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Generative artificial intelligence application for teaching and learning using amazon web services

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Abstract

The realm of education has witnessed a seismic shift with the advent of Generative Artificial Intelligence (AI), which is poised to redefine teaching and learning practices. This technological innovation, characterized by its ability to create content, simulate environments, and generate personalized learning experiences, offers educators unprecedented tools to enhance pedagogical methods. Generative AI, with its capability to produce text, images, and even audio, extends beyond conventional educational resources, providing a dynamic and interactive platform that can cater to diverse learning needs. This paper presents Generative AI application for teaching and learning using Amazon Web Services (AWS) such as Amazon Bedrock, Amazon Elastic Container Service, Application Load Balancer, Amazon DynamoDB and Amazon S3.

Keywords: Generative AI; Foundation Model; Amazon Web Service; Cloud Computing

1. Introduction

Generative Artificial Intelligence (AI) is rapidly transforming the landscape of teaching and learning by enabling the creation of new and dynamic content, personalizing educational experiences, and automating administrative tasks for educators. One of the most significant impacts of generative AI in education is its potential to personalize learning experiences. AI-driven platforms can analyze a student's learning habits, strengths, and weaknesses, offering tailored content that addresses individual needs. This customization helps in bridging the learning gap, ensuring that students receive the support they require to progress at their own pace. Moreover, generative AI can create adaptive learning paths, modifying the curriculum based on real-time feedback, which enhances student engagement and motivation.

Furthermore, generative AI can revolutionize the way educators design and deliver content. By automating the creation of educational materials, teachers can focus more on interactive and meaningful interactions with students. AI can generate quizzes, assignments, and even lesson plans, thereby reducing the workload on educators and allowing them to concentrate on the qualitative aspects of teaching. Additionally, it can simulate complex scenarios or environments, facilitating experiential learning, which is crucial in fields such as medicine and engineering.

The aim of this paper is to present Generative AI application for teaching and learning using AWS services. The application can be used to quickly generate assignments with questions and answers for a given subject matter. The application uses Amazon Bedrock, which has several different foundation models that can provide whatever Generative AI responses are needed. These foundation models can be accessed from the application with basic API calls. The application was hosted on Amazon Elastic Container Service, or Amazon ECS, providing a robust microservice architecture that helps ensure elasticity and availability. It uses Amazon DynamoDB to store the assignments. After

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students complete an assignment, they can receive AI-generated feedback, and they can access their grades from the application.

The rest of the paper is organized as follows: In section 2, we present related work and explain background theory such as Generative AI in education, AWS services for building Generative AI applications, example applications built on AWS and key considerations for implementing Generative AI in education with AWS in section 3. In section 4, we introduce Generative AI application for teaching and learning. Then conclusion is described in section 5.

2. Related Work

The integration of generative artificial intelligence (GenAI) in teaching and learning has emerged as a significant area of exploration within higher education, particularly in light of its potential to enhance educational experiences. This literature review synthesizes recent studies that investigate the perceptions, experiences, and implications of GenAI among various stakeholders in educational contexts, focusing on its application across different generations of students and educators.

Building on this foundation, Cacho [1] proposes a flexible framework for incorporating GenAI into university teaching and learning processes. This framework, informed by feedback from students and educators, aims to provide practical recommendations for the ethical and responsible use of GenAI. The study underscores the importance of context-sensitive guidelines that can be adapted by various institutions, thereby fostering an environment conducive to innovative teaching practices while addressing the concerns raised by educators regarding the implications of AI use.

The potential of AI-generative tools to enhance creativity in education, particularly in English as a Foreign Language (EFL) context, is explored by Alzubi et al. [2]. Their research reveals that students perceive tools like ChatGPT as beneficial for fostering creativity through conversation practice, idea generation, and collaborative learning. However, the study also highlights concerns regarding over-reliance on AI, emphasizing the need for educators to promote critical thinking and ethical AI use. The findings suggest that while AI can enrich the learning experience, it is crucial to implement comprehensive training and monitoring to mitigate potential biases and ensure academic integrity.

In a different context, Żammit [3] investigates the experiences of secondary school teachers in Malta who have integrated GenAI into their teaching practices. The qualitative study reveals that teachers utilize AI for various instructional tasks, leading to improved student engagement and proficiency in the Maltese language. However, the reliance on subjective observations raises questions about the empirical validation of these perceived benefits. The study calls for further research to quantify the impact of GenAI on student outcomes and to explore the long-term implications of its integration into minority language education.

Lastly, Sooriamurthi et al. [4] contribute to the discourse by examining the use of a custom generative AI tool designed to foster authentic learning through scalable feedback mechanisms. Their findings indicate that students engaging with AI-led dialogues experience reduced anxiety compared to traditional instructor-led interactions, suggesting that AI can effectively support student confidence and self-efficacy. This study highlights the potential of AI to facilitate personalized learning experiences, particularly in large classroom settings where individual attention may be limited.

3. Background Theory

This section provides an overview of Generative AI in Education, AWS Services for Building Generative AI Applications, Example Applications Built on AWS, and Key Considerations for Implementing Generative AI in Education with AWS.

3.1. Generative AI in Education

Generative AI offers immense potential to personalize, automate, and enhance the educational experience for both students and educators. Some key applications for students are

- **Personalized Learning Paths:** GenAI can analyze student performance, learning styles, and preferences to dynamically generate customized lesson plans, exercises, and resources. This ensures students receive tailored support and content that adapts to their individual pace and needs.
- **Intelligent Tutoring Systems:** AI-powered tutors can provide real-time, individualized feedback, explanations, and hints, guiding students through complex topics and offering additional practice as needed.

