E-Learning services integration for pre-university education system

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Abstract: *The use of an e-Learning platform in the pre-university education environment in addition to conventional educational means can have a positive impact on a student's performance. The purpose of this material is to present the advantages resulting from extensive literature research, as well as how to create an e-Learning platform that aims to prepare students from the pre-university education environment in order to support and pass the Baccalaureate exam. The platform will be distributed to the target audience based on the SaaS model (Software as a Service). To capitalize on the gaming habits of students, the prototyped platform that we propose will include elements taken from video games, such as levels, points, tasks or rankings in order to make them more willing to engage in educational activity but in an attractive form. Students will be stimulated to regularly use the application by awarding prizes or by the need to solve a task in a limited time. Through the use of interactive elements, the student acquires new knowledge, including the ability to make connections between already existing information.*

Keywords: e-Learning, gamification, microlearning, services, integration.

1. Introduction

The advent of the World Wide Web in the 1990s marked a pivotal shift in how digital technologies are integrated into various sectors, including education. This digital transformation has not only changed how information is accessed and shared but has also introduced innovative approaches to teaching and learning. In the educational sector, particularly in pre-university settings, incorporating e-Learning platforms alongside traditional teaching methods has demonstrated significant potential in enhancing student performance (Zamfiroiu, 2024; Stanciu et al., 2022). Research has shown that when e-Learning tools are effectively integrated into the curriculum, they can provide students with personalized learning experiences, greater access to resources, and increased opportunities for collaboration, all of which contribute to improved academic outcomes (Rafiq et al., 2024). Chiu (2023) highlights that using digital learning environments can lead to

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higher student engagement and motivation, mainly when these platforms are designed with interactive learning that makes them more engaging and enjoyable. These platforms offer a flexible, scalable, and cost-effective means of supporting diverse learning needs, thereby playing a crucial role in modern education systems.

The so-called "Fourth Industrial Revolution" (4IR) which represents the implication of the technology (Artificial intelligence, Internet of Things, etc.) to automate some processes in traditional environments, is responsible for new pedagogical methodologies involving ICT devices, consequently leading to important changes in education over the past decades. Students can now easily collaborate with their instructors and quickly find new information on any topic of interest (Nwosu et al., 2023). Still, without responsible behaviour, technology may lead to unwanted effects in community, even to the colapse of hightech society and top revent this it is important to develop continuos learning program to accustom people to disruptive technologies (Topor & Vevera, 2023). The "Fourth Industrial Revolution" has been a driving force behind developing new pedagogical methodologies that leverage Information and Communication Technology (ICT) devices. This revolution, characterized by the convergence of digital technologies with everyday life, has significantly transformed the educational landscape over the past few decades. As a result, education has become more flexible, accessible, and responsive to the needs of modern learners (Adil et al., 2024) With the integration of ICT tools, students can now collaborate with their instructors and peers more efficiently, participate in interactive and immersive learning experiences, and access a wealth of information on any topic with unprecedented speed and ease. These advancements have enhanced the overall quality of education and empowered students to take greater control of their learning journeys, fostering critical thinking, creativity, and a deeper engagement with the subject matter.

In 2011, Romanian government had regulated a large-scale implementation of an e-Learning platform in 2011, but its full realization remains still unfulfilled. Conceived as a flexible, location-independent learning environment, this platform held the promise of mutual benefits for all the parties involved.

Beyond the numerous advantages associated with e-Learning platforms, resilience should be a key concern. The COVID-19 pandemic revealed the vulnerability of traditional education systems to complete disruption, also proving that a hastily implemented complex technological solutions can induce more chaos than it resolves.

Despite various efforts made by the Romanian government in setting up and implementing the proper functioning of an e-Learning platform in 2011, till now, it hasn't reached its full potential. It was specifically developed to offer a flexible and place-independent educational setting with significant benefits expected for all learners, educators, and the whole educational framework. Its purpose was to transform the education system by providing equal access to resources, enabling a learning continuum outside the classroom, and increasing collaboration beyond geographical boundaries. However, many problems have emerged during its implementation, such as the lack of proper infrastructure and the failure to train teachers enough to use digital tools effectively. These challenges hindered the full deployment of the platform and constrained its potential to realize the transformational impact envisioned.

