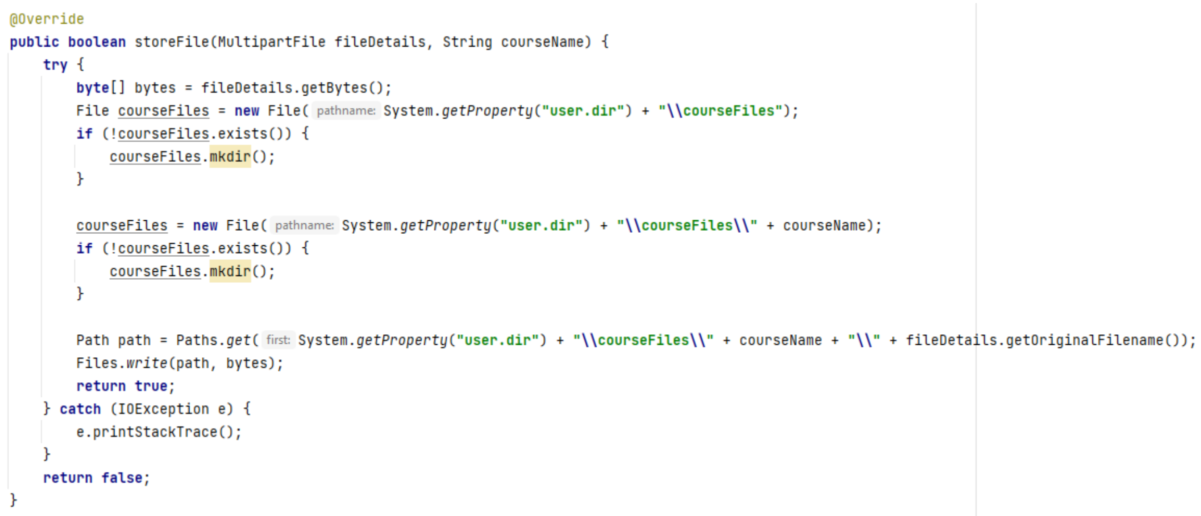
Why you haven't told me this before. I would have helped you before. And now you don't worry. I will help you with the basics. Come to the office evening at 4 o'clock after class and tell your friends also that I am going to take a class for Business Intelligence and ask them to come if they are interested.
6/13/21, 11:40 AM

Thank you so much
6/13/21, 11:40 AM

Figure 34. Live chat conversation section

3.3. Code sequences from the developed e-learning application

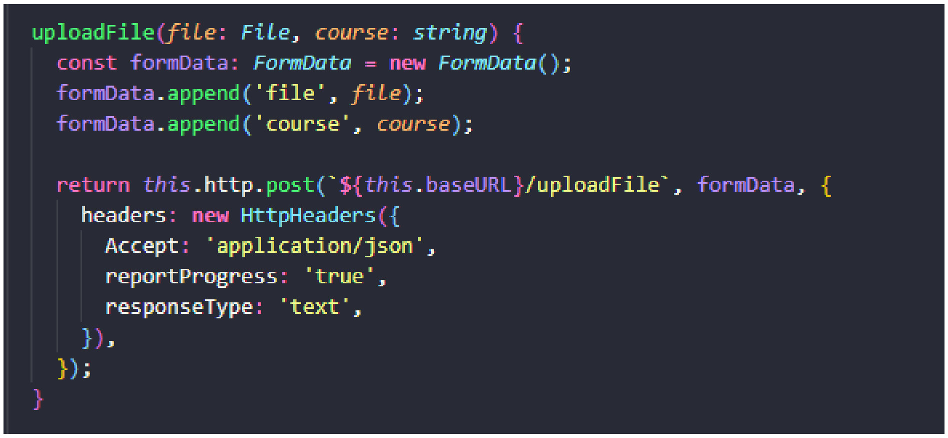
Essentially, we will start with the file upload process. On the backend side, we created a method on the UplaodFile class, called storeFile() (Figure 35). This method will be called each time a teacher uploads a new resource for a course. From the frontend, the details for the new resource will be sent as a MultipartFile. It will be checked if the folder for the course already exists, and if not, it will be created the distinct folder, then the sent file will be added to that folder.



```java
@Override
public boolean storeFile(MultipartFile fileDetails, String courseName) {
    try {
        byte[] bytes = fileDetails.getBytes();
        File courseFiles = new File( pathname: System.getProperty("user.dir") + "\\courseFiles");
        if (!courseFiles.exists()) {
            courseFiles.mkdir();
        }

        courseFiles = new File( pathname: System.getProperty("user.dir") + "\\courseFiles\\" + courseName);
        if (!courseFiles.exists()) {
            courseFiles.mkdir();
        }

        Path path = Paths.get( first: System.getProperty("user.dir") + "\\courseFiles\\" + courseName + "\\" + fileDetails.getOriginalFilename());
        Files.write(path, bytes);
        return true;
    } catch (IOException e) {
        e.printStackTrace();
    }
    return false;
}
```

