Closer: A Tool Support for Efficient Learning Integrating Alexa and ChatGPT

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Abstract: In a society in continuous change due to the astonishing speed with which science and technology develop, the educational system must keep up with these changes and meet the students with effective learning methods integrated in intelligent platforms. In this respect, the paper proposed an e-learning platform whose underlying educational framework is built upon three studied principles that lead to efficient learning, namely: elaboration, retrieval practice and feedback. Furthermore, the core functionalities of the proposed tool consist of a question proposal system and quiz taking system, elements shaped based on active and collaborative learning. Nevertheless, the proposed tool's learning authenticity is ensured by the dedicated voice assistant powered by Alexa and the integration with ChatGPT, an OpenAI product. As for the validity of the proposed solution, an ongoing study is in place. The study consists of integrating the proposed tool as part of the didactic activity for the Data Structures course taken by 1st year students enrolled in the Mathematics and Computer Science undergraduate program offered by Babeş-Bolyai University (Cluj-Napoca, Romania).

1 INTRODUCTION

In a dynamic and ever-changing society, learning methods must adapt to meet the needs of modern learners. The education system plays an important role in equipping future generations with the knowledge and skills necessary to navigate an uncertain world. To accomplish this, educators must utilize effective teaching approaches that engage and empower learners, enabling them to actively participate in the educational process.

It is suggested that education theory should shift towards a more student-centered approach that emphasizes active learning, as supported by various sources including (Bishop et al., 2014), (Doyle, 2008), (J., 2011), (Rich et al., 2014), (Serban and Vescan, 2019), and (Freeman et al., 2014). This approach plays a crucial role in fostering students' creativity and competence in their studies. Essentially, active learning places the onus of learning on the students and assigns the teacher the role of facilitator.

The approach outlined above aims to give the learner a primary role in the learning process and allows them to "discover" knowledge at their own pace or in groups, having a minimal guidance from the lab instructor, who provides support and encourages imagination and creativity. This approach, as suggested by sources including (Bishop et al., 2014), (Doyle, 2008), and (Rich et al., 2014), is also designed to foster the development of communication and teamwork skills, conflict resolution abilities, and time management competencies that can assist students in regulating their learning and achieving their goals. The student-centered paradigm is based on various principles of effective learning that have been robustly supported by research in cognitive and educational psychology over the past few years.

The current paper proposes to design an e-learning platform based on three principles of an efficient learning and to test its efficiency on students' learning performances in a real teaching context. The platform's design was based on three principles of effective learning, namely elaboration, retrieval practice, and feedback, which have been firmly supported by research

The support platform has two core functionalities: multiple choice question proposal system and quiz taking system. But the authenticity of the proposed learning system comes from the following components which are integrated in our system: dedicated voice assistant powered by Alexa and integration with

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ChatGPT, an OpenAI product. In this respect, we enhance the user experience by allowing interaction with the platform by means of voice commands and we acknowledge the power that artificial intelligence (shortly AI) powered tools can have in the learning experience, rather than denying their usage.

As for the validity of the proposed solution, an ongoing study is in place. The study consists of integrating the proposed tool as part of the didactic activity for the Data Structures course taken by 1st year students enrolled in the Mathematics and Computer Science undergraduate program at Babeş-Bolyai University. Validation of the proposed model will be based on 2 surveys handed to students and will aim to understand the student experience of using the proposed model.

The rest of the paper is structured as follows: Section 2 builds an overall image over the trends of research done in the area of E-Learning in the recent years. Section 3 reflects the way the proposed tool abides the principles of an effective learning, while Section 4 describes the Collaborative learning strategy integrated by our proposed tool. Section 5 presents the proposed E-Learning software system, its architecture, the main functionalities and its elements of authenticity. Section 6 presents our conclusions and future development possibilities of the proposed tool.

2 RELATED WORK

The use of computer-based tools to promote active learning in higher education has gained increasing attention in recent years, as noted by (Weinstein et al., 2018b). Various studies, including (Mays et al., 2020), (Weinstein et al., 2018b), and (Greving et al., 2020), have examined the efficacy of such tools in enhancing student engagement and learning outcomes. This section provides a summary of two related computer-based tools to facilitate active learning among students.

