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SUBJECT

Enhancing E-Learning through Automated Quiz Generation and Course Summarization

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Dedication

We dedicate this thesis to all those who, in one way or another, contributed to its completion.

Our deepest gratitude goes to our parents for their unconditional love, moral support, and constant encouragement throughout this journey.

A special thank you to our supervisor, Dr. Brahimi Mahmoud, for his availability, valuable advice, and guidance during this project.

We are also grateful to our friends and colleagues for their support, encouragement, and invaluable assistance in helping us overcome difficult moments.

Lastly, we thank everyone who believed in us and helped us achieve this goal.

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General introduction

The twenty-first century is witnessing an unprecedented shift in education, primarily due to the use of technology into classroom settings. Traditional educational techniques and approaches often include face-to-face training and static resources. Education could be provided through innovative e-learning opportunities that give students unparalleled freedom in accessing educational content at any time and from any location, eliminating geographic and temporal limits, rather than changing and improving old ways. Since e-learning allows for more individualized and self-directed learning, students are now able to take charge of their education.

The entire potential of e-learning remains unrealized despite these advancements. Effective material delivery, assessing learning outcomes, and giving students opportunities for involvement are a few persistent issues. Providing learners with timely feedback on their progress and enabling them to self-assess their learning is a critical area of need. This is where automation could be useful, especially for creating quizzes and summaries of the course materials.

In this perspective, our goal is to propose an application that assists learners in their learning and revision tasks by automating key aspects of the process. The application offers course summaries to help students digest large amounts of knowledge, while also generating personalized quizzes based on their progress, enabling them to evaluate their understanding. Additionally, a chatbot feature facilitates discussions, providing further clarification and deeper insights into the studied material.

By integrating quiz generation, course summarization, and chatbot support, this application not only eases educators' workloads but also creates a more personalized, dynamic, and engaging learning experience. These technologies, when incorporated into e-learning systems, have the potential to revolutionize education by making it more efficient, accessible, and tailored to individual needs, ultimately benefiting learners from all backgrounds.

To achieve our goal, the structure of this dissertation is divided into three main chapters. The first chapter introduces the concept of e-learning, discussing its evolution, benefits, and the various technological tools used to enhance the learning experience. The second chapter focuses on the design of the application, detailing the planned features, educational goals, and the methods employed to create a solution that meets learners' needs. The third chapter covers the implementation of the application, explaining the technological choices, development stages, and tests conducted to ensure the product's quality. Finally, we conclude this dissertation with a general conclusion with some future perspectives to further improve.

Chapter I

E-Learning: An Overview

Introduction

Through the use of technology, e-learning has completely changed education by removing barriers to traditional learning and opening up a variety of flexible learning options. This chapter examines how e-learning has developed through time, starting with computer-based training and moving on to the highly developed online learning environments of today. The conversation centers on three primary topics: developing quizzes with the greatest possible educational impact, summarizing courses using AI, and AI-powered tools for contemporary learning. This chapter explores these revolutionary elements in more detail, highlighting both their potential for even bigger contributions to digital learning in the future as well as their critical significance in the current educational practice.

I.1. E-Learning

I.1.1. Definition

E-learning combines two major areas: learning and technology. Learning is a cognitive process for acquiring knowledge, and technology is an enabler of the learning process, which means that technology is used in the same way as any other tool in the educational praxis, such as a pencil or a notepad. While this may seem simple and reasonable, a pencil is a more technologically transparent tool, and as a result, its use may look more natural to many. Furthermore, because technology encompasses multiple aspects, it serves as a foundation for other problems. E-learning systems combine several tools, including writing technologies, communication technologies, visualization, and storage. For these reasons, various researchers and scientists attempted to transform e-learning systems into technically transparent tools, similar to a pencil or notebook. The literature on e-learning is extensive and continues to increase at a rapid pace. Research into the acceptance and use of e-learning technologies also reveals continuous increase around the world. The growth rate of online courses is 65%, and others argue that state-level e-learning laws should be pushed. E-learning is an interactive learning system that employs communication and information technologies. It is based on an integrated digital and electronic environment that delivers courses via electronic networks, provides advice and counseling, tests, and manages and evaluates resources and processes. E-learning is important for solving the problem of knowledge explosion, increasing demand for education, and

expanding opportunities for admission to education, as well as enabling workers to be trained and educated without leaving their jobs, contributing to breaking psychological barriers between the teacher and the learner, meeting the learner's needs and characteristics, and increasing the return on investment by lowering the cost of education. [1]

I.1.2. A Brief History of E-Learning

The British philosopher Francis Bacon, as early as the 1600s, stated that "Knowledge is power," emphasizing the relationship between knowledge and authority. Education, whether through e-learning or traditional means, plays a critical role in personal and societal development. Learning and knowledge are seen as key factors in economic and social advancement, as highly educated individuals have better opportunities to improve their lives [2].

Education also has a profound impact on individual freedom, as discussed by Sen, who argued that education enables people to live the lives they choose while unlocking their full potential [3].

The development of correspondence education in the 19th century, particularly in Europe and the U.S., marked the beginning of long-distance learning. Universities like Wisconsin and Chicago were pioneers in this area [4]. By the 1970s, new media technologies, such as videotapes and satellite transmissions, transformed long-distance education [5].

The 1990s saw an unprecedented growth in distance learning due to the rise of the Internet. This shift has enabled universities to offer more flexible learning opportunities, allowing students to study remotely and benefiting institutions economically. Society has evolved into a knowledge-based society where creativity drives progress [6].

Modern concepts like the flipped classroom and e-learning have emerged, allowing teachers and students to leverage ICTs in the educational process. Research shows that ICTs and e-learning create flexible solutions for students, particularly those studying remotely [7]. Although transitioning to e-learning can be costly, the long-term benefits include greater accessibility and cost-effectiveness for higher education [8].

I.2. Types of e-Learning

While some e-learning scientists have chosen to concentrate on other metrics like synchrony and learning material, others have classified the different forms of e-learning based on the learning instruments. Overall, distinguishing between the ten different forms of e-learning is simple. The ten distinct e-learning categories are as follows:

1. Computer Managed Learning (CML).

2. Computer Assisted Instruction (CAI).
3. Synchronous Online Learning.
4. Asynchronous Online Learning.
5. Fixed E-Learning.
6. Adaptive E-Learning.
7. Linear E-Learning.
8. Interactive Online Learning.
9. Individual Online Learning.
10. Collaborative Online Learning.

Some instructional scientists have decided to categorize different sorts of e-learning more simply. They distinguish only two types of eLearning: computer-based e-learning and web-based e-learning. Such a classification approach could be considered more accurate because it distinguishes between e-learning and online learning, which are frequently used interchangeably when they should not be. Some forms of e-learning, such as CML and CAI, do not require online delivery yet are nevertheless considered e-learning.

I.2.1. Computer Managed Learning (CML)

Computers are used to manage and assess learning processes in computer-managed learning, also known as computer-managed instruction, or CMI. Data bases are used by computer-managed learning systems to function. These latter include various ranking parameters that allow the system to be customized based on the preferences of different students, along with bits of information that the student must learn. Because there was two-way communication between the learner and the computer, it was possible to determine whether the student had satisfactorily met their learning objectives. If not, the steps can be taken again until the learner meets their intended learning objectives. Educational institutions also utilize computer-managed learning systems to store and retrieve data that supports educational management. This could contain information about lectures, training materials, grades, the curriculum, and enrollment, among other things. [9]

I.2.2. Computer Assisted Instruction (CAI)

Computer-Assisted Instruction, commonly known as computer-assisted learning, is another type of e-learning that combines computers with traditional education. It could refer to interactive software for students or training software used by Stanford University's Patrick Suppes in 1966. Computer-assisted training approaches boost learning by combining multimedia elements such as text, pictures, music, and video. The main advantage of CAI is its interactivity. It encourages students to be active

participants rather than passive learners by providing opportunities for practice through quizzes and other computer-assisted teaching and testing systems. Almost every modern online and traditional school is using different kinds of computer-assisted learning in a bid to facilitate the development of skills and knowledge among their pupils. [9]

I.2.3. Synchronous Online Learning

Synchronous online learning is a kind of learning where groups of students participate in a learning activity together at the same time from any place in the world. Real-time synchronous online learning often involves online chats and videoconferences because these tools enable training participants and instructors to ask and answer questions instantly while being in a position to communicate with the other participants. This kind of community-oriented online learning has been made possible with the rapid development of online learning technologies. Before the invention of computer networks in the 1960s, truly synchronous e-learning was practically impossible to implement. Nowadays, synchronous e learning is considered to be highly advantageous as it eliminates many of the common disadvantages of e-learning, such as social isolation and poor teacher to student and student-to-student relationships. Synchronous e-learning is currently one of the most popular and fastest-growing sets of e-learning. [9]

I.2.4. Asynchronous Online Learning

By definition, asynchronous online learning, for instance, groups of students study at different times and locations without real time communication taking place. It is true, asynchronous e-learning methods are believed to be more student-centered than their synchronous counterpart since they afford more flexibility. A number of students who cannot have flexible schedules also prefer asynchronous e-learning for such reasons since this would allow them to use self-paced learning wherein they can set their own timeframes for learning and are not required to learn at specific time intervals together with other students. Before the development of the PLATO computer system, all e-learning was asynchronous since there were no ways through which computers were able to network. Nowadays, with the presence of computers and the World Wide Web, decisions between synchronous and asynchronous e-learning are even more difficult to make since each has their pros and cons. [9]

I.2.5. Fixed E-Learning

Fixed e-learning is the name for something which you are most likely already familiar with. By the term 'fixed', it means that the content used during the process of learning remains unaltered from their

original state, and the knowledge imparted to all the participating students is the same as received by the others. The materials pre-set by the teachers also do not adapt to the student's preference. This is the standard of learning that has been used in traditional classrooms for thousands of years, but it is not ideal for an e-learning environment. That is because fixed e-learning does not make use of the prized real-time data gained from student inputs. Analyzing each student individually through his or her data and making changes to the materials according to that data result in better learning outcomes for all students. [9]

I.2.6. Adaptive E-Learning

Adaptive e-learning is a brand-new, innovative kind of e-learning that permits adaptation and redesign of learning materials for each learner individually for the first time. Considering several parameters like the performance of students, their goals, abilities, skills, and characteristics, adaptive e-learning tools make education more individualized and student-oriented than ever. Well, we have come to that point in time when the lab-based adaptive instructive techniques can now be utilized for mathematical sequencing of student data. If done right, that could very well mark the beginning of the educational sciences. Although such an e-learning is more difficult to plan and accomplish than traditional teaching methods, yet the potential value and effectiveness is often understated. [9]

I.2.7. Linear E-Learning

Linear, in this context, would mean that information passes from sender to receiver, without exception. For an e-learning situation, this is quite a limiting factor as it doesn't provide two-way communications between teachers and students. Of course, this form of 'e' learning does find its place in education; however, its relevance is too narrow to be practical and is declining with time. Classic examples of such linear e-learning include sending training materials to students through television and radio programs. [9]

I.2.8. Interactive Online Learning

This way, interactive e-learning allows senders to become receivers and vice versa, effectively providing a two-way communication channel between the concerned parties. The teachers and students can change their mode of teaching and learning from the messages sent and received. For this reason, interactive e-learning is considered to be considerably more popular compared to linear, since it allows the teacher and students to have a more open communication with each other. [9]

I.2.9. Individual Online Learning

In this context, individual learning refers to the number of students taking part in achieving the learning goals, not the student-centeredness of the material. This kind of learning has been the practice in traditional classrooms for several thousand years. While practicing individual learning, the students study the learning materials on their own and are expected to meet their learning goals on their own. This kind of learning is not ideal for developing communicational skills and teamwork abilities in students because it greatly focuses on the perspective of students learning individually without communication with other students. Therefore, a modern approach should be required to supplant the communicational of skills and abilities. [9]

I.2.10. Collaborative Online Learning

Collaborative e-learning is a modern learning method where many students learn and achieve their objectives as a group. Students have to work in cooperation and practice teamwork so that they meet the common learning objectives of students. It can be achieved by making effective groups where each individual student takes into consideration the strengths and weaknesses of each other student. This strengthens the communicational skills, team working abilities of the students. Collaborative e-learning extends the thought that knowledge is best created within a group of people where they can share and learn from each other. While this kind of learning is more common in traditional classrooms compared to online courses, it's nevertheless a valid kind of e-learning which can be extremely powerful if executed the right way. [9]

I.3. E-Learning Evolution

E-learning has transformed from a matter of convenience to an integral part of today's education and is flexible, hence dismantling geographical barriers in learning [10]. The COVID-19 pandemic accelerated the pace at which this may happen, propelling e-learning from an important option to an absolute necessity. As campuses of educational institutions across the globe shut their physical doors, e-learning emerged as the foremost means of ensuring continuity in education [11]. This had been an unparalleled situation where e-learning showed its potential for the creation of safe, accessible, and adaptable learning environments during crises. Besides accelerating the adoption of digital learning tools, the pandemic accelerated innovation by educators in developing radically new online teaching methods. The sudden immersion into e-learning brought to light immense potential along with revealing challenges that spurred advancements in online pedagogies, assessment methods, and student

engagement strategies needs community credit [12]. In the future, some of the lessons learned during this period will likely have a lasting impact, and e-learning will be among the suite of educational strategies globally. The rapid shift away from traditional towards online learning has positioned e-learning at the forefront of today's modern education framework, forging ahead towards the next innovative and inclusive processes in learning.