Figure 35. storeFile() method

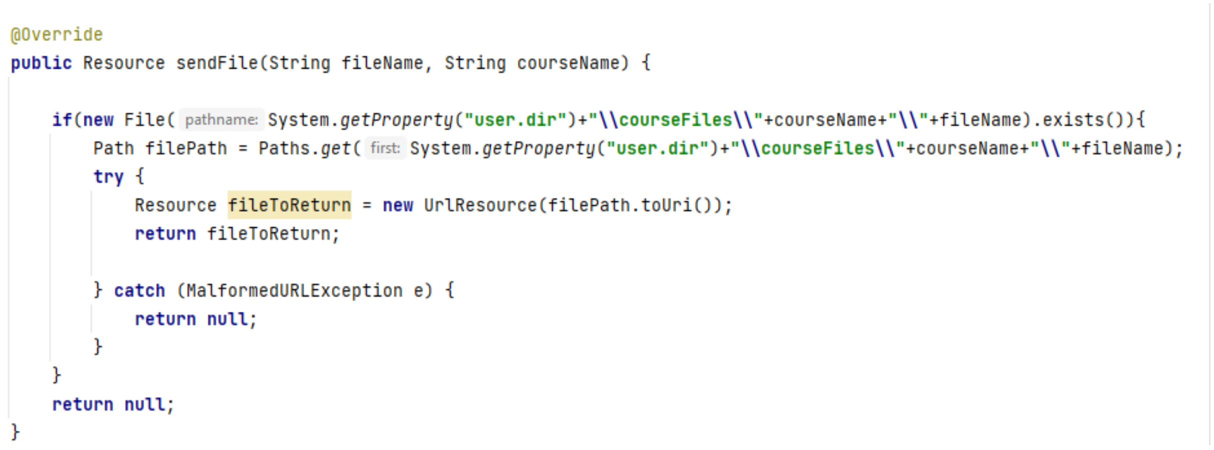
In order to upload a file, on the frontend side, we have a method called uploadFile(). The method will receive the file and the course name as parameters. A new FormData will be instantiated and we will append to it the file and course. After this, a post request is created, and the file is added to the course folder we mentioned above.



```typescript
uploadFile(file: File, course: string) {
  const formData: FormData = new FormData();
  formData.append('file', file);
  formData.append('course', course);

  return this.http.post(`${this.baseURL}/uploadFile`, formData, {
    headers: new HttpHeaders({
      Accept: 'application/json',
      reportProgress: 'true',
      responseType: 'text',
    }),
  });
}
```

Figure 36. uploadFile() method

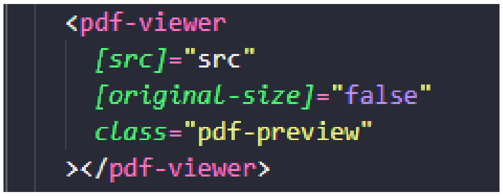
Ultimately, for the preview of each course resource, the method sendFile() from the Spring Boot project will handle the operation of returning the file in BLOB format. The method is shown in the next figure.



```java
@Override
public Resource sendFile(String fileName, String courseName) {

    if(new File( pathname: System.getProperty("user.dir")+"\\courseFiles\\"+courseName+"\\"+fileName).exists()){
        Path filePath = Paths.get( first: System.getProperty("user.dir")+"\\courseFiles\\"+courseName+"\\"+fileName);
        try {
            Resource fileToReturn = new UrlResource(filePath.toUri());
            return fileToReturn;

        } catch (MalformedURLException e) {
            return null;
        }
    }
    return null;
}
```

