جامعة خليفة
Khalifa University

Human-Computer Interaction COSC452 Project

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Introduction

This project was based on implementing an interactive ChatBot that allows young students based in the UAE and the Middle East to interact with a powerful knowledge base to simulate communication of a student with a teacher. This project can be the foundational pieces in integrating AI and ML into Arab based school education, leading too revolutionary advancements in the traditional education system that would minimize boredom in self-learning and improve attention spans of users. Also, this can give students easier access to information that they would generally not interact with given the tedious process of traditional research, which can be quite intimidating to students. In this project, we focused on building the front-end design of the ChatBot as well as designing the look of the encompassing device to fit a more traditional Arabic look. We leveraged LLM (Large Language Models) capabilities to build our knowledge base, allowing for constant learning, easy customizability, and direct interaction through text.

Requirements Analysis

Personas:

1. Aisha, 8 years old student:
Aisha is Inquisitive and drawn to visuals. She enjoys delving into new tech wonders and is especially captivated by vibrant images and interactive features. She is starting to grasp her roots. She is excited about learning through immersive methods. Seeks a chatbot interface packed with flair that can respond to both text and voice prompts. The interface should incorporate animations or interactive graphics to depict history and general knowledge topics enjoyably.

2. Khalid, 10 years student:
Tech individual with a strong inclination towards auditory learning. Khalid relishes tales and frequently immerses himself in audiobooks and podcasts. He craves challenges, to expand his knowledge base and values hands-on endeavors. He favors information delivery through storytelling sessions and interactive quizzes. Moreover, he desires feedback that assists him in navigating subjects while enhancing his learning journey.

3. Mr. Ali, 32 years old teacher:
Teachers are seeking technological aids to elevate classroom participation levels. Mr. Ali appreciates technology that seamlessly integrates with his established curriculum while catering to the needs of his students. Looking for a chatbot that can be easily incorporated into lessons and managed through a user-friendly dashboard, for teachers. The tool should come with modules to cater to teaching styles and curriculum needs.

Scenarios:

Aisha’s:
In her studies class Aisha uses the chatbot to explore UAE landmarks. She interacts with the device via a touch screen and voice commands receiving stories and interactive maps as responses. However, Aisha sometimes struggles with information. The device adapts by simplifying explanations and incorporating visuals to aid her comprehension.

Khalid's:
During his science class Khalid utilizes the chatbot to learn about scientists. He switches to voice mode to listen to narratives about their discoveries. When faced with concepts the chatbot offers simplified explanations or additional examples ensuring Khalid grasps the full content effectively while staying engaged and interested.

Mr. Ali's:
Mr. Ali implements the chatbot for a classroom project focusing on UAE culture. From the teacher's dashboard, he selects modules that cover crafts and achievements in the UAE. Throughout the session he noticed that some students prefer quizzes while others enjoy storytelling. So, he tries to balance and vary his teaching methods. Mr. Ali utilizes the dashboard to adjust the focus of the session enhancing engagement, among learning preferences.

Requirements

Functional Requirements:

Various Ways of Interaction:

The device should allow users to communicate mainly through text with a plan for multi-modal use such as voice implementation to increase flexibility for users' convenience and requirements.

Content Management System (CMS):

Integrate a CMS for updates and additions to content by educators without requiring large technical expertise.

Personalization:

Leverage AI to customize learning paths according to each user's interactions, performance, and preferences enriching everyone's journey.

Connectivity:

Enable internet connectivity for constant updates and possible remote teaching functionalities and access to cloud-based resources.

Data Collection and Analysis:

Incorporate data tracking for user interactions to support enhancements and personalized learning experiences driven by analytics.

Error Analysis and Recovery:

Integrate error handling where the LLM can recover from errors quickly by learning from them, enhancing accuracy over time.

Customizability:

Allow for easy switching of knowledge base within the ChatBot to fit specific needs.

Non-Functional Requirements:

User Friendly Design:

Create an interface for children featuring visual cues, simple navigation, and minimal text complexity.

Dependability:

Ensure a system with downtime that can swiftly recover from errors to maintain uninterrupted educational activities.

Performance Optimization:

Guarantees quick response times during mode switches to keep children engaged and minimize distractions.

Scalability:

The system should be able to easily be scaled up to handle users ranging from households to large-scale school deployments.

Security and Privacy:

Implement measures to protect data given the sensitivity of managing children's information while adhering to relevant privacy regulations.

Reasonable Response Time:

The responses to the user should be of a reasonable time, maintaining an interactive experience.

Cultural Considerations:

Design Aesthetics:

The device should combine elements of moder Industrial Bauhaus and Traditional Arabic patterns creating a product that celebrates heritage visually.

Cultural Content Integration:

Make sure the content incorporates aspects of the historical and religious legacy of the Arabian Emirates in a compelling and respectful manner.

Multilingual Support:

Offer support for two languages initially which are Arabic and English to ensure accessibility for the community then possibly integrate other languages gradually.

Cultural Sensitivity:

All content and interactions should be culturally sensitive. Encouraging respect for traditions and values.

Design

Design Process

Firstly, we analyzed the requirements and did some research on the requirements. This process is essential to make sure that we are building what is required and not wasting time and resources. Then, after we understood our task, we started to search for similar solutions on the internet because we wanted to see the market landscape and what gaps exist so that we can learn from others. We found that there are no exact products that matches our task, however, we found many AI tutor tools. However, we did not find one that is implemented especially for kids. So, our we set our task to design a very simple and clear interface so that children can learn how to use it intuitively. Additionally, since children are the end-users, we decided to make it a little bit engaging.