It was the COVID-19 pandemic that underscored the importance of such platforms in the face of weaknesses inherent in conventional education systems. This abrupt online learning transition has brought home that these systems are ill-equipped to handle far-reaching disruptions. Institutions of learning struggled to maintain continuity, often resorting to hastily contrived technological measures that led, in many cases, to confusion and inefficiency rather than the stability and support expected to provide during the crisis.

2. Related work

Learning is defined as the process of acquiring knowledge through studying or experience. According to Bloom et al. (1956), knowledge is the foundational component of learning, as it emphasizes the retention of information that learners can later apply in real-life scenarios.

The human brain retains and recalls data using the memory system. Atkinson & Shiffrin (1968) identified three structural elements involved in this system: sensory memory (SM), short-term memory (STM) and long-term memory (LTM). Inputs perceived through stimuli are first filtered into SM. Relevant information is then transferred to STM, where it is processed and either discarded or moved to LTM for future retrieval (Atkinson et al., 2024).

Working memory (WM), a more recent concept derived from STM, has been directly linked to intellectual abilities (Ackerman, Beier and Boyle, 2005) and overall academic performance (Blankenship, 2015). STM is involved in retrieving information from LTM in units called chunks. While Miller (1956) famously suggested that STM can store 7 ± 2 chunks at a time, subsequent research indicates a more limited capacity of 4 ± 1 items (Cowan, 2001). To leverage STM limits, Sweller (1986) suggested reducing cognitive load by minimizing the gap between the current problem state and the final goal. This can be achieved by gradually introducing new information and splitting complex topics into smaller, manageable chunks.

Torgeston & Iannone (2020) defined microlearning as "any learning content that can be consumed in less than 10 minutes". Recent research by Lopez (2024) shown that delivering educational content in small modules increases the knowledge retention and engagement.

Nowayads, as advanced technologies such as artificial intelligence arised, adaptive learning is a new educational technology that can adjust content and learning methods based on the course goals and students' abilities (Capuano & Caballé, 2020). Cavanagh et al. (2020) stated that chunking content in small bits of information can help mapping learning objectives and information thus leading to a more personalized learning path for each student.

Incorporating game design elements such as points, badges or rewards for digital activities makes learning more enjoyable, thereby increasing student engagement and performance (Hamari & Koivisto, 2015; Gheorghe et al., 2017). Nakiyemba (2024) recommended that educational institutions should integrate gamification elements, as the study have shown it can significantly improve knowledge acquisition.

3. E-Learning integration

Ellis (2009) defined learning management system (LMS) as being an application that integrates the "administration, tracking and reporting of training events". We identified four interdependent components a fully featured e-Learning application should implement:

- Learning: delivering educational content both for self-paced learning and blended or online learning;
- Assessment: managing assignments or quizzes;
- Collaboration: asynchronously communicating and collaborating on courses and assignments;
- Feedback: continuously monitoring the student performance and adapting the educationl content delivered by tracking the assessment scores and the automatically collected, interpreted data about student's in-app behaviour and other user preconfigured preferences.

These elements should be integrated, like are presented in Figure 1.

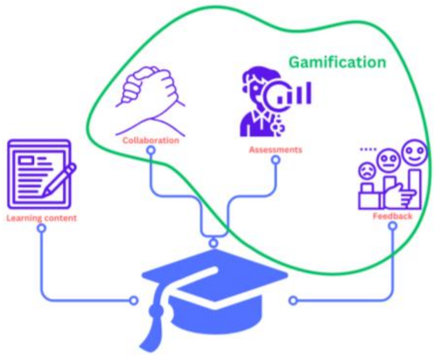

Figure 1. E-Learning features integration

When we think about e-Learning, we might assume that having digital access to course materials and being able to directly communicate with instructors would be the most effective approach. However, a recent study by Sutherland et al.