Figure 37. sendFile() method

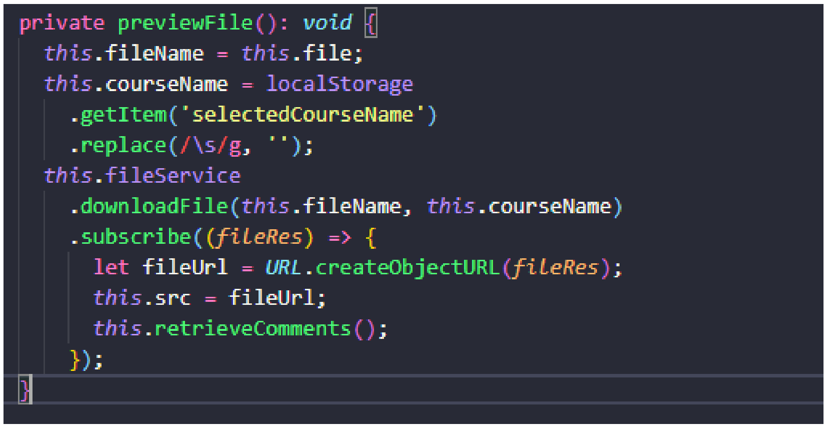
The Angular application receives the file details and will present them using the ng2-pdf-viewer. Accessing the component in our HTML file and the inputs it accepts are presented below.



```html
<pdf-viewer
  [src]="src"
  [original-size]="false"
  class="pdf-preview"
></pdf-viewer>
```

Figure 38. Angular pdf-viewer

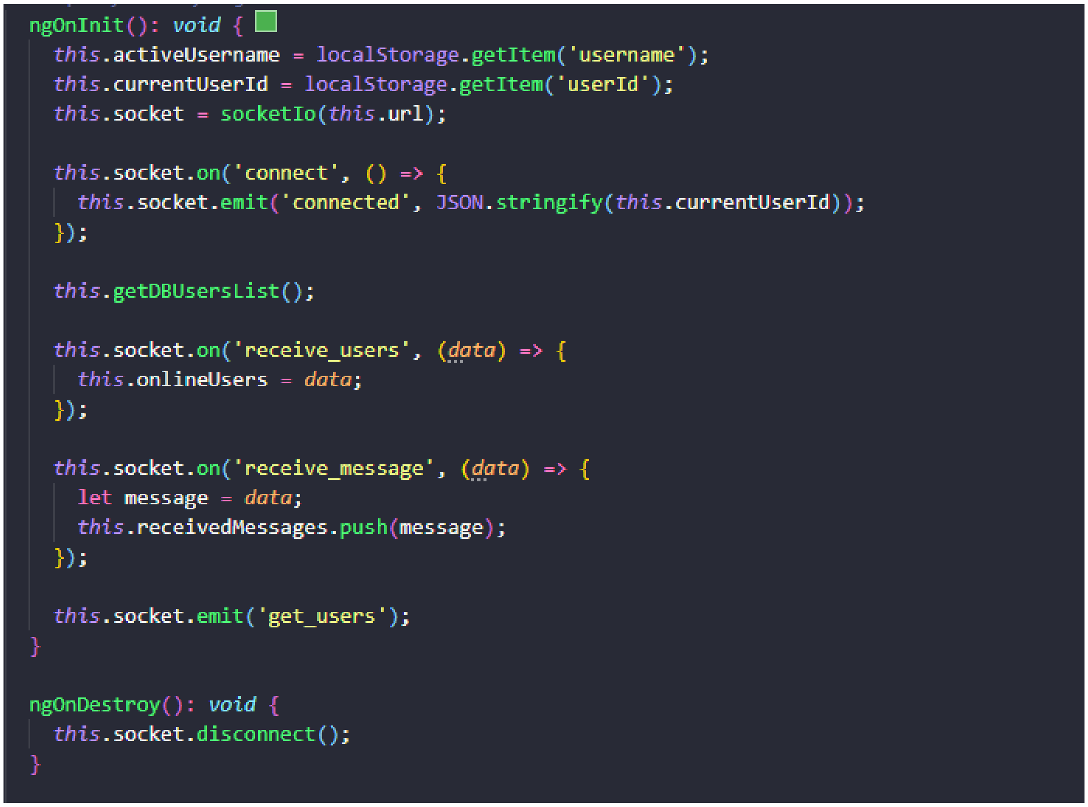
Every time the user selects a new file the src attribute from the pdf-viewer component is changed and new details are displayed. The method previewFile() (Figure 40) from typescript is responsible for this process. By calling the downloadFile() from the fileService service, the frontend calls the API specific for the file download. Then, to preview the file in the web application, it has to be created an URL using the createObjetURL method. This URL will represent the source for the pdf-viewer.



```typescript
private previewFile(): void {
  this.fileName = this.file;
  this.courseName = localStorage
    .getItem('selectedCourseName')
    .replace(/\s/g, '');
  this.fileService
    .downloadFile(this.fileName, this.courseName)
    .subscribe((fileRes) => {
      let fileUrl = URL.createObjectURL(fileRes);
      this.src = fileUrl;
      this.retrieveComments();
    });
}
```