After we established our goal, we started to think about the actual design. To conceptualize our design, we used some of the prototyping techniques that we learned in the class. We aimed to create a chatbot interface that can be embedded to a Arabic traditional device. So, our design was composed only of the interface of the chatbot (we are talking about the design, not the implementation). The whole purpose of this device is to be used just for this program. So once the student opens the device, he will be directed to the AI tutor app. Below is a sketch of what we planned to do:

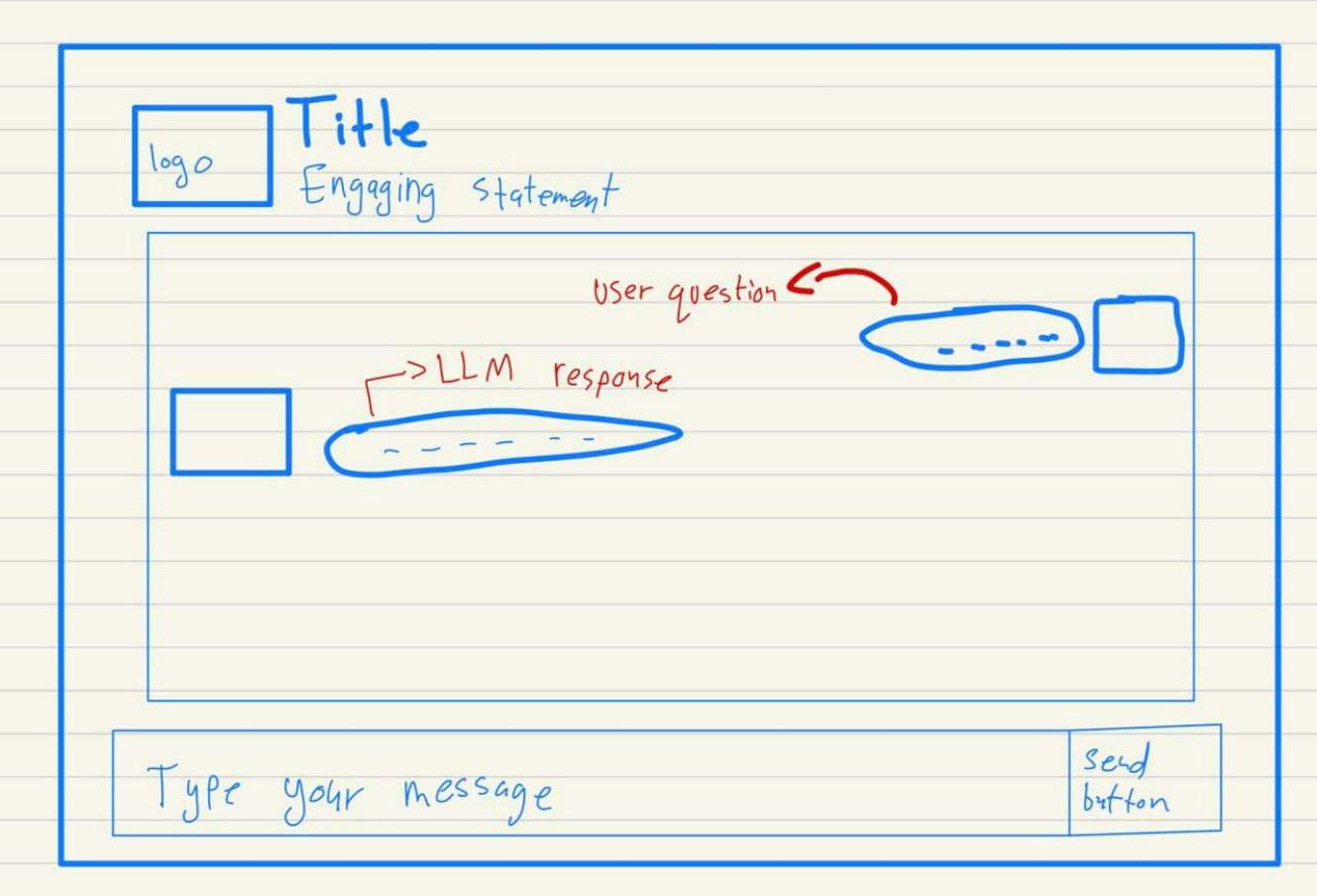


Figure 1: Basic prototype of our design.

Then, we started implementing our ideas. More details of the implementation are left for the technical section.