Moodle (Devi and Aparna, 2020) is a widely used open-source learning management system (LMS) designed to facilitate online learning and course management. It provides a range of features such as course creation, content management, assessment tools, and communication tools. It allows to create and customize course content, track student progress, and communicate with students in real-time.

Educational institutions of various types, including kindergarten through grade 12 (or K-12) schools, universities, and corporate training programs, utilize it to provide online and blended learning experiences. Overall, Moodle is a versatile platform that enables educators to create and deliver effective online learning experiences.

Canvas (Fernández et al., 2017) is a cloud-based LMS that provides a user-friendly interface and a range of course design and customization tools, including multimedia support, quizzes and assessments, and interactive discussions. Canvas also includes features for tracking and analyzing student performance, facilitating communication between educators and students, and supporting collaborative learning. Overall, Canvas is a comprehensive LMS that enables educators to create engaging and effective online courses.

Other tools such as Google Meet, Zoom, Microsoft Teams (Alameri et al., 2020) are also being used for educational purposes. Zoom and Google Meet are mainly used for video live streaming, therefore enabling online lecture streaming. Whereas, Microsoft Teams also brings features specific to LMS tools such as assignment management, grading management and even quiz taking through forms. Moreover, Microsoft Teams is taking the game to next level through its rich available applications integration within the platform (e.g. Microsoft 365)

In relation to existing approaches, the proposed tool engages students in active learning and collaboration by allowing them to propose multiple choice questions based on studied class concepts. The question design process involves students not only creating a question, but also providing the rationale for the answer choices. Teachers and certified class reviewers supervise the entire process, and collaborative reviews are conducted to improve question quality, if required. Thus, the proposed tool introduces a new approach to enhance the learning process through active learning and collaboration.

3 DESIGNING A TOOL FOR EFFICIENT LEARNING

Over the past few years, significant progress has been made in the science of learning, enabling us to gain a better understanding of effective teaching and learning principles. Through rigorous research, we now have compelling evidence and specific recommendations regarding the strategies that educators and learners can employ to gain learning efficiency, as highlighted in (Agarwal and Henry L. Roediger, 2018), (Dunlosky et al., 2013), and (Weinstein et al., 2018a). As for the scope of this research activity, three learning strategies - elaboration, retrieval practice, and feedback are integrated into the proposed e-learning

platform with the aim of enhancing the student learning process in their formation as professionals.

3.1 Closer Abides to Elaboration Principle

Elaboration refers to the process of generating an explanation for why a given fact or concept is true, as noted in (Dunlosky et al., 2013). This approach helps connect new information with existing knowledge, thereby enhancing learning. However, research suggests that it is crucial for students to check their answers with available class materials or teachers when using this technique, as poor elaboration content may hinder learning (Clinton et al., 2016).

Our proposed platform, *Closer*, is used by students to elaborate multiple choice questions for assessment tests based on a specific to be learned concept. The elaboration questionnaire format for adding questions includes different fields such as: question field, correct answer/s field, *elaboration field*, covered concepts and syllabus fields, difficulty level field. The course's instructor analyses the proposed question and sends individual feedback to each student. In this way, by using the designed platform, students are challenged not only to process the content in order to develop specific questions for a test, but, at the same time, they are challenged to elaborate the rationale on which the questions and the correct answer are based on, following in this way the elaboration principle of effective learning.

3.2 Closer Abides to Retrieval Practice Principle

The retrieval practice learning strategy, also known as practice testing, involves recalling information in low or no-stakes contexts for formative purposes. It includes also various forms of testing that students can engage with independently. This strategy not only shows knowledge of the information, but also strengthens and expands it. The efficacy of testing as a learning tool is based on numerous studies, such as (Runquist, 1983), (Henry L. Roediger and Karpicke, 2006) and (Zaromb and Roediger, 2010). Moreover, research states that testing a subset of information can also impact memory for related but untested information (Chan, 2009), (Chan, 2010), (Chan et al., 2006), (Cranney et al., 2009), (Dunlosky et al., 2013).