I.4. Key Challenges in the E-Learning Landscape

While e-learning has demonstrated immense promise and has grown increasingly important, particularly in light of global events such as the COVID-19 pandemic, it is not without obstacles. These challenges cover the technological, pedagogical, and social domains, and overcoming them is critical to the continued progress and efficacy of online education.

I.4.1. Student Engagement and Motivation

Maintaining student involvement in a virtual setting can be difficult. The lack of face-to-face interaction and the possibility of distractions in home contexts might lead to lower motivation and participation [13]. E-learning platforms must find new ways to encourage active learning and keep students interested over time.

I.4.2. Adapting Pedagogy to Online Formats

Many educators struggle to effectively translate traditional teaching approaches into online formats. This includes difficulties in developing engaging activities, facilitating group work, and offering hands-on experiences in virtual environments [14]. There is a need for innovative pedagogical techniques that take advantage of the distinct characteristics of digital platforms while retaining educational quality.

I.4.3. Assessment and Academic Integrity

Ensuring the credibility of online tests is a significant challenge. Traditional examination methods may not be appropriate for online situations, and there is a higher possibility of cheating or plagiarism [15]. Creating secure and fair assessment systems that effectively measure student learning in online environments remains a challenge.

I.4.4. Social Interaction and Collaborative Learning

E-learning can sometimes create feelings of isolation among pupils. Replicating social aspects of learning, such as peer-to-peer interactions and collaborative projects, in a virtual setting is difficult yet necessary for a well-rounded educational experience [16].

I.4.5. Teacher Training and Technological Proficiency

Many educators, particularly those accustomed to traditional classroom settings, may lack the abilities required to effectively employ e-learning tools. There is an urgent need for comprehensive training programs to assist teachers in adapting to online teaching approaches and tools [17].

I.4.6. Quality Assurance and Standardization

With the development of online courses and programs, maintaining consistent quality across multiple platforms and universities is difficult. Developing and applying standardized quality assurance criteria for e-learning is critical to ensuring the legitimacy and effectiveness of online education [18].

I.4.7. Data Privacy and Security

Because e-learning platforms collect and retain massive amounts of student data, maintaining the privacy and security of this information is critical. Compliance with data protection rules and security against cyber-attacks present constant issues. [19].

I.5. Enhancing E - Learning Experience with AI-Driven Tools

The field of e-learning is rapidly expanding, fueled by an ever-increasing need for better ways to learn and teach online. Traditional online courses typically face numerous challenges in maintaining student attention and frequently fail to meet each need individually. This was demonstrated when colleges and institutions around the world were forced to close abruptly owing of the COVID-19 pandemic. There is an urgent need for innovative technologies that will make e-learning more successful and engaging for everyone. Artificial intelligence is emerging as a viable solution to these issues. AI has a significant impact on online learning. It generates tailored study plans that take into account individual demands in terms of content and pace. Lessons are tailored to students' learning styles, which keeps them interested and improves learning outcomes significantly. AI can analyze students' performance in real time, providing teachers with useful insights into who may require

additional assistance. Even better, some of the fascinating ways AI can aid include course summaries and quiz production. The AI will then obviously study a lot of course material and summarize the important ideas in short lines to save the learner time during review. It is also capable of creating quizzes that assess the student in a very specific manner. These tools will undoubtedly save students time and allow them to focus on what is most important while periodically testing their knowledge. This pandemic necessitated the transition to online modes of learning, emphasizing the growing need for adaptable and resilient e-learning platforms. While AI technology improves by the day, so does its potential to make online education more interactive, efficient, and accessible to a larger number of people across the world. It can help create learning experiences that are at least as excellent as traditional classrooms, if not better.

I.6. Enhancing Educational Effectiveness through Course Summarization and Quiz Generation

Automatic course summarization and quiz production are popular methods for improving the e-learning experience. First, such AI-powered features address two critical difficulties in online education, thereby significantly increasing its efficiency. Course summary is critical in assisting students in dealing with huge amounts of material by utilizing advanced technologies such as natural language processing and machine learning. This saves time and improves recollection of essential topics. This is ideal for review because it allows students to quickly cover the essential elements of a course. Automated quiz production enables both immediate and individualized assessment chances. Such quizzes can adjust to a student's progress, focusing on areas where they require more experience. Continuous assessment enhances learning, highlights knowledge gaps in specific areas, and is particularly beneficial for providing feedback to both students and instructors.

I.7. Benefits of Course Summarization and Quiz Generation

- Efficient Learning: Summarization allows for quick review and reinforcement of key concepts.
- Personalized Pace: Students can focus on areas they find challenging, using sum-maries as a guide.
- Self-Assessment: Regular quizzes help students gauge their understanding and identify weak areas.
- Flexible Study: Summaries and quizzes can be accessed anytime, supporting self- paced learning.
- Improved Retention: The combination of summarization and quizzing enhances long-term memory retention.
- Time-Saving: Automated summarization and quiz generation reduce manual con- tent creation

time.

- Insight into Student Progress: Quiz results provide data on student performance and areas of difficulty.
- Adaptive Teaching: Instructors can adjust their teaching strategies based on data from summarization and quiz analytics, helping them create more understandable and effective courses.
- Consistent Quality: AI-generated materials maintain a standard quality across the course.
- Scalability: These tools allow instructors to manage larger classes more effectively.

Together, these techniques improve e-learning efficiency and engagement. They enable a more tailored learning experience by catering to various learning speeds and styles. As e-learning expands, features like as course summaries and quiz production play an increasingly important role in making online education more effective, accessible, and similar to traditional classroom settings.

Conclusion

In conclusion, e-learning has emerged as a transformative force in global education, driven by AI-powered technologies that enhance personalized learning experiences. Features like course summaries and automated quiz generation have significantly improved educational outcomes, showcasing the potential of technology to create adaptive, accessible, and efficient learning environments. As digital innovations continue to evolve, they pave the way for a future where education is more inclusive, engaging, and tailored to individual student needs, fostering lifelong learning and preparing learners for success in an ever-changing world.

Chapter II

Analysis and design

Introduction

Like any IT project, the development of our e-learning enhancement tool, a Chatbot designed to assist students in revising their lessons, requires a thorough analysis phase followed by a detailed design stage. In the analysis phase, our primary objective is to deeply understand and precisely de ne the needs of students who will interact with the Chatbot as part of their learning process. The design phase then translates these insights into a practical solution that not only meets educational goals but also enhances the overall e-learning experience.

To ensure the Chatbot is both modular and user-friendly, we employ the Unified Modeling Language (UML) and its various diagrams, including use case, sequence, and class diagrams. These tools help us to carefully map out the Chatbot's structure and behavior, focusing on creating an intuitive interface and effective functionalities. Ultimately, our aim is to design a tool that seamlessly integrates into e-learning environments, improving the way students engage with and revise their course material.

II.1. UML (Unified Modeling Language)

The Unified Modeling Language (UML) is a pictogram-based graphical modeling language designed as a standardized visualization method in the fields of software development and object-oriented design. UML is a synthesis of previous object modeling languages: Booch, OMT and OOSE. Mainly derived from the work of Grady Booch, James Rumbaugh and Ivar Jacobson, UML is now a standard adopted by the Object Management Group (OMG). UML 1.0 was standardized in January 1997; UML 2.0 was adopted by the OMG in July 2005. The latest version of the specification validated by the OMG is UML 2.5.1 (2017). [20]

II.2. UML diagrams

UML diagrams are divided into three categories: Fonctionnelle, Statique and dynamique diagrams as shown in the figure 1

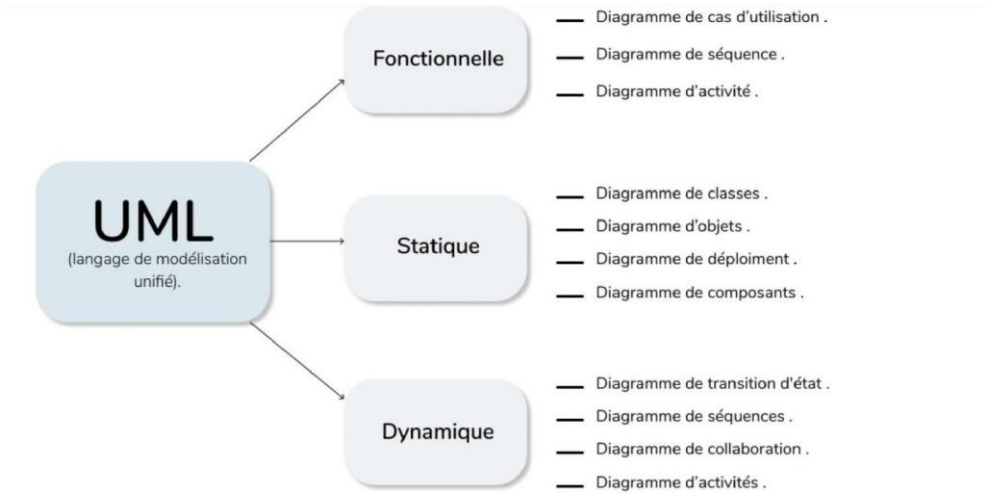

Figure 1. UML diagrams

II.3. Benefits of modeling

Modeling is describing in a visual and graphic way the needs and the functional and technical solutions of the project. [21]. Advantages of modeling can be summarized as:

- Modularity
- Abstraction
- Concealment
- Coherent structuring of functionalities and data

II.4. System modeling

In what follows, we explain the different UML diagrams used in our modeling work

II.4.1. Use case diagram

Use case diagram is a description of the system from the point of view of its user (facilitates the expression of needs), it allows the representation of the functionalities of the system, as it represents the external view of the system. Use case diagrams are developed to visualize the relationships between actors and use cases. [22]

II.4.1.1. Identification of actors

An actor represents a role played by an external entity, such as a human user or another system that interacts directly with the system under study. This interaction can involve consulting and/or modifying the state of the system by sending and/or receiving messages that may carry data.

In the context of our learning assistant Chatbot, we have identified a single primary actor which is the student. He is the primary user of the system, responsible for uploading course materials, interacting with the learning assistant Chatbot to review content, asking questions related to the course material, receiving summaries, and participating in generated quizzes to reinforce their understanding. The learning assistant Chatbot is specifically designed to support the student in these activities, thereby enhancing the overall e-learning experience.

General Use Cases:

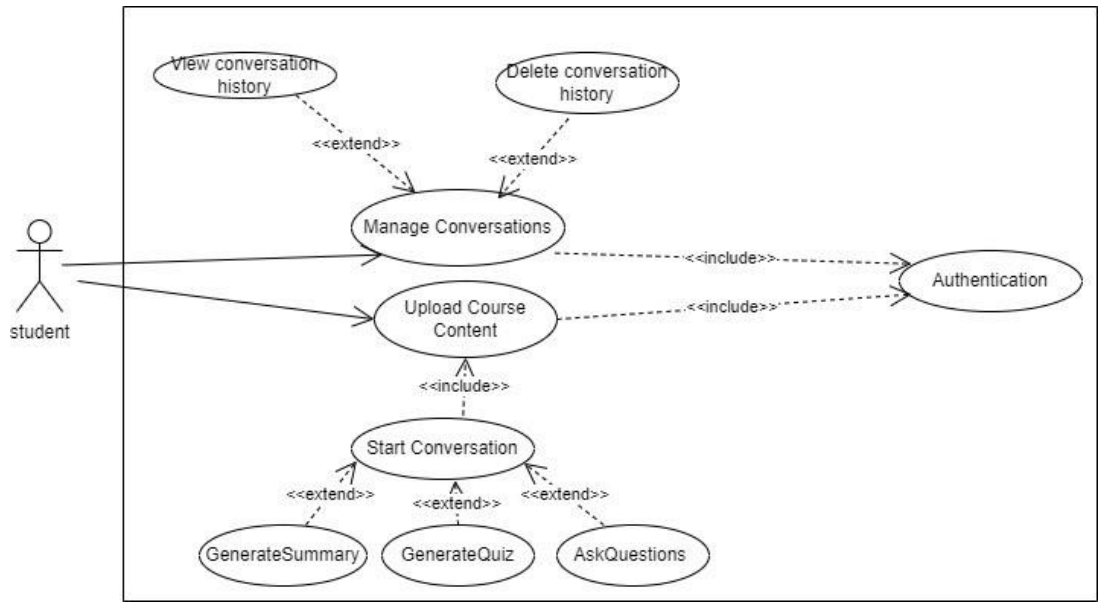

Figure 2. General Use Cases

II.4.1.2. Explanation of the use case diagram

Authentication use case:

Summary: This use case allows a user to securely log in to the system using their credentials (email and password).