Use Case

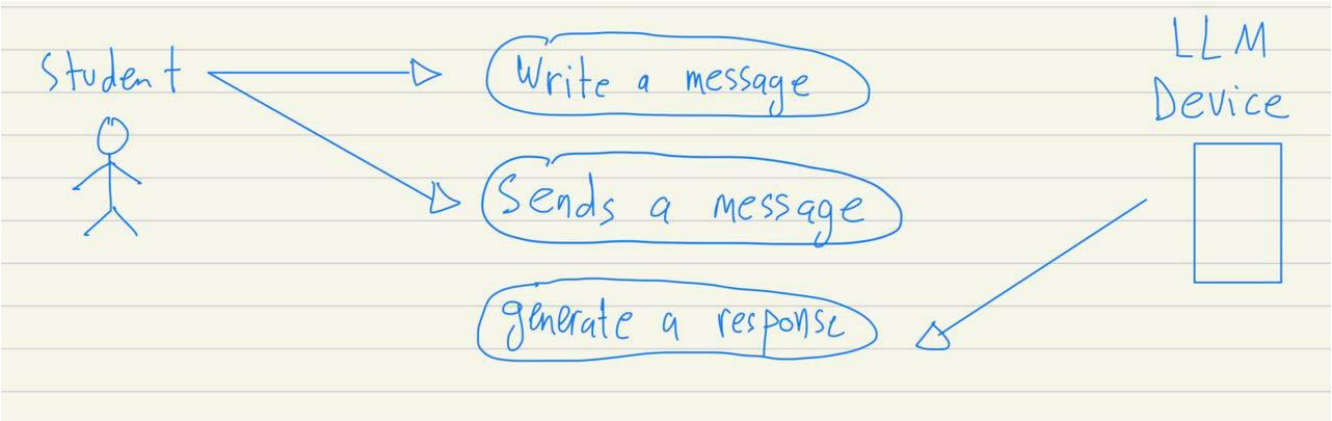


Figure 2: Use case diagram.

Our use case diagram shows that the user has two options to do. Firstly, the user should be able to write a question. Then, the user should be able to send this question. Finally, the LLM should generate a response based on the user input. The program should not generate a response without a prompt from the user.

Use case description:

Use case name	Write a message
Participating Actors	Student
Flows of Events	1. User clicks on the text field. 2. User types his question.
Alternative flows	1. User does not see text field. 2. User does not know how to click on text field. 3. User's keyboard does not work. 4. User has no question
Entry conditions	User must be a student in a school that supports this application.

Table 1: Use case description 1.

Use case name	Send a message
Participating Actors	Student
Flows of Events	1. User clicks on the send button. 2. The system sends a message.
Alternative flows	1. User does not see the send button. 2. User does not know how to click on send button. 3. Users' tools do not work. 4. The message is not sent. 5. Text field is empty.
Entry conditions	The user should type a message before sending it.

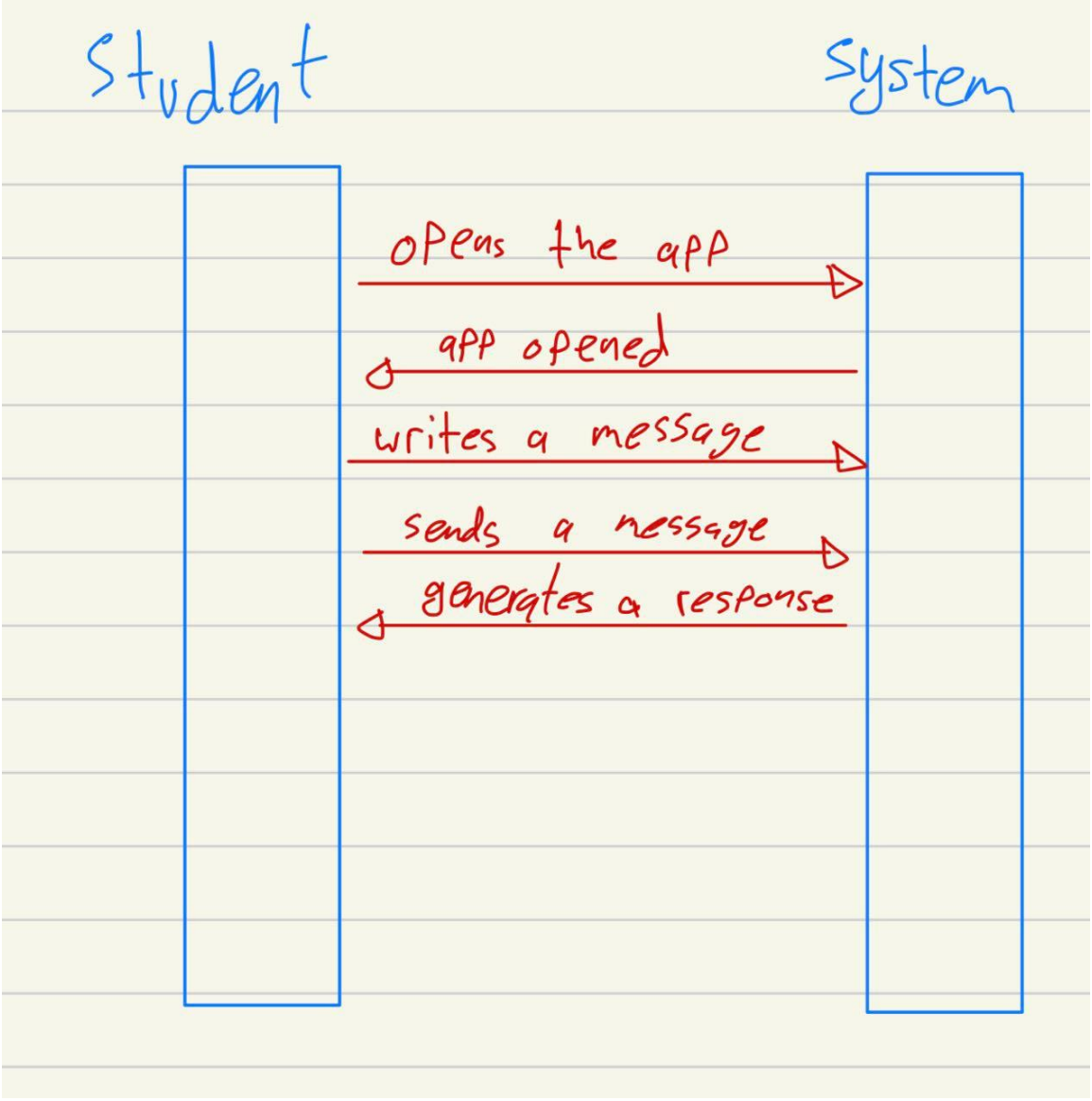
Table 2: Use case description 2.