The Closer platform was designed to offer a context for students by self-testing the learned content. The tests consist of multiple choice questions developed by students and analysed and approved by teachers. The platform allows the combination of these questions using different criteria – level of difficulty, the specificity of the content. In the validation phase of the platform, the students practice self-testing, where each practice test is accompanied by feedback involving the presentation of the correct answer.

3.3 Closer Abides to Feedback Principle

The feedback strategy improve learning by revealing students about their strengths and weaknesses and also helps them to become more aware of their own learning process (Agarwal and Henry L. Roediger, 2018). In addition, it is strongly advised to incorporate feedback into practice testing as research indicates that it can protect students to repeat errors when responding to practice tests (Butler and Roediger, 2008).

Feedback is another strategy on which our proposed platform was built on. Thus, the Closer platform was designed so that students obtained feedback in different moments along their learning process: when the multiple choice questions were finalized, individualized feedback was delivered by teachers in order to help students to refine their questions; at the end of each self-test practice, feedback was offered regarding correct answers, the quantity of covered content, the position of student in his/her group hierarchy based on his/her testing results.

4 COLLABORATIVE LEARNING

The term of collaborative learning can be found in a variety of activities where students, or both teachers and students involve their powers in solving problems, understanding new concepts or developing new products (Smith and MacGregor, 1992). Collaborative oriented learning environments no longer aim for individual performance, but rather focus on fostering a culture of teamwork, cooperation and team growth. In this respect, collaborative learning contributes on shaping students on two dimensions: information gaining and social skills development (Johnson and Johnson, 1984).

Given the benefits of collaborative learning, this section concentrates in presenting two collaboration mechanisms: student-teacher and student-student collaboration, and their integration as part of the proposed E-Learning software system. Although it is described in more depth as part of Section 5, one of the core features of the proposed platform is the question proposal system. Through this feature, students can contribute to their course by proposing multiple

choice questions which, once accepted, are added to the course question data-pool.

4.1 Student-Teacher Collaboration

The first collaborative aspect of the question proposal system is built upon the student-teacher collaboration. Once a student proposes a new question, the question review process begins. Among the persons involved in the review process are the course coordinators (involved actors described also in Subsection 4.2). Hence the first collaborative process is integrated as part of the proposed E-Learning software system. Through the question proposal system, besides the class contribution aspect, the solution also aims for students to develop their skills and abilities in terms of writing on the studied topic in a professional manner. In this respect, students collaborate with teachers in order to achieve the best version of a question before it gets added to the course question data-pool.

Once a student submits a question for review, teachers can view the course pending questions on the *Question Data-Pool* section from the course dedicated page within the web platform. Regardless if a student proposed is directly accepted (without further modifications required), or not, the student will receive feedback from teachers. However, the collaborative mechanism is put in place when a question requires modifications before it gets added to the course data pool of questions (illustrated in Figure 1).

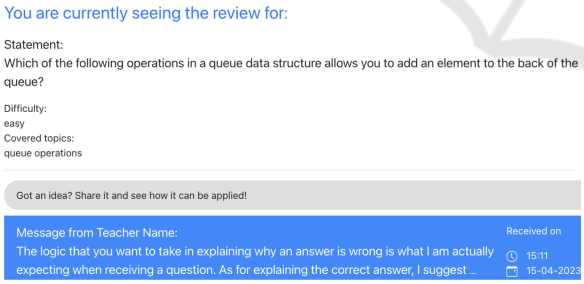

Figure 1: Teacher-student Collaboration.

4.2 Student-Student Collaboration

Up until now, the student-teacher collaborative component of the question proposal system has been presented. In this respect, throughout this part the focus will shift towards the second collaborative component of the question proposal system: student-student collaboration. In a similar fashion, certain students can review and send feedback to questions proposed by their classmates. This collaborative process is inspired by the peer review which happens in software development teams (and not only), when a team member will perform code review for a task implemented by another team member. As part of designing an efficient collaborative process of type student-student one should ask himself/herself the following: *Should all students be reviewers? and What makes a student suitable to become a reviewer?*. Therefore, as part of creating an efficient learning environment, the question proposal system of the proposed software system is designed based on the following concepts: course eligibility criteria and enforced reviewer mode.