Main Scenario:

- The user opens the application and selects the login option.
- The system prompts the user to enter their email and password.
- The user enters the required credentials.

- The system verifies the credentials against stored records.
- If the credentials are correct, the user is authenticated and granted access to the system's features.

Error Chains:

If the user enters incorrect credentials, the system displays a message indicating the account is locked. The user is instructed to contact support or follow a procedure to unlock their account.

Post condition: The user is successfully authenticated and can now access the system's features, such as uploading course content and starting a conversation.

Register use case:

Summary: This use case allows a user to sign up in to the system using their information (email and username and password).

Main Scenario:

- User submits a registration request with a desired Email and password to the System.
- System queries the DB to check if the Email already exists
- DB validates the username:
- If the Email exists, the System responds with an error message indicating that the username is already taken
- If the Email is available, the System stores the new user data in the DB.
- DB confirms the successful storage of the new user data.
- System sends a registration success message to the User and redirect him to the ChatUi.

Error Chains:

- User sends a registration request.
- System checks with DB if the Email exists.
- DB finds that the username already exists.
- System returns an error message to the User indicating that the Email is taken.
- User receives the error message and may need to choose a Different Email.

Post condition: Successfully registered user or an error message if registration failed.

Upload Course Content use case:

Summary:

This use case allows the user to upload course material (PDF, WORD) to the system, which will be used for further interactions like generating summaries, quizzes, and answering questions.

Main Scenario:

- The user selects the option to upload course content.
- The system prompts the user to choose a le from their device.
- The user selects and uploads the le.
- The system processes the le, extracting the text and chunking it.
- The system automatically generates a summary of the uploaded course content.
- The system saves both the course le and the generated summary in the user's account.
- The system confirms that the upload and summary generation were successful, and the content is ready for interaction.

Error Chains:

- If the le fails to upload due to a network issue:
- The system displays an error message indicating the upload failed.
- The user is prompted to try again or check their network connection.
- If the system fails to generate a summary:
- The system notifies the user that the summary generation failed.
- The system allows the user to manually request a summary later.

Post condition: The course content is successfully uploaded, a summary is generated and saved, making both available for further interaction, such as generating quizzes or asking questions.

Description of the Start Conversation use case:

Summary: This use case allows the user to initiate a conversation with the system based on the uploaded course content. The conversation may involve asking questions, generating summaries, or quizzes.

Main Scenario:

- The user navigates to the conversation interface.
- The system checks if the user has uploaded any course content.

- If course content is present:
- The system enables the conversation text input.
- The user starts typing a question or selects an option to generate a summary or quiz.
- The system processes the input and provides the appropriate response (e.g., answers the question, generates a summary, or creates a quiz).
- If no course content has been uploaded:
- The system disables the conversation text input.
- The system displays a message indicating that the user must upload course content before starting a conversation.

Error Chains:

- If the user tries to access the conversation feature without uploading course content:
- The system disables the text input for conversations.
- The system displays a message guiding the user to upload course content first.
- If there is a system error while processing the conversation input:
- The system displays an error message.
- The user is given the option to retry or contact support.

Post condition: A conversation session is successfully started, allowing the user to interact with the course content through questions, summaries, or quizzes.

Ask Question use case:

Summary: This use case allows the user to ask questions related to the course content during an active conversation session. The system provides answers based on the uploaded material.

Main Scenario:

- The user selects the option to ask a question within an active conversation session.
- The user types their question and submits it to the system.
- The system processes the question, referencing the relevant course content.
- The system provides an answer based on the course content.

Error Chains:

- If the question is out of context of the course:
- The system notifies the user that the question cannot be answered.
- The user is asked to ask questions about the course only.

- If the system fails to process the question:
- The system displays an error message indicating a failure in processing.
- The user is prompted to try again

Post condition: The system successfully answers the user's question based on the course content, and the conversation continues.

Generate Summary use case:

Summary: This use case allows the user to generate a summary of the uploaded course content.

Main Scenario:

- The user can request a customized summary, choosing between a brief bullet-point version or a detailed paragraph. A shortcut button also lets them generate another summary with consistent structure and flexibility, using the "Generate Summary" option.
- The system processes the course content to extract key points and create a summary.
- The system presents the summary to the user.
- The user can request another summary again from the system.

Error Chains:

- If the system fails to generate the summary:
- The system displays an error message indicating the failure.
- The user is prompted to try again.

Post condition: A summary of the course content is successfully generated and presented to the user.

Generate Quiz use case:

Summary: This use case allows the user to generate a quiz based on the uploaded course content.

Main Scenario:

- The user requests the chatbot to generate a customized quiz during an active conversation session, selecting options such as the number of questions and difficulty level. A shortcut button also allows them to click "Generate Quiz" to produce the quiz with consistent structure and flexibility.
- The system analyzes the course content to create relevant questions.
- The system presents the quiz questions to the user.

Error Chains:

- If the system fails to generate the quiz:
- The system displays an error message indicating the failure.
- The user is prompted to try again.

Post condition: A quiz based on the course content is successfully generated and presented to the use.

Manage Conversations use case:

Summary: This use case allows the user to view or delete past conversation sessions.

Main Scenario:

- The system displays a list of past conversation sessions.
- The user can select a conversation to view details, continue the conversation or delete it

Error Chains:

- If the system fails to retrieve past conversations or delete a conversation:
- The system displays an error message indicating the failure.
- The user is prompted to try again or contact support.

Post condition: The user successfully manages past conversation sessions, including viewing or deleting them as needed.

II.4.2. Sequence diagrams

The purpose of sequence diagrams is to represent communications with and within the software [23]. It offer a temporal representation of interactions between objects and a chronology of messages exchanged between objects and with actors.

II.4.2.1. Sequence diagrams roles

- Describe the implementation of use cases on the system described by the class diagram
- Internal perspective on how the system works.
- Description at the instance level (state of the system at a given moment).
- Description of particular scenarios
- Representation of message exchanges: Between the actors and the system, between the objects of the system chronologically.

II.4.1.2. Explanation of the sequence diagrams

Upload course sequence diagram:

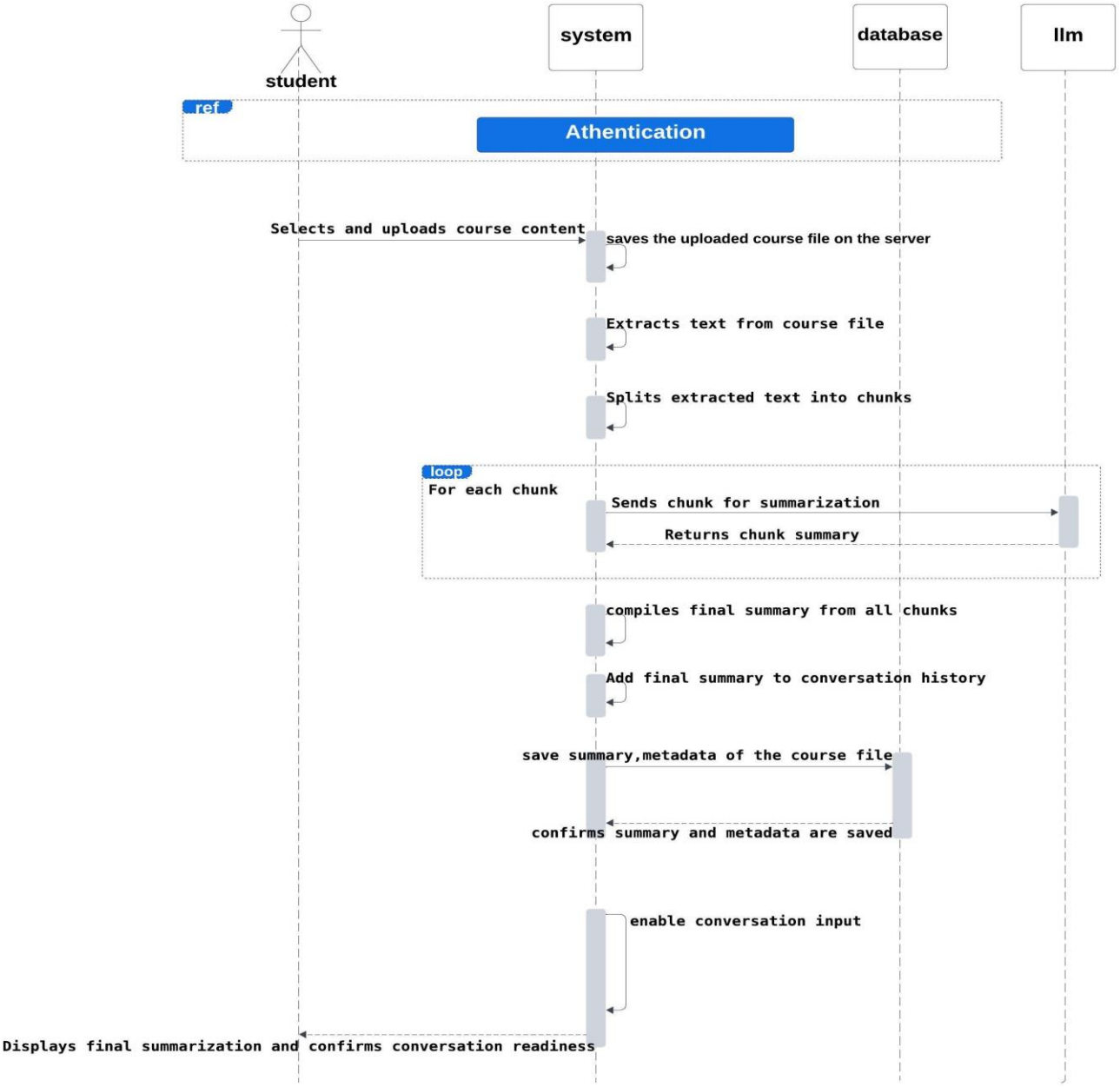

Figure 3. Upload course sequence diagram

Start conversation diagram:

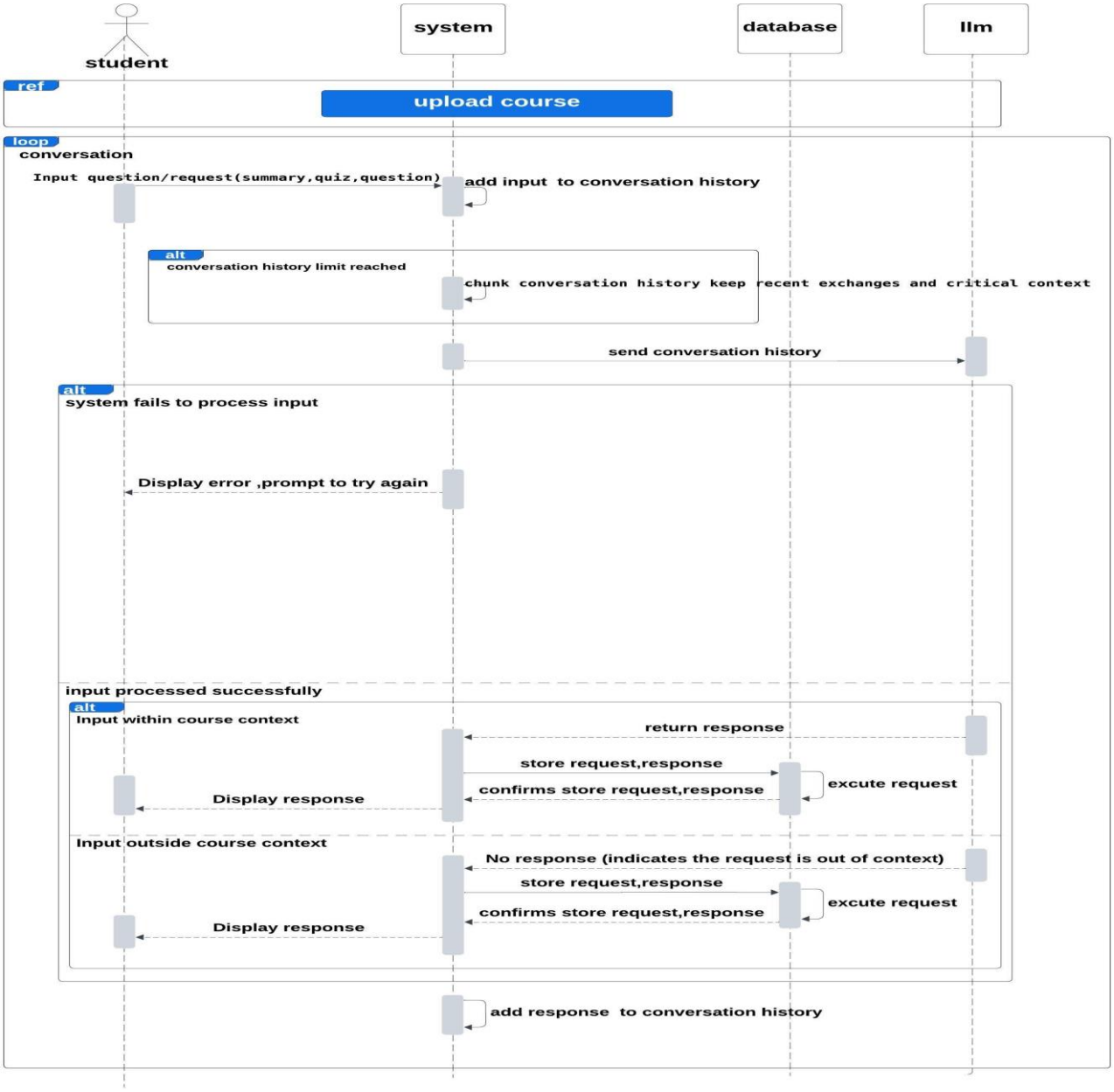

Figure 4. Quiz generation and evaluation diagram

Quiz generation and evaluation diagram:

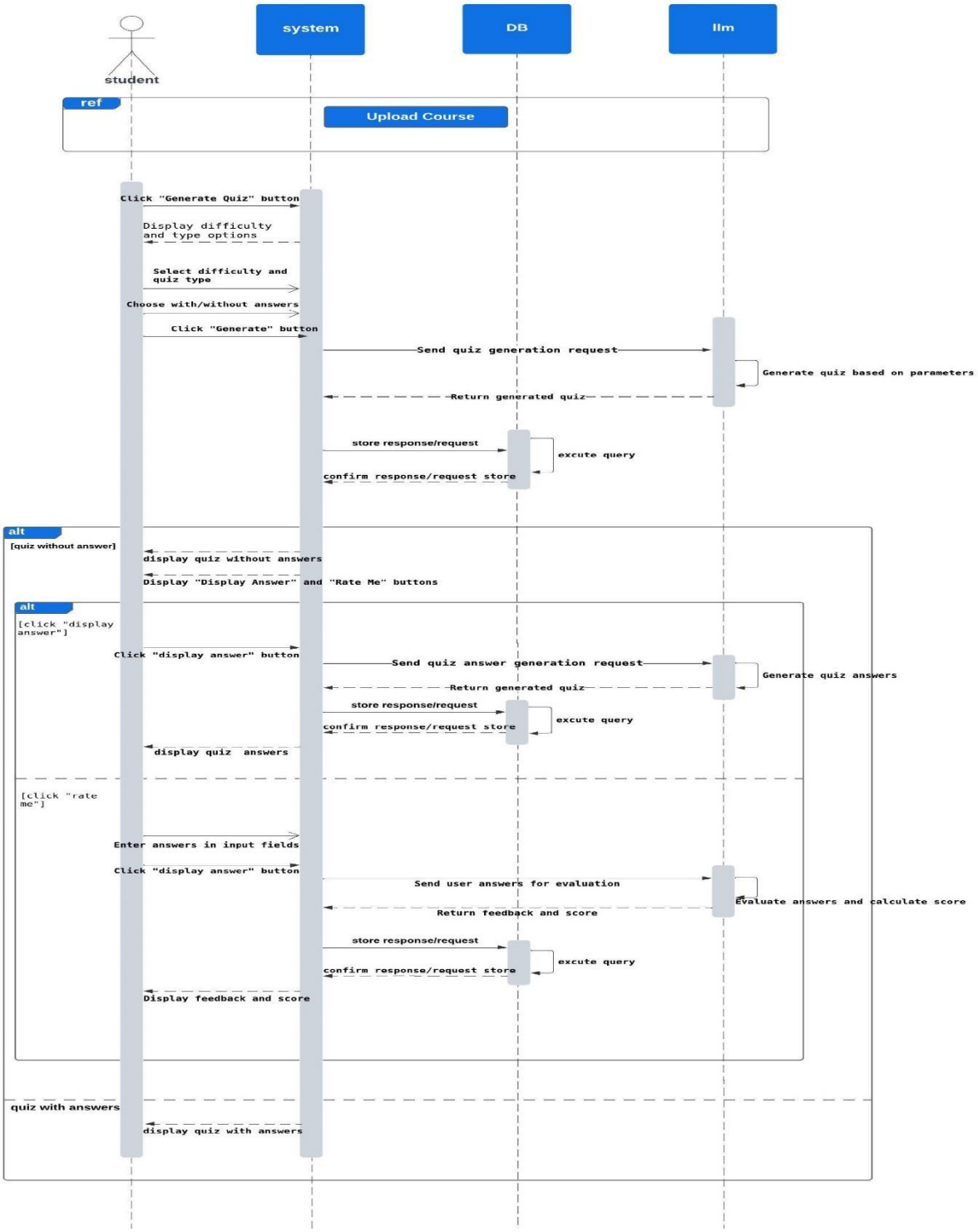

Figure 5. Start conversation diagram

Manage conversation diagram:

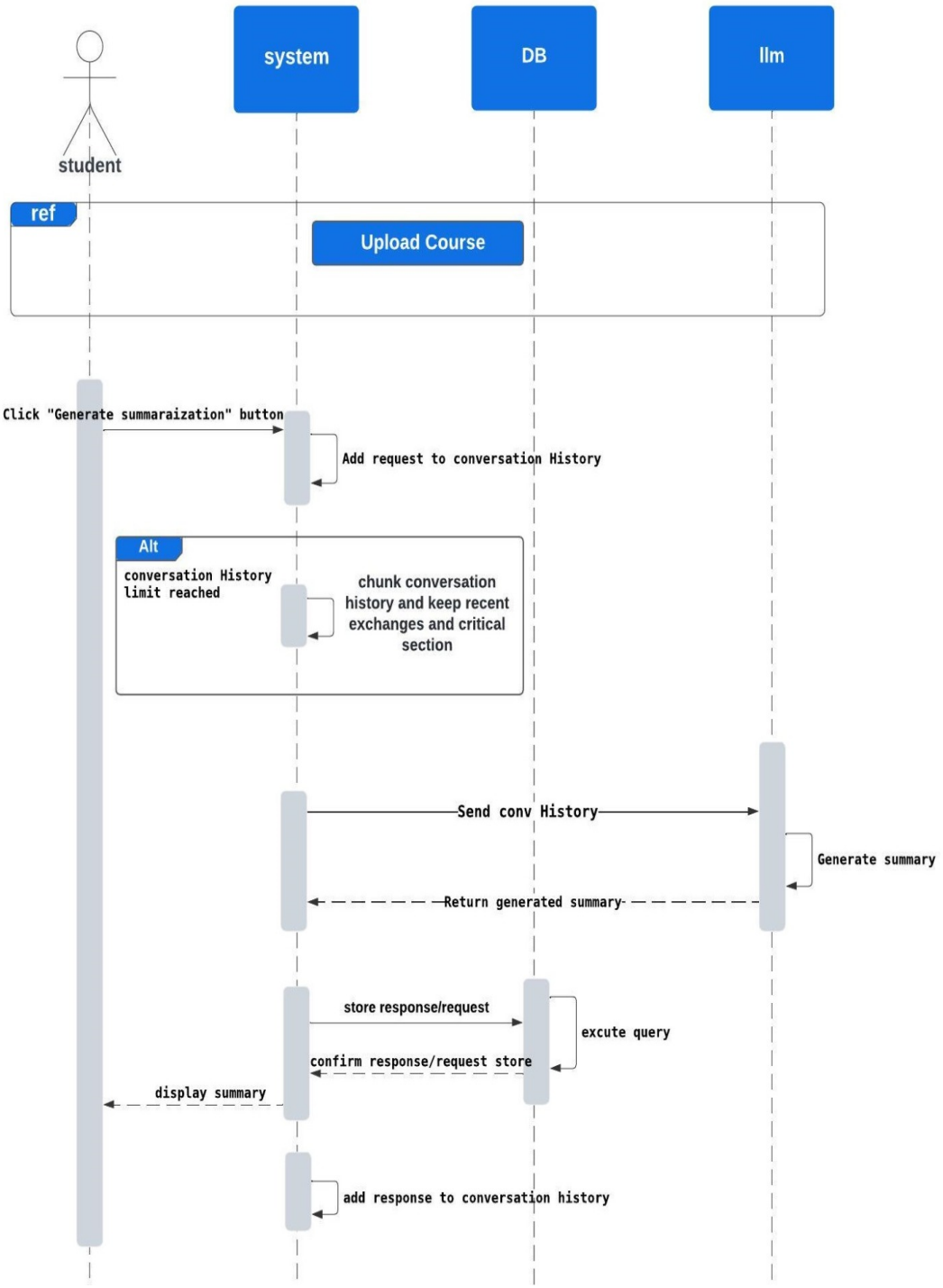

Figure 6. Generate summarization diagram

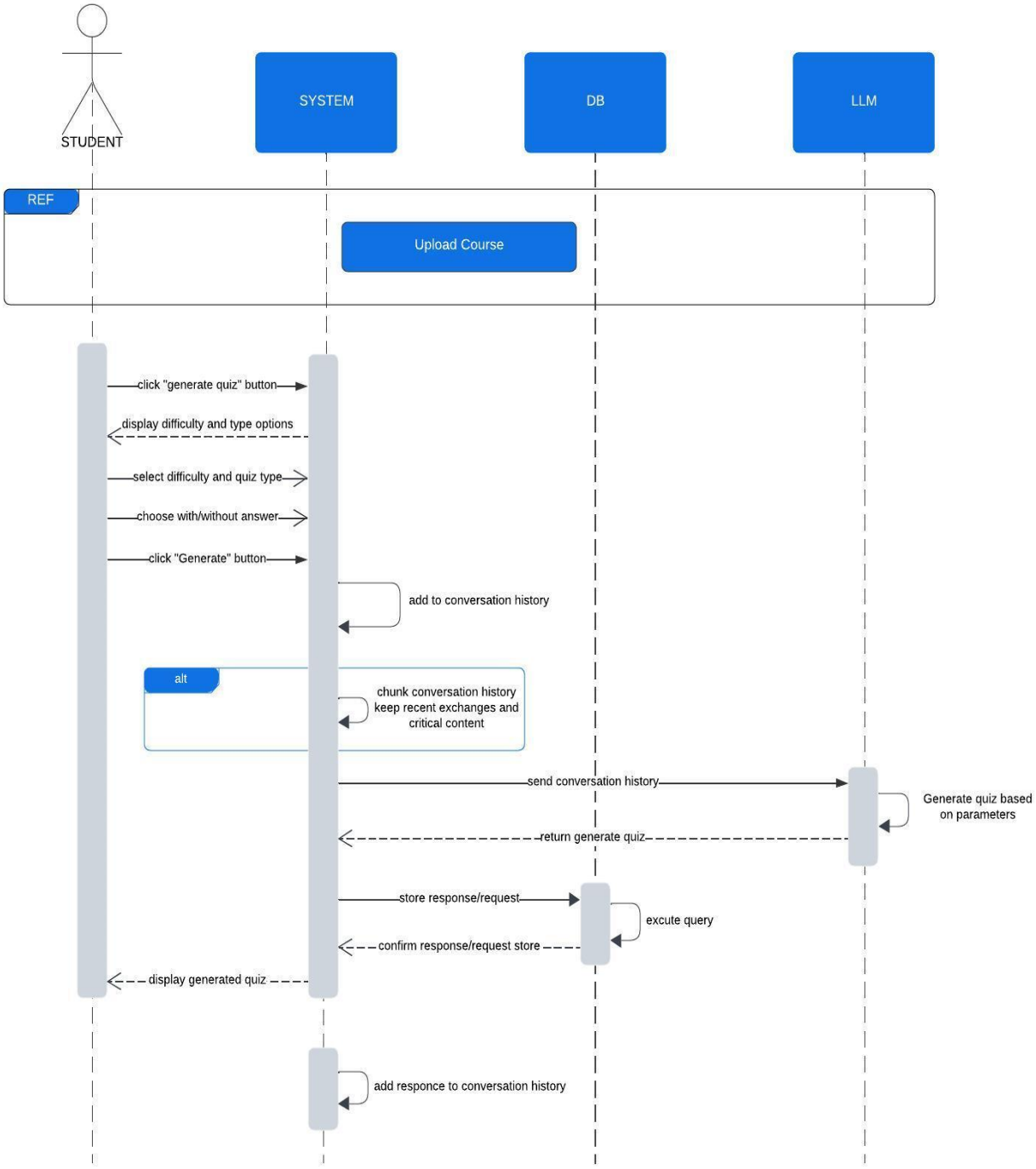

Figure 7. Quiz generation diagram

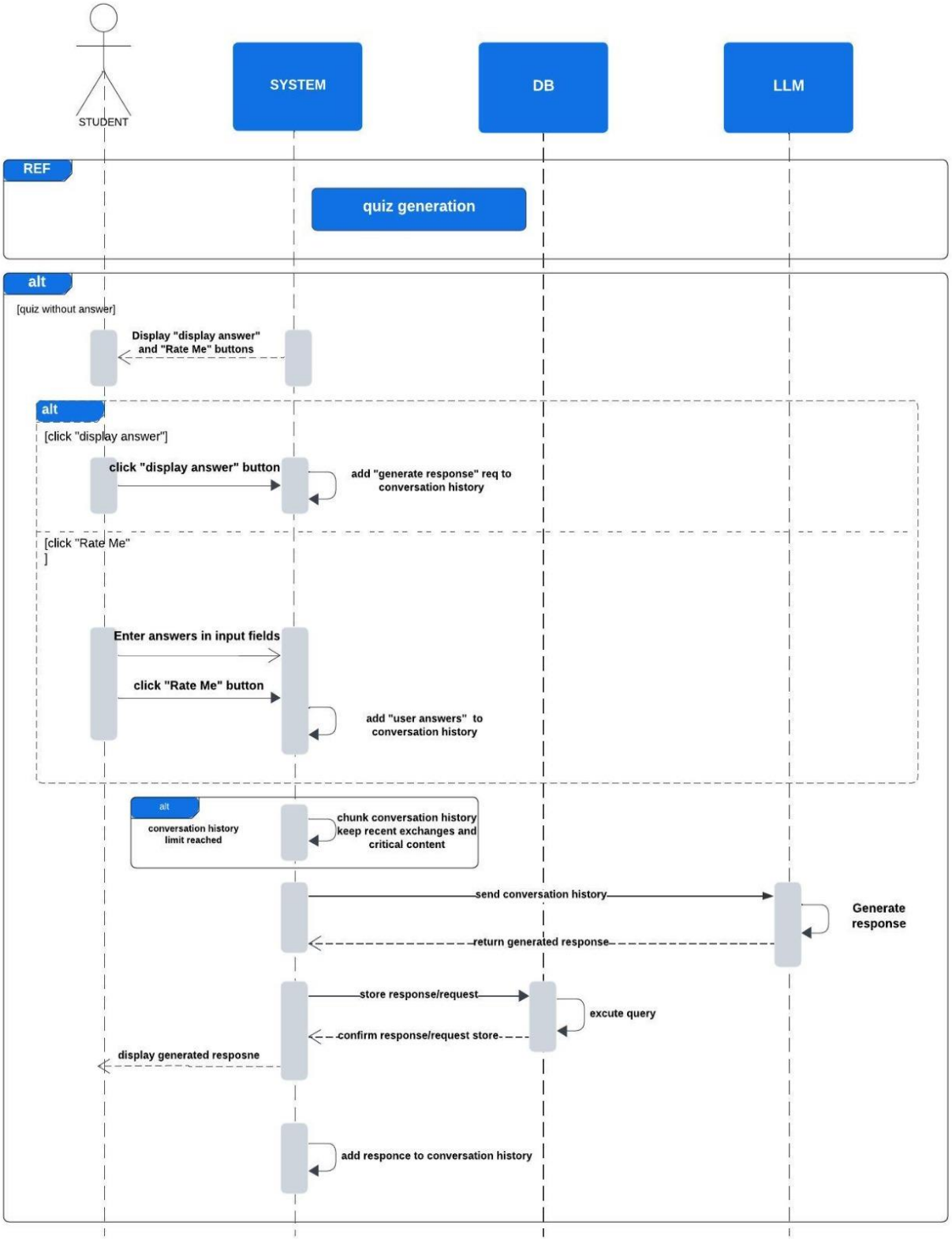

Figure 8. Evaluation and generate answers diagram

II.4.3. Class diagrams

It is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects.[24]

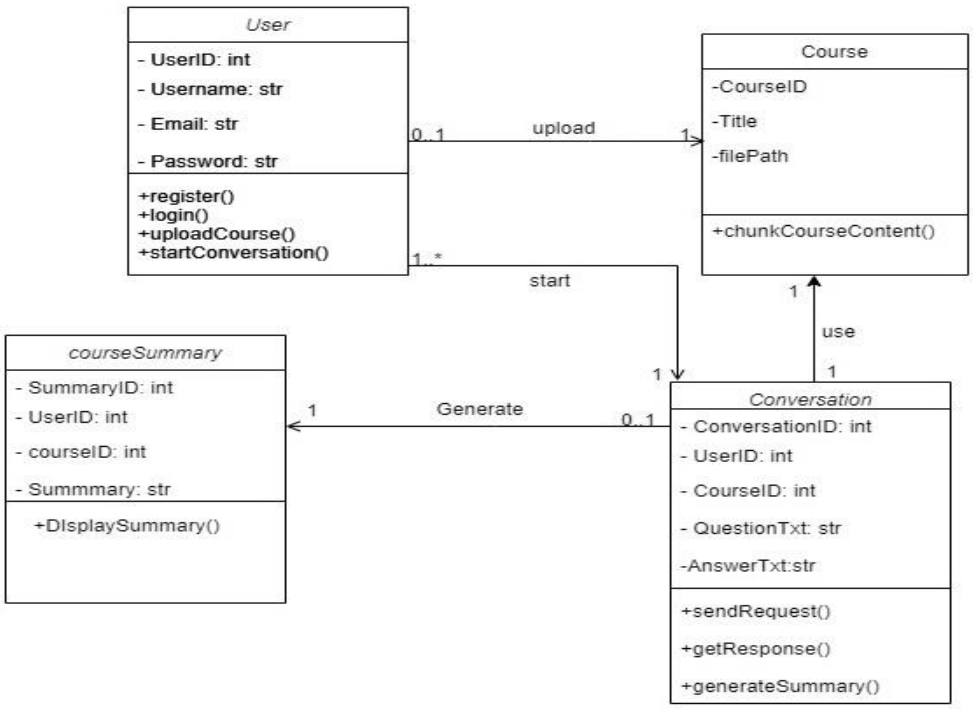

Figure 9. Class diagram

II.4.3.1. Class diagram components

Class: A class represents a blueprint or template for objects in a system, defining the properties (attributes) and behaviors (operations) that the objects created from the class will have. [25]

Attribute: An attribute is a property or characteristic of a class, representing the data or state that objects of the class will hold. [18] Attributes are typically variables like UserID, Email, or Password.

Operation: An operation (or method) is a function or behavior that objects of a class can perform.[25] Operations de ne how objects of the class can interact with data, such as login(), uploadCourse(), or generateSummary().

II.4.3.2. Relational Model

In this section we move from the conceptual description to the relational model, in order to implement our database. A relational model is a model that is not specific to a database and that describes the elements on which an organization wishes to collect data, as well as the relationships between these elements [26]. Consequentially our resulting relational model is as follows:

- Users (*UserID, Username, Email, Password).
- Course(*CourseID,Title,filePath)
- Conversation(*ConversationID,#UserID,#CourseID,QuestionTxt,AnswerTxt)
- CourseSummary(*SummaryID,#UserID,#courseID,Summary)

Conclusion

In this chapter, we have modeled our application using the three main UML diagrams, use case diagram, sequence diagram, class diagram. This modeling has allowed us to improve the understanding of the system developed, also to deduce the relational model that will be used to implement our application which is the subject of our next chapter

Chapter III

Implementation

Introduction

In this chapter, we will delve into the technical aspects of developing our e-learning enhancement tool. We begin by presenting the development tools and programming languages chosen to build the application, explaining how each technology contributes to the functionality and performance of the system. We will also provide an overview of the application interfaces, showcasing the user interface (UI) design and highlighting the key features that make the Chabot intuitive and easy to navigate.

III.1. Software Environment and Development tool

III.1.1. VS Code

VS Code Visual Studio Code, also commonly referred to as VS Code, is a source-code editor developed by Microsoft for Windows, Linux, macOS, and web browsers. Features include support for de- bugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and embedded version control with Git. [27]

III.1.2. Lucidchart

Lucidchart is a web-based diagramming application that al- lows users to visually collaborate on drawing, revising, and sharing charts and diagrams, and improve processes, systems, and organizational structures. It is produced by Lucid Software Inc., based in Utah, United States, and co-founded by Ben Dilts and Karl Sun.[28]

III.1.3. HTML

HTML Hypertext Markup Language is the standard markup language for documents designed to be displayed in a web browser. It defines the content and structure of web content. It is often assisted by technologies such as Cascading Style Sheets and scripting languages such as JavaScript.[29]

III.1.4. CSS

CSS Cascading Style Sheets is a style sheet language used for specifying the presentation and styling of a document written in a markup language such as HTML or XML. CSS is a cornerstone technology of the World Wide Web, alongside HTML and JavaScript.[30]

III.1.5. JavaScript

JavaScript, often abbreviated as JS, is a programming language and core technology of the Web, alongside HTML and CSS. 99% of websites use JavaScript on the client side for webpage behavior. Web browsers have a dedicated JavaScript engine that executes the client code.[31]

III.1.6. MySQL

MySQL is an open-source relational database management system. Its name is a combination of "My", the name of co-founder Michael Widenius's daughter my, and "SQL", the acronym for Structured Query Language. [32]

III.1.7. Express JS

Express.js, or simply Express, is a back end web application framework for building RESTful APIs with Node.js, released as free and open-source software under the MIT License. It is designed for building web applications and APIs. It has been called the de facto standard server
Framework for Node.js. [33]

III.1.8. Groq API

Groq API enables ultra-fast AI inference for Llama 3.1 models, leveraging Groq's Latency Processing Unit (LPU). This infrastructure offers significant improvements in speed, energy efficiency, and scalability compared to traditional systems like GPUs. It supports massive models, such as Llama 3.1 405B, which offer enhanced features like custom tool calling, longer context handling, and multilingual capabilities.

The platform allows developers to easily integrate these models to build applications like real-time decision-making and dynamic content generation. [34]

III.1.9. Llama

The Llama 3 70B is part of Meta’s Llama 3 family of large language models, featuring 70 billion parameters. It comes in both pre-trained and instruction-tuned variants, designed primarily for high-quality dialogue and natural language processing tasks. This version supports a context window of up to 8,192 tokens, enabling it to handle longer and more complex inputs.

The model is optimized for a wide range of uses, including generating text, answering questions, and producing code, with a strong emphasis on safety and helpfulness through techniques like Reinforcement Learning with Human Feedback (RLHF). The instruction-tuned models are specifically fine-tuned for dialogue, making them particularly effective for chat-based applications. Its architecture includes the use of Grouped-Query Attention (GQA), which enhances its scalability and inference. [35]

III.1.10. The Cloudmersive

The Cloudmersive API for text extraction allows the translation of documents into readable text by implementing Optical Character Recognition. Support for a wide range of document formats-from PDF and DOCX to scanned images-allows developers to easily extract structured or unstructured text from these sources. This is useful in the extraction of data, automation of document workflows, or digitization of documents to conduct further analysis on them.[36]

III.2. Presentation of the realized application

In the following section, we present the application that has been developed, detailing its main functionalities.

III.2.1. Authentification page

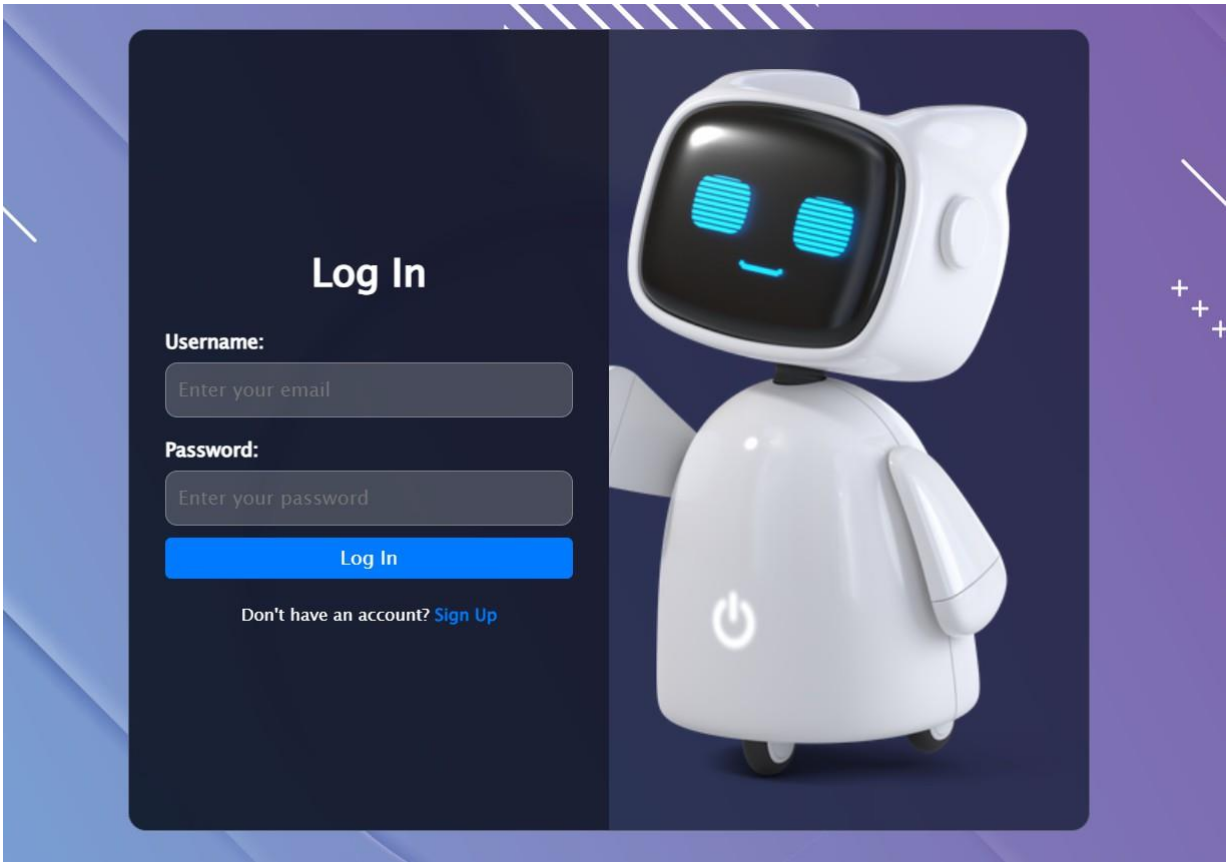

Figure 10. Authentification page

The authentication page where the user enters login data and clicks on login, if the information entered is correct he will be authenticated, otherwise an error message is displayed:

- Incorrect email address
- Incorrect password

III.2.2. Registration page

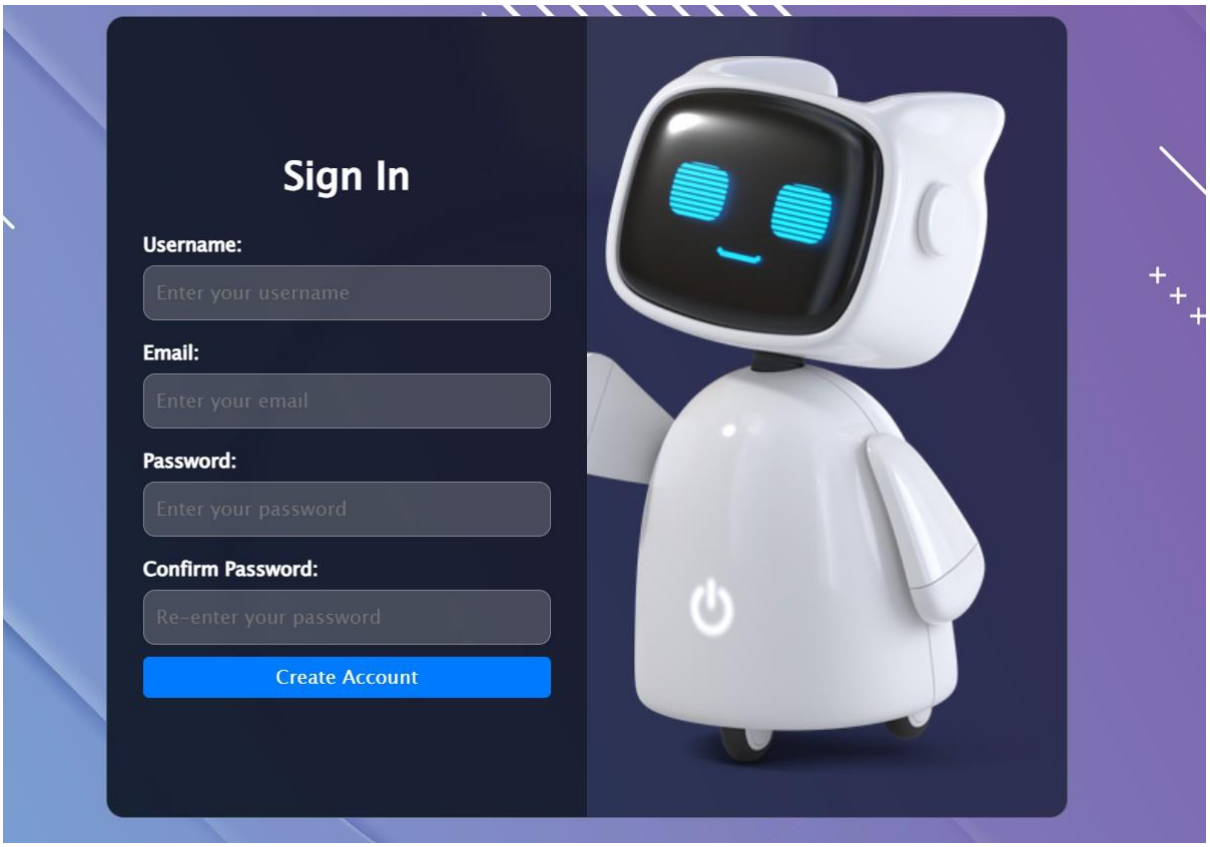

Figure 11. Registration page

The registration page where the user introduce in his personal data and clicks on register. If the information entered is correct, a success message will be displayed and then he will have moved on to the confirmation step of his account, otherwise an error message is displayed:

- Incorrect email address
- Incorrect email address
- Incorrect password
- Passwords are not the same
- Email already exists
- An error has occurred

III.2.3. Chatbot Interface

Introduction and Guide Prompt Description

The first time one opens the chatbot, it will provide instructions on how to use the chatbot

- Welcome Message: Introduces the chatbot and asks users to upload course materials to begin.
- 2-Upload Course Button: The very first step or action users have to execute to upload their course content for all future interactions.
- Generate Summary Button: After uploading, with one click, it summarizes the material by highlighting the key points of the material.
- Generate Quiz Button: Users can create customizable quizzes, such as Multiple Choice, True/False, Short Answer, among others, based on course content.
- Submit & Get Evaluation: Allows the user to submit the quiz answers and get immediate feedback with scores and corrections.
- Ask Questions Box: A text input field where users can ask specific questions regarding their course.
- New Course Reminder: Informs users to start a new conversation when uploading a different course.

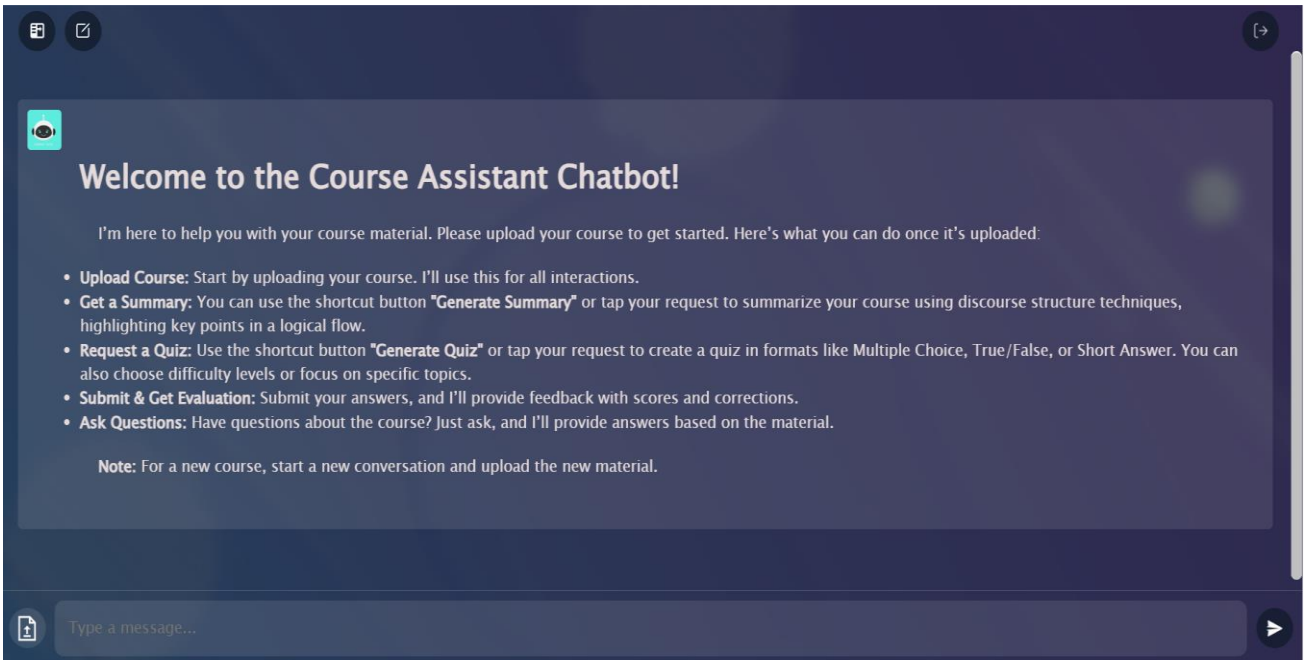

Figure 12. Guide prompt

Summarization Process

Stage 1: Upload of Course and Content-Defined Chunking

When a course document is uploaded, the chatbot uses the Cloudmersive API to extract the text in the course and presents it for processing.

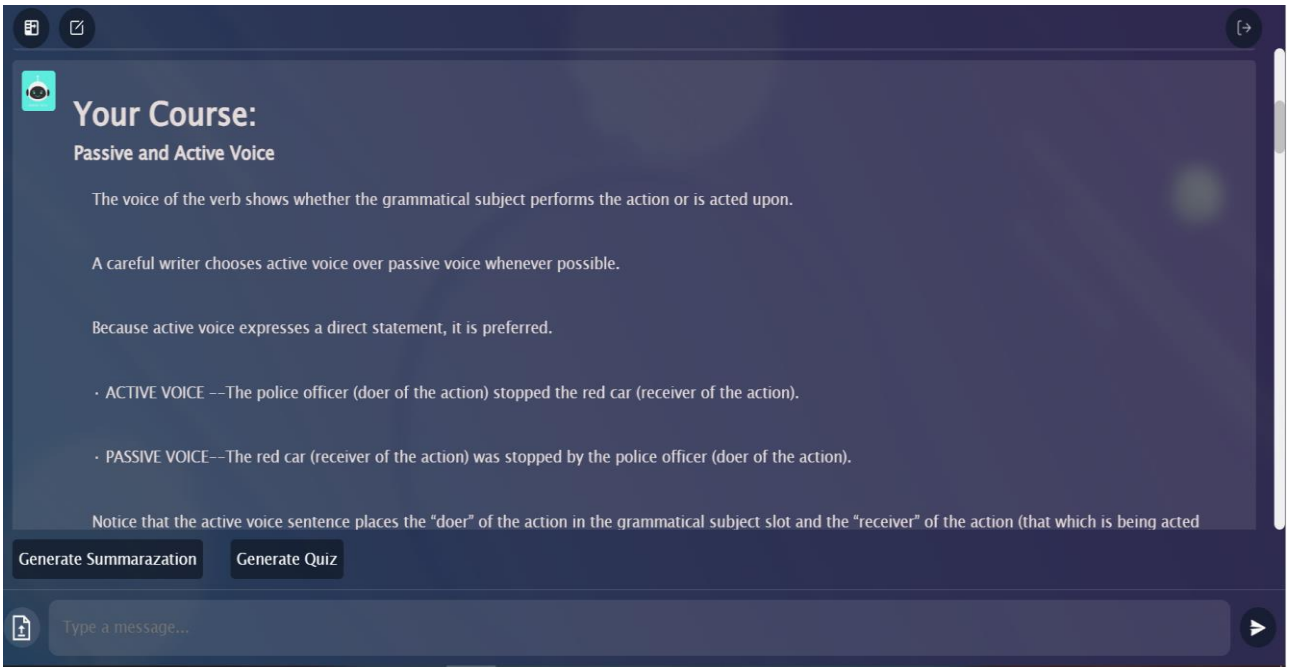

Figure 13. Course Content

The summarization begins by using Content-Defined Chunking. CDC is a method of segmenting data into variable-sized chunks based on the content, rather than based on fixed-size boundaries. By means of a rolling hash technique, CDC determines patterns in the text upon which it decides to set chunk boundaries .This method comes in handy in processing documents that have gone through minimal edits, since it separates only the changed portions and keeps the others unchanged, hence streamlining the processing of the content. [37]

With this course segmented, the model may process each chunk in isolation using Discourse Structure Summarization, a technique designed to stress logical building blocks of information. This approach truly teases out the relations across various segments of the document: the introductions, transitions, and conclusions-and it makes it an effective algorithm for long or intricate materials. First, the model applies Semantic Understanding to identify central ideas, concepts, and discourse markers that are connected to the information. Next, it summarizes into a short form, all original, for each chunk, maintaining the logical flow so that the summary will preserve how different sections are related. This allows the maintenance of coherence, comprising key ideas and supporting details. [38]

Individual summaries are then combined into a comprehensive overview of the course, again

using Discourse Structure Summarization. The model Emphasizes transitions smoothly from one section to the next and refines the final summary to ensure logical relationships that present an overall narrative are preserved.

Outcome

The model summarizes in a concise way using CDC and discourse structure summarization, where the course is divided first into logical chunks and then relationships among key concepts are preserved.