Figure 39. previewFile() method

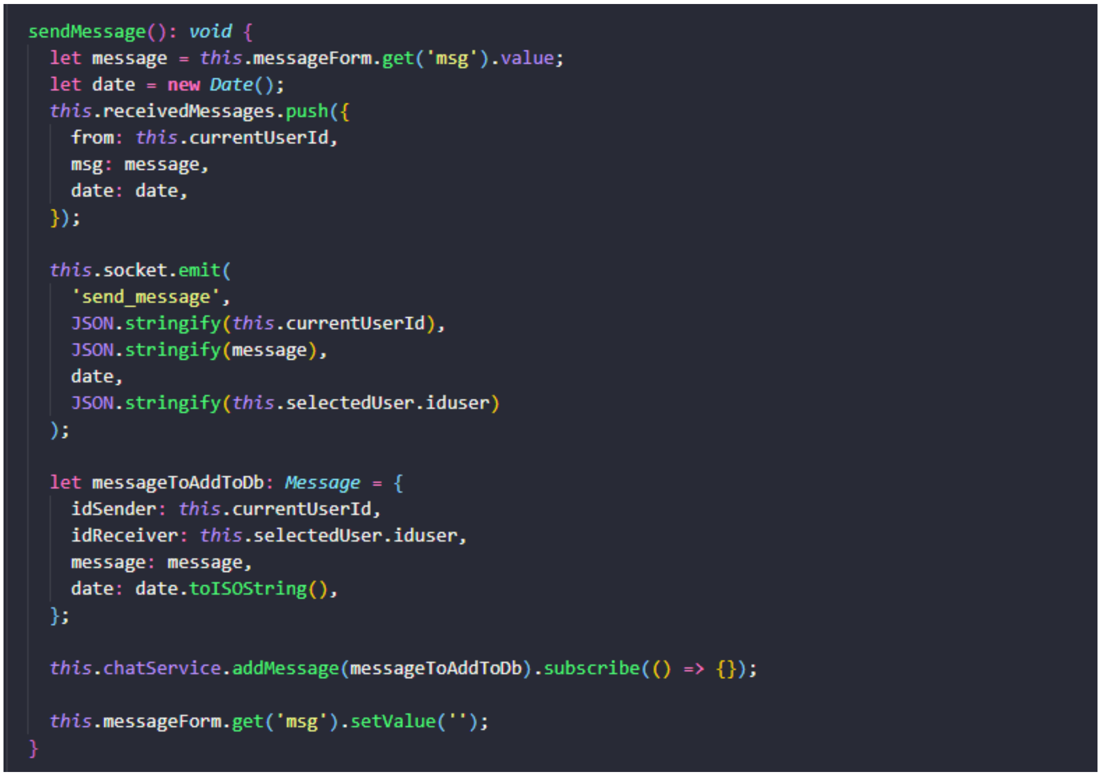
In regard to the live chat, we will use Socket.IO, a JavaScript library that handles real-time changes for web applications. That will be needed to receive or send messages as soon as the send button is pressed, not needing to refresh the page to get the data. The endpoints that facilitate the real-time chat will be configured on the backend side and the frontend will just call each of them at a specific time. When the live chat component is firstly initialized, it will be created a new instance of socketIo that points to the backend application. The first method that is called is the connect one. From the frontend, we send the current user id to establish a new connection. After this, we need to get all the online users, to know to whom we can send real-time messages. We will keep them in the onlineUsers array. The receive_message endpoint has to be called also on ngOnInit() so that we can listen for new messages all the time. In order to close the socket connection, we need to call the disconnect method in the onDestroy lifecycle. The ngOnInit() and ngOnDestroy() methods can be seen in the figure below.



```
ngOnInit(): void {
  this.activeUsername = localStorage.getItem('username');
  this.currentUserId = localStorage.getItem('userId');
  this.socket = socketIo(this.url);

  this.socket.on('connect', () => {
    this.socket.emit('connected', JSON.stringify(this.currentUserId));
  });

  this.getDBUsersList();

  this.socket.on('receive_users', (data) => {
    this.onlineUsers = data;
  });

  this.socket.on('receive_message', (data) => {
    let message = data;
    this.receivedMessages.push(message);
  });

  this.socket.emit('get_users');
}

ngOnDestroy(): void {
  this.socket.disconnect();
}
```