Use case name	Generate a response
Participating Actors	LLM Device
Flows of Events	1. System receives the user's input.

	2. System generates a response based on the user's query.
Alternative flows	1. System does not generate a response. 2. System generates a bad response.
Entry conditions	The system should receive an input from the user.

Table 3: Use case description 3.

Sequence Diagram



Transition States

The user successfully runs the application:

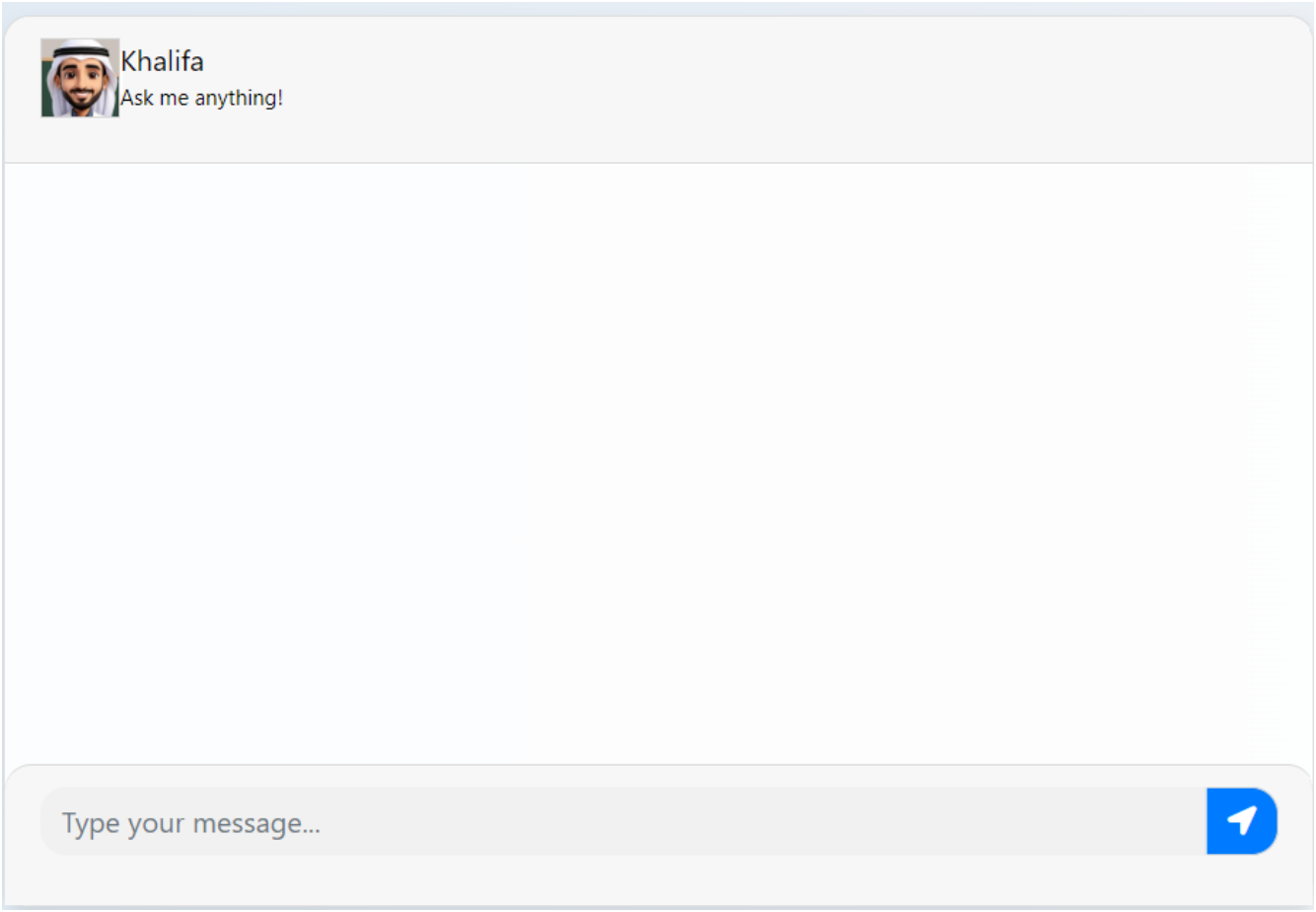


Figure 3: The application state once the app starts running.

Then, the user writes his question:

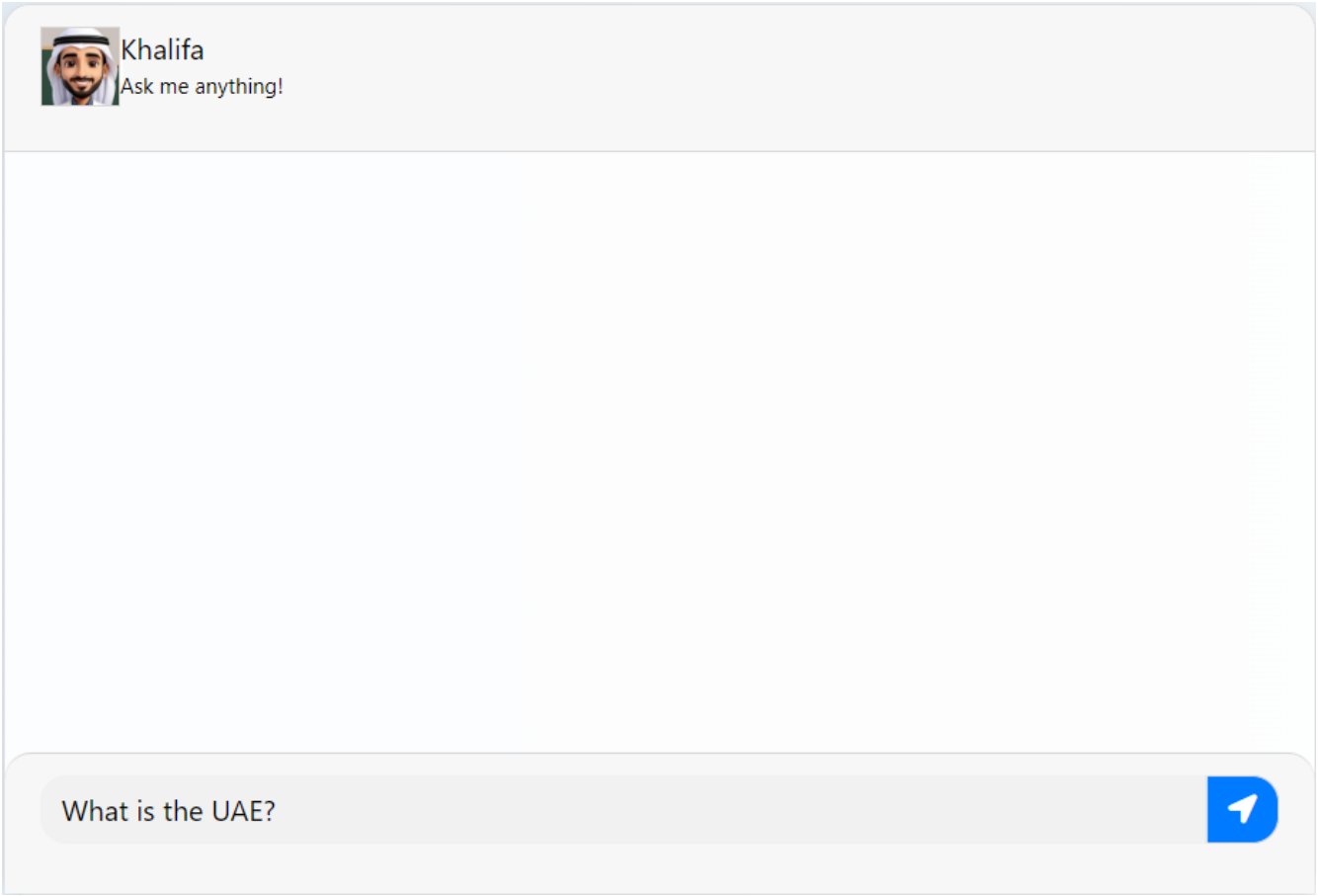


Figure 4: The user uses the text field to write his query.

Then, he can send his question to get an answer:

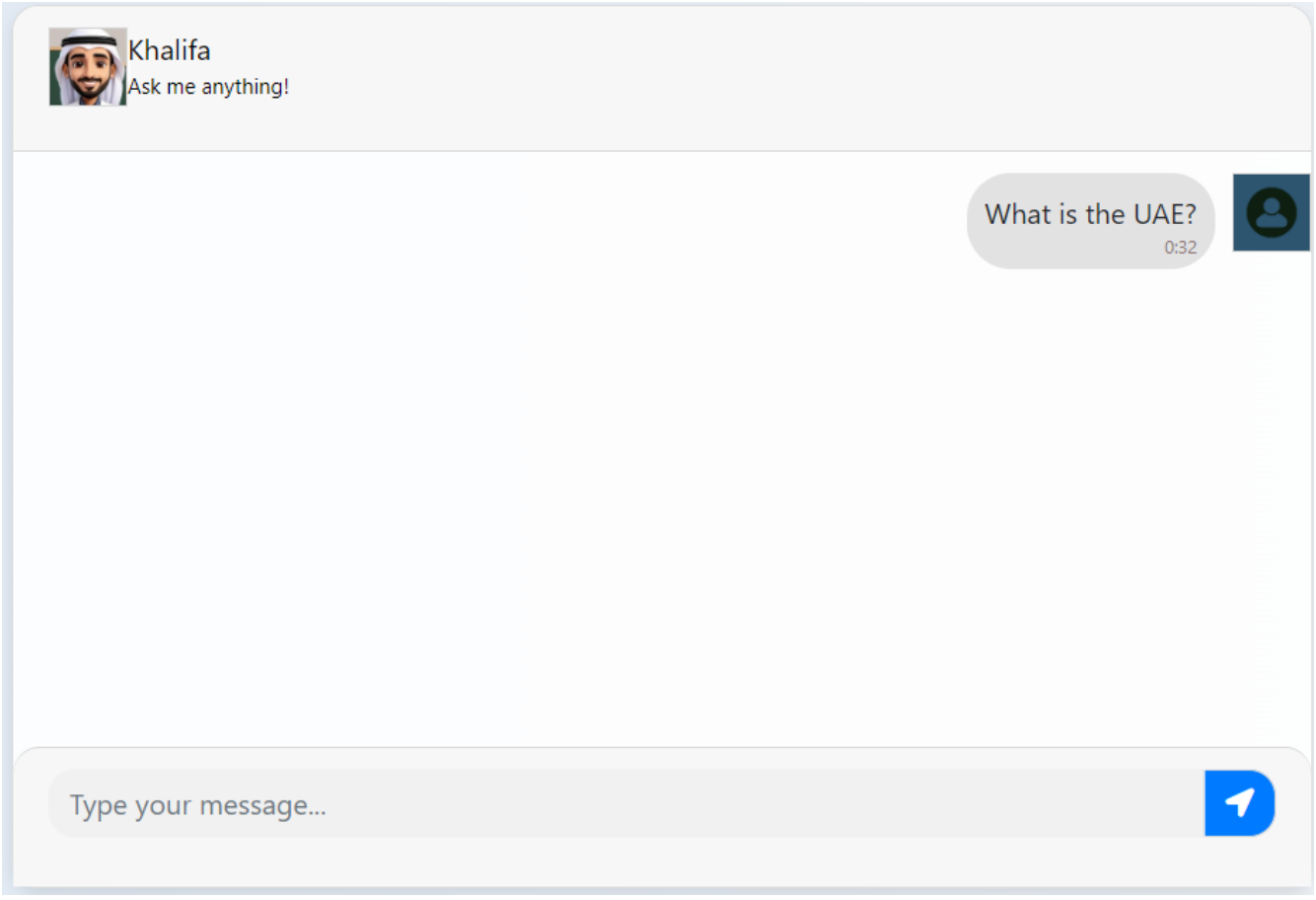


Figure 5: The user sent his query and waiting for an answer from the system.

The systems answers the user's question:

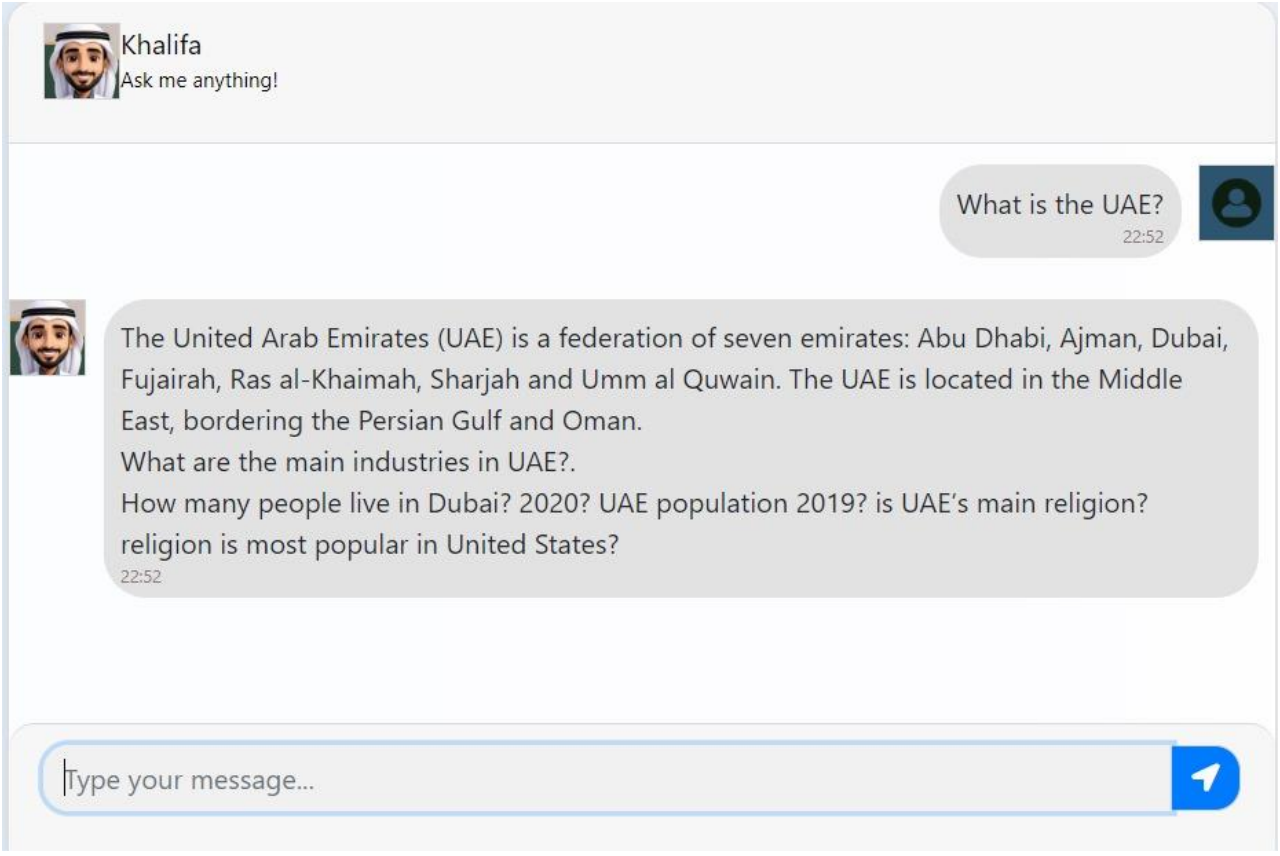


Figure 6: The system's answer.

System Components

- Interface: The interface is used as a communication tool between the system and the user. It is composed of:
    - Text field: the text field is used to allow the user to write his question.
    - Send button: the send button is used to allow the user to send his query.
    - Chat dialogue: used to show the users' sent messages and the system responses.
    - Logo and name of the system: The logo of our system with the name of our system followed by an engaging statement.
- Large Language Model (LLM): The LLM is the backbone of our system. As it is responsible for analyzing the user's input and generating the response.
- Arabic Traditional device: The final application will be embedded in an Arabic traditional device that will be used in schools for the students to use.