The course eligibility criteria is a mechanism through which teachers decide the minimum requirements for a course participant to become a reviewer. Teachers are allowed to build their criteria according to their liking, being able to create simple conditions such as: *"student should have at least one accepted proposed question"*, to more complex conditions containing conditionals. As for what an eligibility criteria can be, the proposed solutions features the following options: Points Criteria, Proposed Questions Criteria and Compounded Criteria (using the logical operators: and, or). All of this is available in the Class Customization page of the a coordinated course.

The idea that there is no one-size-fits-all type of system is also valid for the proposed solution, therefore the course eligibility criteria may not be suitable for all students. In this respect, the *enforced reviewer mode* is enabled for special cases. Through this feature teachers can make some of their students reviewers, even if they do not yet fully meet the eligibility criteria. Based on observation, teachers can see whether some students already have the necessary skills required for performing a good question review. In this respect, teachers are allowed to enforce the reviewer quality for a student on a course. In order to design a fail safe mechanism, teachers are also provided with the possibility of withdrawing the enforced reviewer status of a student.

The student-student collaboration process can increase the culture of teamwork and help students in developing social skills and abilities that will serve them later in life. Besides the long term benefits, through this system the overall waiting times for a question to be added to the course data pool could also be reduced. Nevertheless, the course data pool is constantly updated, which means that students can generate tests based on a wider range of questions.

5 CLOSER: AN E-LEARNING SOFTWARE SYSTEM

As part of this paper a possible solution to be used in higher education (but not only) as an E-Learning software system is being presented. This section will cover the key features of the proposed E-Learning tool, delve into the platform's architectural aspects, and outline the essential elements that contribute to an authentic learning experience.

5.1 Closer Overview

The proposed E-Learning software, Closer, is built upon the concepts of active learning (Freeman et al., 2014; J., 2011) and collaborative learning. The platform is built based on the following ideology: each organization (in this scenario: universities) has affiliated teachers and students registered on the platform. Each teacher can create courses and let other teachers join their course as coordinators, while students enroll in the taken university courses. Courses have their syllabus attached, bringing transparency for students and each lecture is present in the platform as a module. Each module has a list of attached keywords through which a student can easily understand the main covered topics of that module. The collaborative aspect of the platform has already been described in more depth as part of Section 4 and it consists of the multiple choice question proposal system. The platform comes as a helping tool for students in their preparation for exams, in this respect each student or teacher proposed question is gathered in a question data pool from which students can generate tests. Each question from the data-pool has an attached list of keywords describing the main covered topics and at the quiz generation step, students can customize tests to cover desired class covered topics.

5.2 Closer Architecture

The proposed E-Learning system is entirely hosted on cloud, making use of the Amazon Web Services (AWS) cloud provider services. However, as part of this subsection the focus will be centered on presenting the main application components, making abstraction -as much as possible- of the cloud services involved in building the application. Figure 2 presents a simplified view over the system's architecture, which is composed of: web client, data layer (or the API), serverless component and the storage layer.

By far, the most important component is the data layer, which consists of a Django based REST API application and is the core of the proposed software system. Through this layer, the web client is provided with all the required information and functionalities. The data layer assures data persistence by communicating with the Postgres database and object storage through an AWS S3 dedicated bucket. This layer also handles the integration of the system with other systems, such as OpenAI and the serverless component. More about the serverless component is described as part of Subsection 5.4 and the OpenAI integration is described as part of Subsection 5.5.

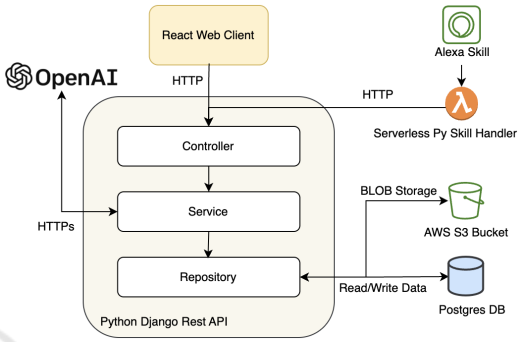

Figure 2: Closer: Simplified Architecture Diagram.