(2023) revealed that students prefer simpler approaches to learning, with most of them being satisfied with accessing lectures in video format. The study also shown that students are most likely to use familiar communication methods, such as email or Facebook Messenger, rather than adopting new platforms.

While the simpler approach provides some of the necessary tools for online learning, they are not sufficient on their own. Assessments cannot be effectively conducted using apps like WhatsApp, and integrating gamification elements is impossible with static materials.

Recent researches (Keane et al., 2022) highlights that students prefer a hybrid approach that combines online and in-person elementswhich requires a more versatile e-Learning solution that support blended learning while also allowing the students to learn at their own pace.

In the Romanian national context (but not limited to), the adoption of a large-scale e-Learning solution faces several significant challenges such as discrepancies between urban and rural areas. Those discrepancies can be identified as unequal access to technology or the internet, which are essential requirements for every complex e-Learning system.

Moreover, beyond these infrastructural and social challenges, accessibility for students with disabilities is a crucial concern. Adding support for screen readers and keyboard navigation should be a priority to meet the needs of vision-impaired users. Additionally, providing transcripts for each video lecture and other educational materials with audio elements is mandatory for supporting hearing-impaired students.

4. Implementation strategies

Implementing a comprehensive e-Learning solution requires the seamless integration of multiple services to ensure that all the necessary features properly work together. A learning management system should be the central hub, enabling the integration of various tools and functionalities for an effective learning environment. The integration strategy must prioritize interoperability, user experience and scalability to support a diverse student population and accommodate different learning styles.

There are three main roles within our application: student, instructor and school management. Each student can be given access to a limited number of courses based on their specific curriculum and educational needs. Instructors have the direct responsibility for creating and updating educational content and they also should be able to conduct complex assessments. School management can generate and browse various reports which can improve the decision-making process.

Since our solution focuses on motivating users through gamification, encouraging voluntary engagement without the need for instructor coercion, a key project requirement is to prevent the app from becoming overloaded with excessive or intrusive features. Chukwu (2024) emphasized that careful planning and finding the right balance between the course content and gamification elements is essential.

To further enhance the effectiveness of the e-Learning platform, a critical aspect is ensuring that the system is adaptable to various learning environments and responsive to user feedback. Flexibility in the platform's architecture will allow educational institutions to tailor the application to their specific needs.

When evaluating who should take the lead in implementing this e-Learning system – whether the government or the private sector – this decision must be informed by the unique challenges each approach has.

The government, with its ability to regulate and standardize large-scale initiatives, could be well-positioned to address the infrastructural and social challenges associated with implementing a nationwide e-Learning platform. Government-led implementation would ensure that the platform strictly follows the national educational standards and provides equitable access to all students, including those in rural areas. Moreover, a government initiative could also benefit the funds to upgrade existent physical equipment or acquire new devices for the users, when needed.

However, government projects often face bureaucratic issues such as delays and a limited flexibility in features being implemented, or technologies being utilized. Those issues are non-existent in the private market which prioritizes profit over inclusivity, potentially leading to unequal access where only wealthier institutions or students benefit from advanced features. Without government oversight, there could be less focus on standardization.

In Romania exist some educational platforms that can be used to manage the process in the educational institutions, to create and integrate the educational content, to evaluate the students and to obtain the feedback from students for teachers. These platforms are available for any level of educational process. A list of these platforms are available at (LivresQ, 2024).

Table 1. Implemented charactestics on e-Learning platforms

Platform	Characteristics				
	Content creating	Collaboration between users	Assessments evaluation	Feedback	Gamification
LivresQ	X	-	-	-	-
Adservio	-	X	-	-	-
Edus	-	X	X	-	-
MyKoolio	-	X	X	-	-
CoffeeLMS	X	X	X	X	-
ASQ	X	-	X	-	-
Kidibot	-	-	X	-	X
Brio.ro	-	-	X	X	X
Vboard	-	X	X	X	X
Edu For Life	X	X	X	-	-

Given these considerations, a hybrid approach may be the most effective. The government could lay the groundwork by setting regulatory standards and providing initial funding. The private sector could then take on the role of developing and scaling the system, introducing innovations and continuously improving the platform based on user feedback. This public-private partnership would leverage the strengths of both sectors, ensuring a robust, scalable and equitable E-Learning solution that meets the diverse needs of all students.