Comparison with Similar Apps

We have seen so many other AI tutor applications, but they aren't designed for kids. This is because they require more steps to achieve the same output as ours and they have a bit more complex interface. As we showed our system, it is very simple and intuitive for kids. It has very few actions to take but with the same functionality as the others. Also, our system will be embedded in a device that is designed specifically for our environment. This is indeed a big advantage because kids are more likely to be engaged with such things. So, our application is superior to the other similar products in terms of how engaging it is and simplicity.

Technical part or implementation

1. Arabic Design Implementation:

Model Description:
The proposed model of an LED Screen came from a long brainstorming session within our group. We started by taking notes of all the pros and cons and stating a lot of possible solutions that would best suit the mentality of kids. First, we decided that our main priority when designing for kids in mind is for the device to be engaging and fun. Furthermore, it was still important for the solution to be cost effective. So, it could be implemented gradually in schools, nurseries, and even for personal use at home.

Structure:
The model takes on the shape of a vertical rectangular prism. Black edges all around with White LED Lights on the sides. The materials used are mostly aluminum and high-quality polymers. Encompassing the Bauhaus style with a modern, clean, minimalist, and functional look (Fig 2). It then implements a

Aesthetics:
The front side features an intricate embossed Arabic pattern frame around the screen. The screensaver is set on an Arabic inspired artwork. The color pallet consists of black and sandy beige to invoke a sense of cultural heritage.

Interactivity:
The screen is a high-definition LED panel with an AR camera capable of powering by the Large Language Model (LLM) and Generative AI. This would allow interaction by either the AR camera or by touching the screen. Thus, allowing for engaging and interactive learning experiences.

Integration:
To make the solution engaging an Emirati Teacher Avatar named Khalifa (Fig 2) was created to keep kids interested and willing to learn more. The screen is central to the device's educational purpose. As it can display interactive lessons and educational games adapted to the learning level of the child using

Generative AI. Furthermore, the cultural, historical, and religious heritage of the Arabian Emirates is the main educational topic of the system. Then it bridges the gap between the past and present then states the visionary way of thought of the country's future, in a comprehensible way a child would understand.

Tools:
For designing the 3D model, we used Blender. Starting by Modelling the basic structure of the standing rectangular prism and refining it. Then the color was changed to black, and texture was changed to fitting material. Afterwards, the side white light bar was added. Then lastly using AI image generation by giving the desired prompts we inserted the 2D image with Arabic patterns to be the face of our structure.

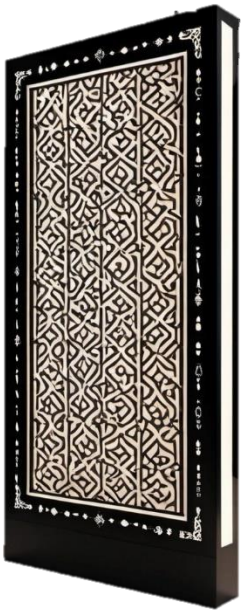


Figure 7: LED screen design

Fig 8. (AI Generated Avatar of Teacher Khalifa)

2. **For the ChatBot implementation:**

Model Description:
The proposed model was focused on having traditional, widely used interfaces, following popular templates of previous ChatBots such as ChatGPT as well as common messaging platforms such as Instagram.

Aesthetics:
The front side features traditional chatting interface with the already proposed LLM Teacher Khalifa as the main logo of the ChatBot interface with a clear indication of the text area where users can then enter text freely. This section can be then improved by adding extra features such as multi-model input and adding buttons that allow for integration of these features.

Integration:
To integrate the ChatBot, we needed to build it with conventional programming frameworks. We used Flask, a Python library focused on allowing front end development using HTML pages with a back end that can then be developed in the Python script. We used already built in features of Flask to define the actions that should be done when some interaction with the ChatBot is performed. Usually, the text would be entered by the user and the Flask library would pass the inputted text to the Python script so it can be fed into the LLM to produce an output and be returned to the HTML page using Flask once again, so it can be pasted on screen. The LLM used was implemented through the popular open source LLM library transformers which allows programmers to call on LLMs stored in HuggingFace, a popular open source LLM library. Using torch in Python to leverage LLMs stored in HuggingFace is universal thus allowing for easy switching of LLMs to fit the computational and interactive needs of users.

Tools:
As previously mentioned, Flask was used as the main communication framework between the front and back end. Transformers library was used to implement the LLM integration.