5.3 Closer Infrastructure Overview

When talking about a software system such as the proposed one, another important aspect to be mentioned is the underlying infrastructure and the existing deployment processes. As part of Subsection 5.2, it was mentioned that the proposed E-Learning software system is cloud based, however the underlying used cloud services were not mentioned. In this respect, through Figure 3 the services and processes involved in creating a production ready ecosystem for the proposed system are emphasized.

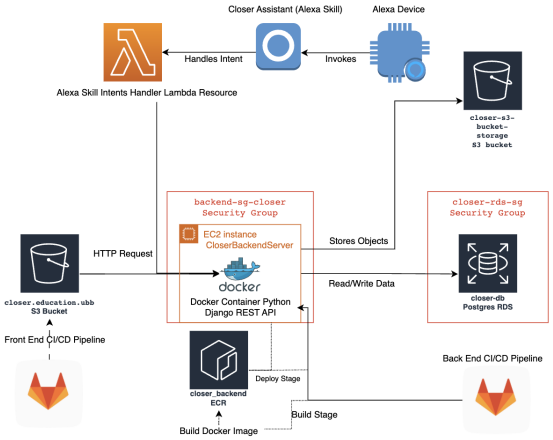

Figure 3: Closer: Infrastructure & CI/CD Processes.

Before jumping into the particularities of some in-

frastructure components, one of the main problems that arise in infrastructure building is the problem of efficient infrastructure management. In this respect, some DevOps best practices from the industry are integrated in the proposed software system: Infrastructure as Code (IaC) and Continuous Integration/Continuous Development (CI/CD) pipelines. In a more formal way, one could understand by IaC as the process whose aim is to achieve infrastructure automation by means of techniques used in software development (Morris, 2016). This underlying used tool for IaC is Terraform, through which the infrastructure corresponding to the proposed system is configured via HashiCorp Configuration Language (HCL) configuration files. HCL is similar to JSON and is the underlying configuration language used by Terraform. By using the Terraform tool, one could easily manage the infrastructure for a cloud based application, while spinning up an entire environment in cloud is as done via a simple *terraform apply* command.

As for the underlying CI/CD involved processes, the proposed system present three main pipelines: *Infrastructure Deployment Pipeline*, *Back-End Deployment Pipeline* and *Front-End Deployment Pipeline*. The first pipeline has the role of creating/updating the underlying cloud infrastructure, while the last pipelines build and deploy on cloud the REST API and web client. In this respect, through CI/CD practices one could enhance the speed of delivering new features by means of automating some steps, such as software delivery and testing (Fitzgerald and Stol, 2017; Kumar and Mishra, 2016).

Nevertheless, some other particularities that come across the infrastructure of the proposed software system are the following: dockerized back-end application and serverless component. Docker is a *Platform as a Service* product which enhances the development of a software product. Through virtualization the application run inside a docker container becomes platform independent, thus a more efficient development process is created. As for the serverless component, the proposed solution runs a Python script inside an AWS Lambda Function. Serverless components take out the responsibility of infrastructure management, while it also enhances easiness in scalability and lower response times. Thus, the serverless component contributes to a better overall user experience and faster development.

5.4 An Authentic Learning Experience

Voice assistants have rapidly become part of our daily lives, providing convenience and ease in performing various tasks. From controlling lights to making calls, these voice-powered devices have simplified our routines. In this respect, the focus will now shift towards one of the most important components of the proposed E-Learning software system, namely the Closer Voice Assistant, which is powered Alexa (Amazon powered voice assistant).

The decision of integrating a voice assistant as part of the proposed E-Learning system was born based on the desire of creating a learning experience that is more relaxant and appealing for students. Traditional web applications are mostly based on visual interaction and user manual input, which can be inconvenient for simple actions. In this respect, by integrating the platform with the Alexa voice assistant, students can now obtain their desired information by means of simple voice commands.

Given its current state, the commands available through the voice assistant can be classified into two categories based on their scope: general class commands and quiz taking commands.

The first category of commands, the general class commands, are commands through which the students can quickly get information with respect to their academic status. Such commands include listing taken courses, next class on a day's schedule, or retrieving current study level on a class (element of gammification). Through such commands students reduce unnecessary interaction with the web platform, enhancing the overall learning experience and reducing time spent on finding desired information.