5. Use case: proposed platform

Our proposed application is a solution meant to solve all identified issues discussed earlier in this paper. The business layer is thoroughly implemented using a microservices architecture which consists of four microservices. Each major feature should be wrapped into an independent microservice, but for cost saving purposes, some of them have been included in a single service, Figure 2.

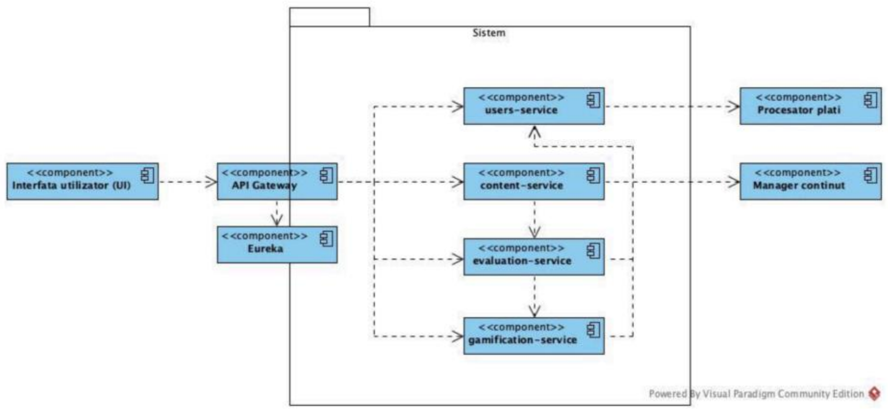

Figure 2. Microservices architecture of the application

For the user to access the application, it requires a device capable of connecting to the Internet and a stable internet connection to allow multiple HTTP requests. The complete abstraction of business layer allows us to further develop a native application for mobile devices without the need to redesign all the core features.

The view layer is developed using Next.js 14 since it provides a few additional performance improvements over vanilla React such as server-side rendering (SSR), advanced built-in routing system or components which optimizes the default ones. Since our application is available on the Internet, it should be accessible to all the search engines. SSR allows us to generate static pages where needed which can be then easily crawled by search engine robots. The performance is also significantly improved since the server should only serve static content for certain pages, instead of fetching the same data every single request. For the advanced UI features, React Context API is being used to temporarily store the state of certain user flows such as onboarding. Every form is validated and handled using Zod and react-form-hooks.

The business layer is contained within a private network which is not publicly accessible. Each request initiated by the client goes through API Gateway (by default, running on port 8080) which is responsible for validating it and furtherly routing it to the responsible microservice. For every validated request, API Gateway queries the Eureka server to get all the available instances and performs load balancing by routing the request to the designated instance by the load balancing algorithm to facilitate faster response times.

Every microservice has been developed using Spring Boot, a largely used Java framework. There are four microservices, each of them being responsible for learning (content-service), evaluating and assessing users (evaluation-service), gamification (gamification-service) and managing users, including authorizing them for certain actions (users-service).

The service responsible for learning consists of a few REST API endpoints which allows clients to fetch educational content in a static state. The content is modelled as a tree-shaped hierarchical structure where the discipline is the primary component. Each discipline consists of many chapters whereas each chapter consists of many lessons. Further down, each lesson has arranged blocks of content, where each block can be a paragraph, an image or a LaTeX equation.

To allow non-technical users to create content, we've used Notion, a popular note-taking application which provides cloud collaboration tools similar to Google Docs. Instead of learning a markup language such as Markdown, instructors can build their courses by using an intuitive user interface and they can add as many blocks variants as they want.

All the data is stored in Notion databases (which is a default table with rudimentary querying capabilities), which allows defining metadata for each tree node such as difficulty, order or visibility. Difficulty levels allow filtering tree nodes based on user preferences, thus marking the node as optional if it overflows the range selected by the user. Querying the Notion database can be a time-consuming task; therefore, a configured scheduled job is expected to sync the content at an hourly interval in the Firestore database provided by Google Firebase.