In addition, students can ask questions about the course, request more summaries, and take quizzes to gauge their understanding of the material. The approach is made to be supportive, enabling users to revisit the content and gain a deeper knowledge of it.

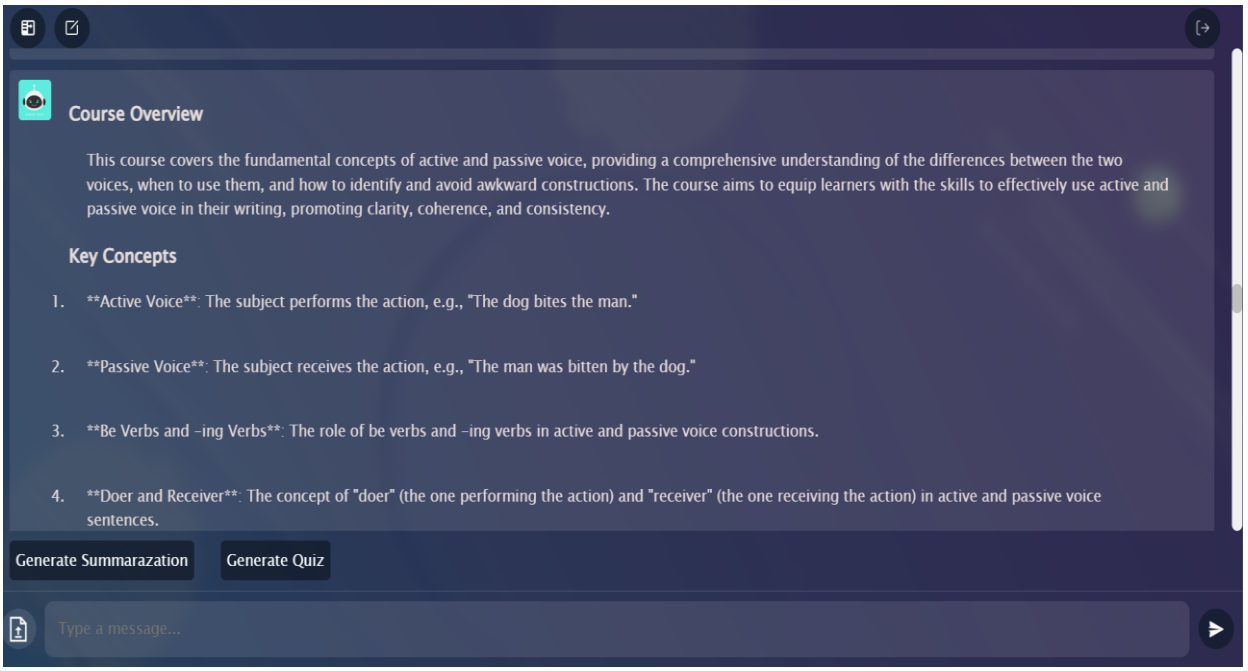

Figure 14. Summary of the course

A shortcut button appears that allows users to create another summary by clicking the "Generate Summary" option. In this manner, the creation of a new summary can be done using similar speech structure techniques in maintaining consistency, while offering flexibility to a new perspective.

Quiz Generation

Generate Quiz Click Button:

- User clicks on a button saying "Generate Quiz."
- Quiz Customizing Options: A combo box would appear listing the following options
- Difficulty: Easy, Medium and Hard.
- Format: The format of the quiz, such as True/False, Multiple Choice, Short Answer.
- Correction: Automatic correction or without correction.

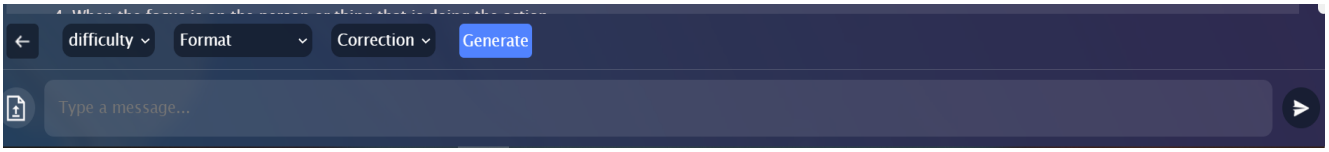

Figure 15. Quiz Customizing Options

Outcome

According to the choice selected by the user, upon clicking the "Generate" button, the quiz generation starts.

With answer:

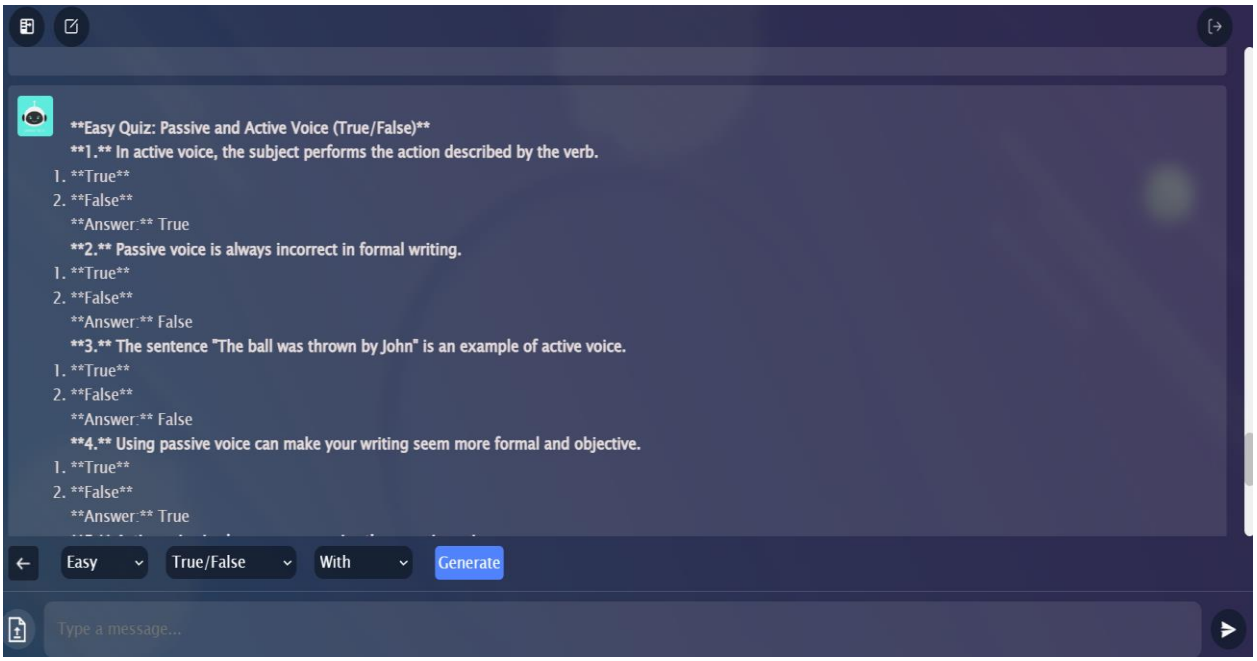

Figure 16. Quiz with answer

Without answer:

Figure 17. Quiz without answer

If the user clicks "Generate Answer", the chatbot displays the correct answers for the quiz, allowing users to compare or study.

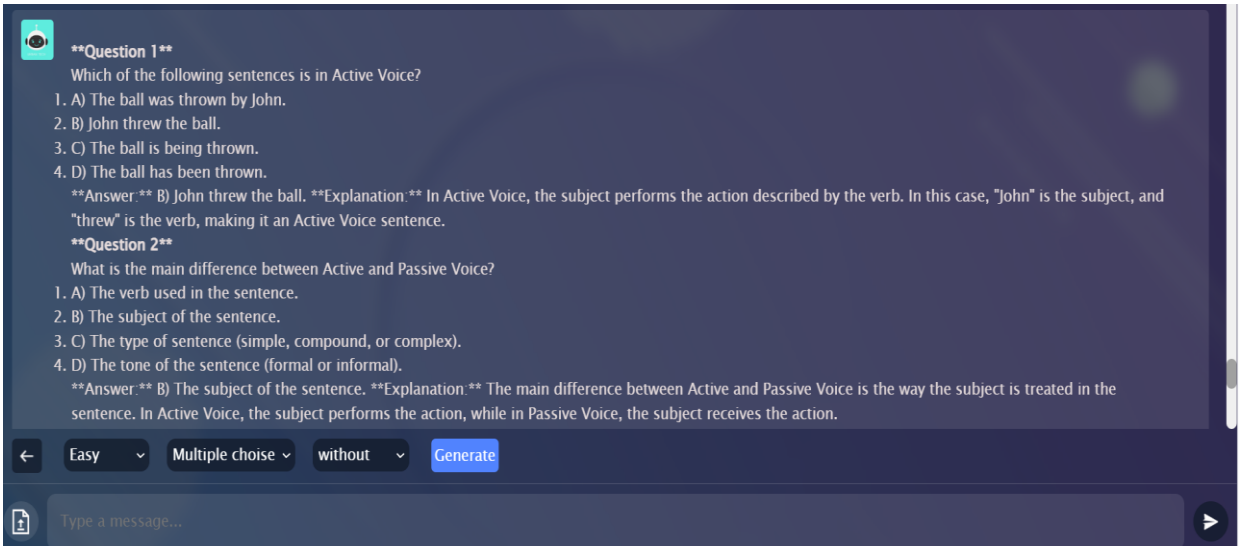

Figure 18. Generate Answer

Evaluation process:

Answer Submission: Users can type their answers in the input fields provided for each question. Once completed, they can click the "Rate Me" button.

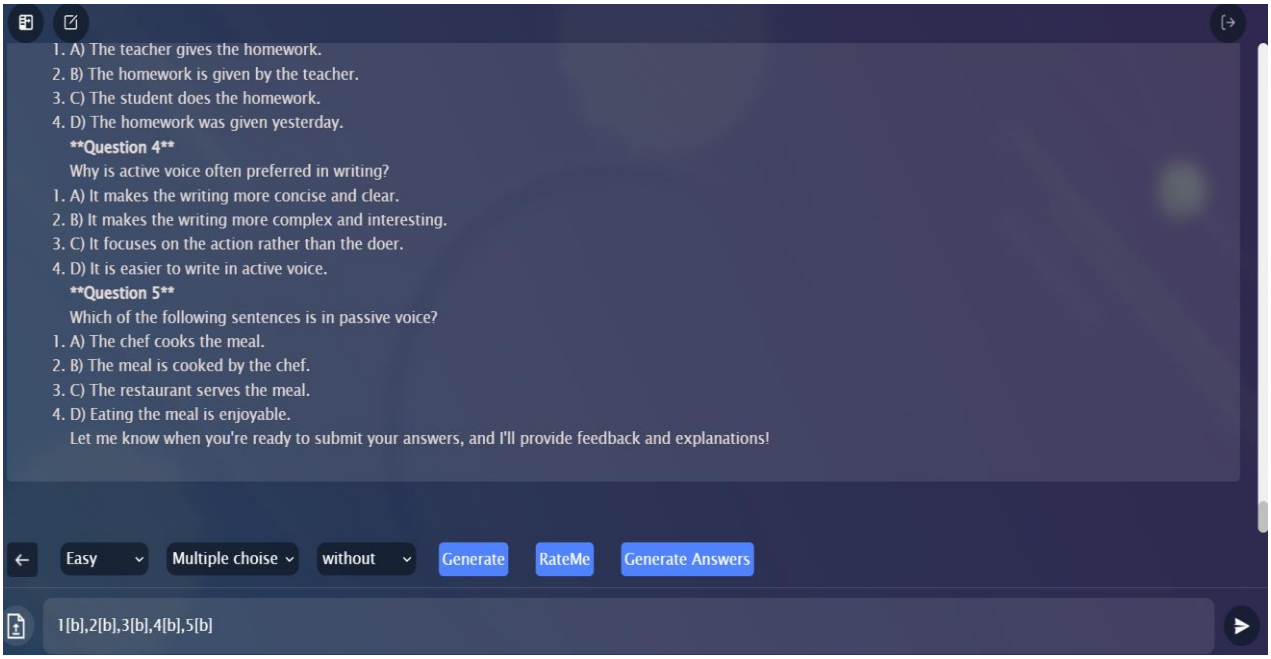

Figure 19. Answer Submission

Answer Correction:

- The chatbot reviews the answers, providing:
- Corrections for any mistakes.
- Explanations to clarify errors and highlight weak areas.
- Score based on the performance.