The second category of commands consists of integrating the examination system with the Alexa voice assistant. The quiz generation flow is illustrated through figure 4. However, students can not fully customize Alexa generated tests, which is possible on the dedicated web platform. In this respect, as a way of overcoming the earlier mentioned drawback, a new set of commands have been introduced and allow students to take through Alexa platform generated tests.

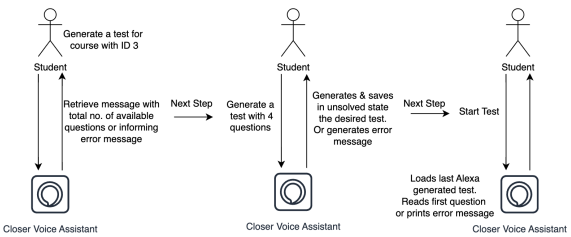

Figure 4: Closer Voice Assistant: Quiz generation flow.

Besides bringing an authentic learning experience, the quiz taking via Alexa can help students in getting more comfortable with the oral exams, which were more common during the pandemic times.

5.5 Acknowledging the Power of AI

Regardless of ones personal preferences, artificial intelligence is experiencing a rapid surge in popularity and utilization across various domains. In this respect, it is important to acknowledge the benefits that AI usage can have in education. Thus, the question proposal system is integrated with the engine that also powers the newest miracle of AI: ChatGPT, an OpenAI product launched in late November 2022.

The integration of the proposed E-Learning software system with OpenAI aims to enhance the student skills in question proposal, helping them to understand how to classify a question based on a defined difficulty scale, understand the covered topics of a question and many more. This feature enables the concept of personalized tutoring (Baidoo-Anu and Owusu Ansah, 2023) with instant feedback, which almost impossible in asynchronous activities such as the one modeled through the question proposal system. It is important to allow students to explore what the world has to offer, rather than restricting them in a rigid system.

On a technical level, ChatGPT uses a Generative Pre-training Transformer model, which is a deep learning neural network usually used for natural language processing and it proves to be efficient for text generation, language translations and many others (Haleem et al., 2022). However, no AI product is perfect, and ChatGPT is no exception. Among some of the acknowledged problems of ChatGPT one can spot biased responses (due to training data set containing biased data) and bad responses on simple questions. Thus, usage of such a tool requires increased attention from the user.

Given the benefits that such an integration brings to the proposed E-Learning software system, it is time to shift the focus towards what this integration actually consists of. The proposal of a new question consists of 3 steps: selecting the target modules covered by the question, building the question statement and answer building step. In this respect, the last two steps were the ones that have been integrated with OpenAI.

As part of the question creation step, students have to complete the question statement, assign a level of difficulty for that question and select the main covered topics based on a provided list of keywords. If the student did not overuse the OpenAI integration, a message stating the possibility of using that feature will be shown. If enabled, the system will automatically generate live suggestions regarding the suitable level of difficulty for that question and the covered topics (based on the available topics). Furthermore, if the proposed question is vague and the system can not clearly state a level of difficulty, the system will automatically suggest a list of possible answers for which the proposed question has the suggested difficulty level. In a similar fashion, the OpenAI integration can be used during the answer creation step.

6 CONCLUSIONS AND FUTURE WORK

The rapid increase in technology development comes with specific environments for educational purposes. Events such as Covid-19 forced the education system to change the way of teaching. These constraints create gaps between how teachers transfer knowledge to students and how students acquire that knowledge. To counter these limitations, both student-centered teaching methods and educational platforms that integrate these methods are needed.

The proposed solution takes into consideration the three main principles that lead to efficient learning and models active and collaborative learning through the question proposal system and the quiz taking system. Moreover, the authenticity of the platform and the overall learning experience is given by integrating the Alexa voice assistant and empowering students to use, in a controlled environment, some of the functionalities provided by ChatGPT, an OpenAI product.

As for the future work with respect to this solution, one important step will be marked by validating the proposed solution based on the ongoing research study by analysing data gathered from the handed surveys. Moreover, integrating the platform through multiple university classes, would be another target with respect to the future of this project.

Lastly, further developing the proposed learning model is also an aspect to be considered for future work. In this respect, one possible addition would be enabling students to collaboratively build questions within the platform.

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