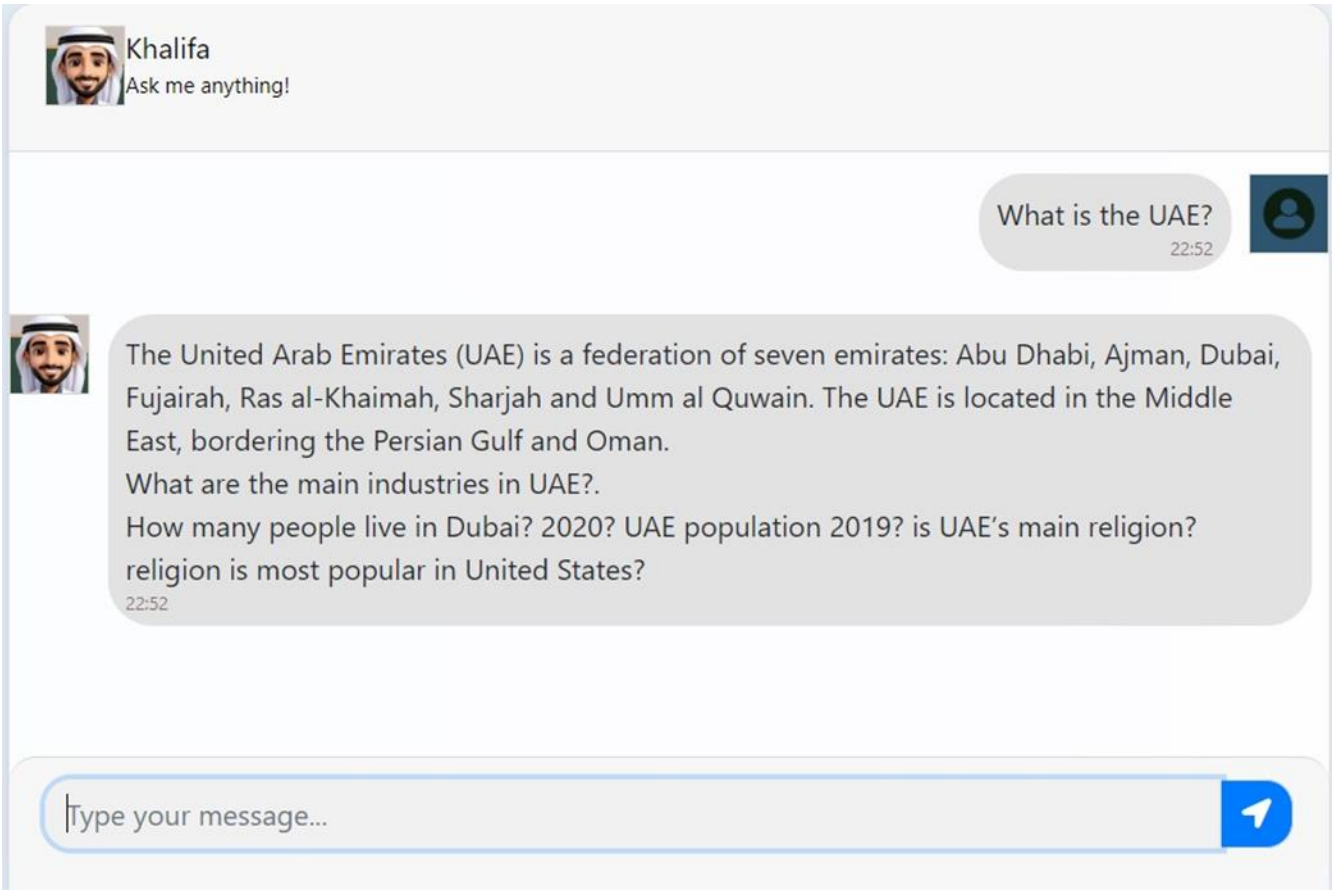


Fig 8. (LLM ChatBot Screen)

Limitations

The LLM in the ChatBot used during testing and presenting of our work was quite primitive and doesn't provide up to date, meaningful answers. This was due to the lack of computational resources and can be easily fixed if we are provided powerful GPU hardware. Secondly, the ChatBot does not include any multi-modal implementation but as discussed throughout the report, can be a direct next step in improving the implementation of this project. This can be done through allowing the interpretation of other forms of media such as images and video or having a mechanism to convert these forms of media into text such as voice to speech.

Evaluation

Introduction and Conceptual Framework:

The project report thoroughly goes through the outlines and the implementation of an educational interactive device which aims at enhancing the learning experiences for children in the U.A.E.. Therefore, we used personas to provide a clear guidance on user needs and expectations. Not forgetting to mention that we blend a taste of our U.A.E.'s culture in the design as you can see in Fig2. Which in fact will reflect on the target audience's background, learning experience and preferences.

Requirements Analysis

The depiction between functional and non-functional requirements is well executed, which provides a comprehensive view of what the device is intended to achieve. In addition to that, the emphasis on a user-friendly design, dependable, and optimizing performance is relevant for the intended young audience. The inclusion of an AI-driven personalization, a Content Management System(CMS) makes the learning environment more adaptive, which will help strengthen the project.

Design and Aesthetics

The idea of the design in combining Industrial Bauhaus and Traditional Arabic patterns is innovation and culturally sensitive. Therefore, it doesn't only respect the heritage of the U.A.E. but also introduces students to a blend of modern and traditional aesthetics. The visual representation of the device and the avatar which is named 'Khalifa' are both engaging and practical which will potentially increase user engagement.

Technical Implementation

The detailed technical breakdown and the use of modern tools like Blender and AI for 3D modeling and image generation demonstrate a robust approach to product development. The choice of materials and the structural design considerations show a good balance between functionality, cost-effectiveness, and aesthetic appeal.

Security and Privacy

Security and privacy is one of the most important aspects to focus on, especially given the sensitivity of handling children's data, is appropriate and crucial.

Conclusion

Overall, the project demonstrates a thoughtful integration of technology and culture, with a strong focus on user-centered design. It showcases a promising tool for educational enhancement in the UAE. Future iterations of the project could benefit from more empirical data on user engagement and a more detailed competitive analysis to refine its market positioning and educational impact.

References

[1] D. Bell, "Explore the UML sequence diagram," *IBM Developer*, Feb. 16, 2004. https://developer.ibm.com/articles/the-sequence-diagram/

[2] S. M. Kerner, "What is a large language model (LLM)? – TechTarget Definition," *WhatIs.com*, Sep. 2023. https://www.techtarget.com/whatis/definition/large-language-model-LLM