The service responsible for assessing users is the most complex one in the system and it can be refactored in a few microservices if the costs would not be an issue. On the view layer, instructors have access to a dashboard where they can see and manage all the disciplines.

By being able to perform CRUD operations on evaluation items, they can manage all the evaluation items in the application. They can also build quizzes based on existent evaluation items which can be later solved or downloaded in PDF format by students. When adding a new evaluation item, instructors are required to set certain metadata fields which can be useful when grouping them. There are a few evaluation item types such as multiple-choice answers or fill-in answers, allowing the instructors to build the quiz according to their needs. Fill-in answers require a Levensthein distance tolerance value to avoid special characters such as diacritics to invalidate a correct answer.

Students can also access “Evaluation” page to solve all the available quizzes, or they can generate new quizzes with publicly available evaluation items. For generating new quizzes, students provide a difficulty level parameter, and each evaluation item is assigned with a non-null probability of selection value, based on their difficulty. Students can also choose to evaluate a non-STEM topic such as literature by leveraging new AI trends, by submitting a scanned copy of their essays. Spring AI is being used to wrap the GPT-4 Turbo model developed by OpenAI and certain instructions have been configured to allow feedback aligned with official examination methods.

The assessment results are sent over to the microservice responsible of managing users to allow storing them in the database for further use by configuring OpenFeign clients which abstract the communication method between different microservices.

The service in charge for gamification within the application consists in a few of REST API endpoints which allow submitting an event name such as “lesson-finished” which translates to several XP awarded to the user. When the request is received, the action is validated to avoid duplicate XP awards and, if validated, the result is transmitted to the microservice responsible of managing users to update the total XP value and level, if needed. The user is informed within the view layer by using toasts and other visual elements which provide a gamified experience such as emoticons or funny phrases.

Daily challenges are also generated in this service, each discipline having selected three evaluation items of different difficulties. They are stored in the database to allow the same challenge to be rolled to each individual user. For generating them, three items are randomly picked based on their difficulty level and saved into the database.

The microservice responsible for user management handles authenticating and authorization within the application for certain actions using Firebase Admin and properly updates data about the user when needed. It is also used to communicate with the payment processing software by configuring a POST method which is used by Stripe to update status about the users such as payment status and invoicing.

6. Conclusions and discussions

By corroborating the results obtained during the theoretical research with how similar applications in the educational field address the underlined educational needs, we designed an application that implements two essential components in the educational process: 1. learning and 2. evaluation. Our application tries to propose a general solution, designed for the majority of students, not a limited niche of users. We removed features that would not have been suitable for all learning styles, even if they could have a positive impact on school results for certain categories of students.

So, the solution allows the dynamic management of the educational content in the platform and its visualization in a modularized form. User evaluation is carried out by solving pre-existing tests in the platform or by generating new tests. Experimentally, the possibility of checking an essay using AI models is introduced, with the student receiving the result shortly after submitting it. To achieve the goal of keeping the user motivated to access the app frequently, we have implemented gamification elements using experience points or daily challenges.

The proposed solution represents a solid starting point for building a complex educational platform, addressing the most important needs specific to the field. In the future, the application can be developed in two directions, namely the attractiveness of educational units and the implementation of advanced artificial intelligence solutions.

Attractive educational units are achieved by implementing complex user management and audit tools from the application or by adding collaborative components such as virtual classes. For example, it is important for an educational unit to know the activity of a student from the application and assign him to a virtual class. For the cases of virtual classroom, the teaching staff can propose activities such as evaluating students with a randomly generated test, with the possibility of following in real time the progress of each user within the test, delivered in a control screen.

Artificial intelligence is the most important opportunity of the moment, with AI models having the ability to easily identify different patterns, including in educational field. Therefore, more data on user activity can be collected, and based on them, complex profiles can be made so that the student's learning style can be identified along with many other important aspects that could improve the efficiency of the educational process.

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