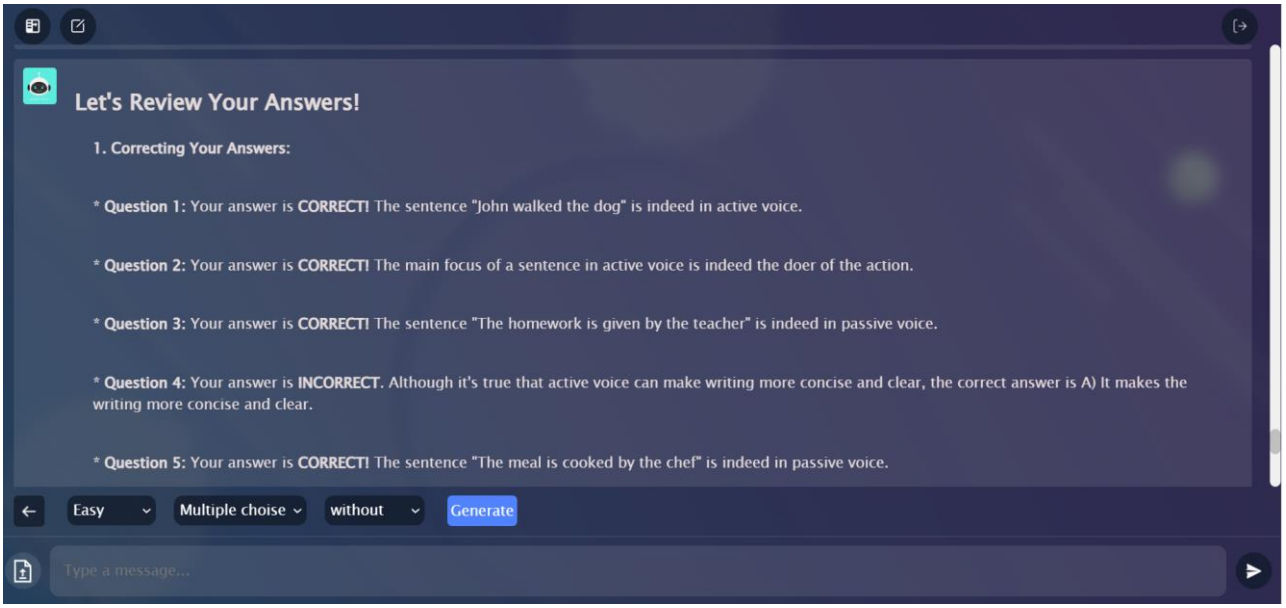

Figure 20. Evaluate answers 1

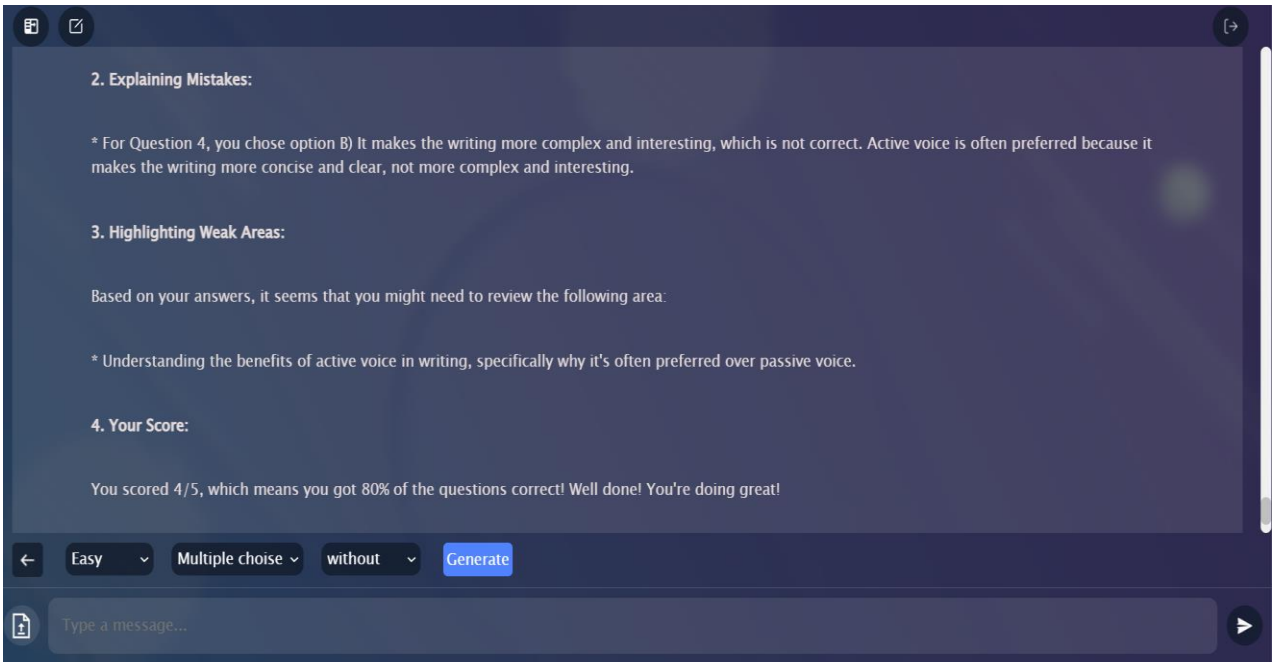

Figure 21. Evaluate answers 2

Custom Request:

Users can also type specific questions about the course material into the input field and then click on the "Submit" button to have their question presented. Once the chatbot has processed the question, it generates an answer relevant to that question by taking data from course contents and presenting the response clearly for users to understand and engage in further. Additionally, users can ask for a quiz with given parameters or summarization of selected topics- making every student's learning experience much more fun.

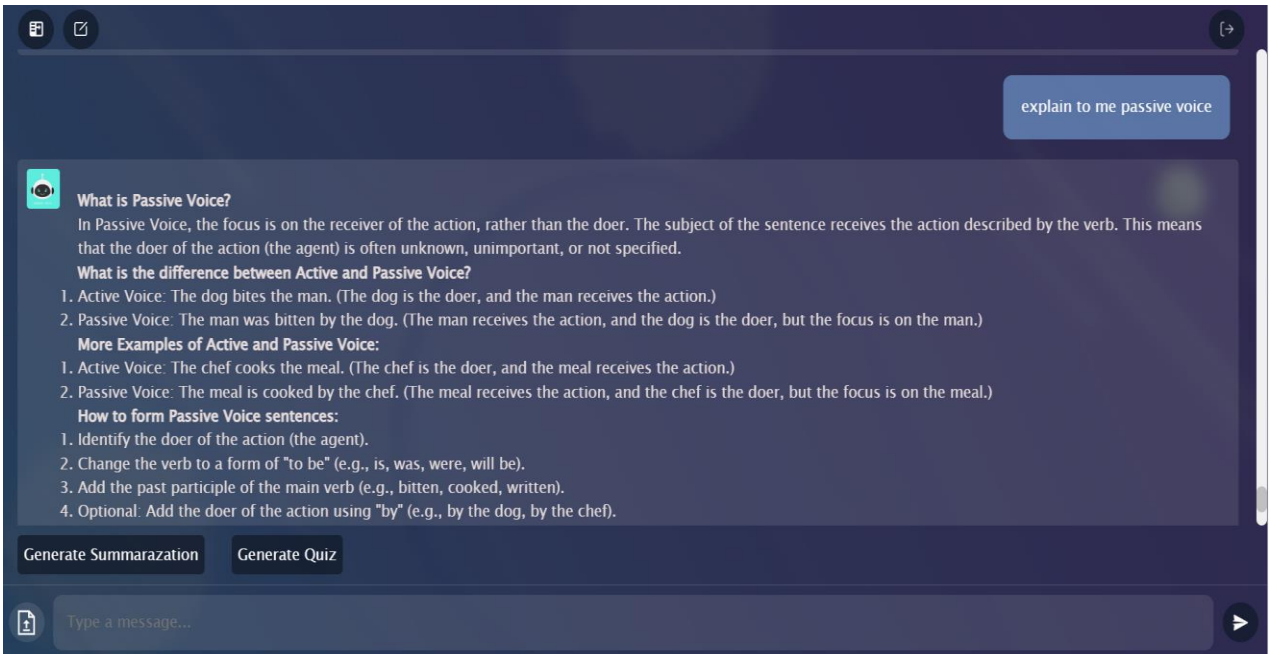

Figure 22. Custom Question

Chatbot Functionality and Model Communication:

The chatbot carries out several major functions that ensure smooth and meaningful interactions with users. A key feature is its statefulness, which tracks and maintains context across multiple interactions. This allows the chatbot to manage multi-turn conversations effectively, remembering past inputs and responding coherently to follow-up questions, even when the user switches between tasks like summarization or quiz generation.

At the heart of its operation is prompt engineering, which guides the 'LLaMA3-70B' model. Each user request is transformed into a well-structured prompt that includes:

- The specific user query
- Relevant course context
- The desired task (e.g., quiz generation, summarization)
- Task parameters (e.g., quiz format, difficulty level)

This approach ensures that the model's response aligns with user expectations. However, since the model has a token limit, the chatbot manages conversation history by chunking it. This process involves splitting the conversation history into manageable sections, so that the prompt remains within the model's token limit. The chatbot intelligently selects relevant portions of the history—prioritizing recent exchanges and crucial context—ensuring the model has enough information to generate accurate responses while avoiding exceeding token limits.

The 'Grok API' bridges the interaction between the Chabot and the model, sending these prompts and retrieving responses. Once the model processes the input, the Chabot refines and presents the output to the user, ensuring clarity and coherence.

Through this combination of stateful conversation management, prompt engineering, and conversation chunking, the Chabot efficiently handles complex interactions and provides users with accurate,

Conclusion

In conclusion, this chapter will provide a comprehensive look into the technical foundation of our e-learning application. By exploring the development tools, programming languages, database implementation, and user interface design, we aim to demonstrate how each component contributes to creating an efficient, user-friendly system.

Conclusion and perspectives

To conclude, the e-learning landscape is undergoing substantial transformation due to the integration of technological breakthroughs in education, particularly through advancements like automated quiz generation and course summaries. These technologies not only streamline and improve the efficiency of the educational process but also offer opportunities for more individualized and interactive learning experiences. As these technologies continue to evolve, e-learning is expected to become even more effective, yielding better learning outcomes and fostering the development of future generations in a more innovative and flexible environment.

In this work, we have explored the integration of technology into education through the development of an e-learning application designed to enhance the learning and revision process. We demonstrated how automated quiz generation, course summaries, and chatbot support can significantly personalize and enrich the student learning experience. Our solution utilized UML during the analysis and design phases and explored various technical tools for implementing the application.

There are several opportunities for future advancements. More sophisticated AI-driven features, such as adaptive learning algorithms that further customize material based on real-time performance, could be integrated into the application to enhance its functionality. Additionally, incorporating more interactive elements, such as peer-to-peer discussions and collaborative learning tools, could improve student engagement. With advancing technology, the e-learning platform may also leverage virtual reality (VR) or augmented reality (AR) to offer immersive learning experiences, further enhancing the dynamic and inclusive nature of education for learners everywhere.

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ملخص:

يهدف هذا العمل إلى تعزيز مفهوم التعلم عبر الإنترنت من خلال دمج أدوات مدعومة بالذكاء الاصطناعي للتصدي للتحديات الرئيسية في التعليم عبر الإنترنت. بشكل محدد، يركز على تطوير نظام قادر على تلخيص الدروس وإنشاء اختبارات تلقائية، مما يعزز تفاعل الطلاب في بيئات التعلم الرقمية. من خلال الاستفادة من نماذج الذكاء الاصطناعي المتطورة مثلLlama-3-70B ، تستكشف الدراسة كيف يمكن للذكاء الاصطناعي تسريع تقديم المحتوى والتقييم. من خلال تحسين التجارب التفاعلية من خلال واجهة دردشة، يسعى هذا العمل في النهاية إلى المساهمة في تطور التعلم عبر الإنترنت كنموذج تعليمي أكثر تكيفًا وفعالية.

الكلمات المفتاحية: التعلم الالكتروني، تلخيص الدروس، توليد الاختبارات، روبوت الدردشة

Abstract:

This work aims to advance the concept of online learning by incorporating AI-powered tools to address key challenges in online education. Specifically, it focuses on developing a system capable of summarizing courses and generating automated quizzes, thereby enhancing student engagement and personalization in digital learning environments. By leveraging cutting-edge AI models such as Llama-3-70B, the study explores how artificial intelligence can streamline content delivery and assessment. By enhancing interactive experiences through a chatbot interface, this work ultimately seeks to contribute to the evolution of online learning as a more adaptive and effective educational model.

Key words:

E-learning, course summarization, Quiz generation, Chatbot

Résumé :

Ce travail vise à faire progresser le concept d'apprentissage en ligne en incorporant des outils alimentés par l'IA pour répondre aux défis clés de l'éducation en ligne. Plus précisément, il se concentre sur le développement d'un système capable de résumer les cours et de générer des quiz automatisés, améliorant ainsi l'engagement des étudiants et la personnalisation dans les environnements d'apprentissage numérique. En tirant parti des modèles d'IA de pointe tels que Llama-3-70B, l'étude explore comment l'intelligence artificielle peut rationaliser la diffusion de contenu et l'évaluation. En améliorant les expériences interactives grâce à une interface de Chabot, ce travail vise en fin de compte à contribuer à l'évolution de l'apprentissage en ligne en tant que modèle éducatif plus adaptatif et efficace.

Mots clés : E-learning, résumé de cours, génération de quiz, Chatbot