Figure 40. Live chat onInit and onDestroy lifecycle hooks

Each time a new user is selected, all the messages from the current user and the selected one are retrieved from the database. If we want to send a message and the user is not online, the sent message will be added to the message table from the database, and the user will see it the first time he connects to our application. Otherwise, if the user is connected, he will receive the message immediately. In the sendMessage() (Figure 41) method we can see that we have to emit an event of type send_message to the socket so that the messages are sent in real-time.



```
sendMessage(): void {
  let message = this.messageForm.get('msg').value;
  let date = new Date();
  this.receivedMessages.push({
    from: this.currentUserId,
    msg: message,
    date: date,
  });

  this.socket.emit(
    'send_message',
    JSON.stringify(this.currentUserId),
    JSON.stringify(message),
    date,
    JSON.stringify(this.selectedUser.iduser)
  );

  let messageToAddToDb: Message = {
    idSender: this.currentUserId,
    idReceiver: this.selectedUser.iduser,
    message: message,
    date: date.toISOString(),
  };

  this.chatService.addMessage(messageToAddToDb).subscribe(() => {});

  this.messageForm.get('msg').setValue('');
}
```

Figure 41. sendMessage() method

Conclusions and future directions

During the last period of time, e-learning has become a part of each learners' life, no matter if the learning process is bound to a university or it's done on their own. The diversity of applications for this field is extensive on the market, but each user has different needs or mindsets about what will be helpful during the learning process. With all the variousness, only one application will be used at a time, the one considered most suitable for the users' knowledge and situation. The developed e-learning application tries to come and help the user when it comes to the interaction with the developed modules, but also with the other users. The user-friendly interface allows the user to easily navigate to the courses or live chat modules, from the header of the application. Also, the left side menu, which is always visible, gives the user a better overview of the courses that need to be taken or the themes for the final thesis. Another useful element is the preview of the PDF resources loaded for each course, preview that is done by pressing the view icon from each resource and which leads to loading the pdf inside the application, and also on the same page, so the user doesn't lose its focus on the other resources. It is desired that the interaction between students and teachers be as pleasant and simple as possible, and because of this, it was introduced the comments section for each file so that students can ask any questions regarding a specific resource and get the needed information. The asked questions might help other users and is more efficient to have them visible for all the users so that the teacher doesn't have to answer them individually. Since the communication between students and teachers is very significant, the live chat section supports real-time chatting between users. The search functionality from the live chat page helps the user find contacts easily and start a new conversation with them.

The main advantages of the application are that it offers an easy-to-use interface and enhances the communication between users with the help of the comments sections and the live chat. But, considering that the application is still in a prototype phase, there is room for improvements and new functionality. One thing that could be improved is allowing the user to modify the chosen thesis theme. In the current implementation, a student can choose a theme just once and after this, they can only see its details. Also, for the live chat section, each user could have an icon attached in the user list, in order to show the status, if the user is either online or offline. For the teachers, a new column could be added to the view assignments table, to allow them to grade each specific project. After this, the graded assignment should be returned to the student who uploaded it.

If the development of the proposed application will be continued, the following features could be added:

- Create an admin module for the user with admin rights, to supervise all the added users, courses, and other resources.
- A search functionality inside each pdf preview so that users can find much easily the needed information.

- Push notifications functionality.
- Ratings and reviews for each teacher.
- Test and quiz module.
- Real-time analytics for the admins, so that they can track the performance of the application.

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