- **Content Creation and Summarization:** Students can use GenAI to brainstorm ideas, generate outlines, draft papers, summarize lengthy texts, and even create multimedia content like presentations or interactive simulations.
- **Language Learning and Practice:** GenAI can facilitate language acquisition through interactive conversations, translation tools, and pronunciation feedback.
- **Enhanced Research and Writing Skills:** AI tools can assist students in identifying relevant sources, structuring arguments, and improving their writing style.
- **Adaptive Assessments:** GenAI can create quizzes and tests that adjust in difficulty based on a student's responses, providing a more accurate evaluation of their understanding.

Some key applications for educators are

- **Streamlined Lesson Planning:** Teachers can use GenAI to quickly draft lesson outlines, generate activities, create quiz questions, and adapt materials for diverse learning needs.
- **Automated Administrative Tasks:** GenAI can significantly reduce the time spent on grading assignments, tracking attendance, generating reports, and even drafting announcements with a consistent institutional tone.
- **Creation of Engaging Learning Materials:** AI can help design interactive content like virtual labs, simulations, and gamified exercises, making learning more enjoyable and effective.
- **Professional Development and Collaboration:** GenAI can summarize research articles, draft proposals, and facilitate the creation of shared resources among educators.
- **Insights and Performance Review:** AI can analyze student data to identify trends, evaluate the effectiveness of teaching methods, and inform continuous improvement.

3.2. AWS Services for Building Generative AI Applications

AWS [5] offers a robust and scalable ecosystem of services ideal for developing and deploying GenAI solutions in an educational context. Key services include:

Amazon Bedrock: This is a fully managed service that provides access to a variety of state-of-the-art Foundation Models (FMs) from leading AI companies (like Anthropic, AI21 Labs, Cohere, Meta, Mistral AI, and Stability AI) and Amazon itself (e.g., Amazon Nova models). It simplifies the process of building and scaling GenAI applications by offering an easy-to-use API interface, while also providing essential guardrails and governance capabilities critical for educational environments.

- **Knowledge Bases for Amazon Bedrock:** Enables you to connect FMs to your organization's data sources (e.g., course materials, research papers, internal documentation) to provide more accurate, relevant, and context-aware responses using Retrieval Augmented Generation (RAG).
- **Amazon Bedrock Agents:** Allows for the creation of AI agents that can understand user intentions, orchestrate multiple tasks, and integrate with various AWS services to automate workflows (e.g., automatically update assignment due dates in an LMS based on a teacher's prompt).
- **Amazon Bedrock Guardrails:** Crucial for responsible AI implementation in education, enabling the setting of policies to detect and prevent generation of harmful, off-topic, or sensitive content.
- **Amazon SageMaker:** For more advanced users and data scientists, SageMaker provides a comprehensive platform to build, train, and deploy machine learning models, including fine-tuning existing FMs or building custom models from scratch. It offers flexibility and granular control over infrastructure and tools.
- **Specialized AI Services:** These services can be integrated to handle specific types of educational content:
- **Amazon Textract:** Extracts text, handwriting, and data from scanned documents (e.g., student submissions, historical texts).
- **Amazon Transcribe:** Converts speech to text (e.g., transcribing lectures for accessibility, analyzing student oral responses).
- **Amazon Rekognition:** Analyzes images and videos (e.g., for content moderation in student-generated media, identifying objects in educational visuals).
- **Amazon Polly:** Turns text into lifelike speech (e.g., for creating audio versions of learning materials, providing vocal feedback).

3.2.1. Data Management Services

- **Amazon S3 (Simple Storage Service):** For highly scalable and durable storage of diverse educational content, including large datasets for training GenAI models. The new S3 Vectors feature can further optimize vector storage and querying for RAG applications.
- **AWS Glue:** A serverless data integration service for preparing and transforming data from various sources into a format suitable for GenAI models.
- **Amazon DynamoDB:** A fast and flexible NoSQL database service for storing and retrieving structured and unstructured educational data, such as assignments, student answers, and grading scores.

3.2.2. Compute and Infrastructure

- **Amazon EC2 (Elastic Compute Cloud):** Provides scalable computing capacity for running GenAI models and applications.
- **AWS Lambda:** A serverless compute service that can run code without provisioning or managing servers, ideal for event-driven GenAI functions.
- **Amazon CloudFront:** A fast content delivery network (CDN) service that securely delivers educational content to users with low latency.
- **Elastic Load Balancing (ELB):** Distributes incoming application traffic across multiple targets, ensuring high availability and scalability for GenAI applications.
- **Security and Governance:** AWS prioritizes security and privacy with features like Identity and Access Management (IAM), encryption, and compliance certifications, which are crucial for handling sensitive student data.

3.3. Example Applications Built on AWS

Some example applications build on AWS are

- **Instructure's IgniteAI (built on Amazon Bedrock):** Integrated with the Canvas LMS, IgniteAI simplifies classroom administration by using AI agents to automate tasks like managing IEPs, creating rubrics, summarizing discussions, generating assignments/quizzes, and drafting announcements. It emphasizes responsible AI and keeps sensitive student data in-region.
- **AI Teaching Assistant (demonstrated by AWS):** An example solution that uses Amazon Bedrock to generate questions, answers, and assignment images from input text, and then grades student answers in real-time using Amazon Titan Embeddings for similarity scoring. It also leverages AI21 Labs' APIs for grammatical and sentence improvements.

3.4. Key Considerations for Implementing Generative AI in Education with AWS

Key considerations for implementing Generative AI in education with AWS are

- **Responsible AI:** Prioritize ethical considerations, data privacy, fairness, and transparency. AWS provides services like Bedrock Guardrails and SageMaker Clarify to support responsible AI development.
- **Data Governance:** Establish clear policies and practices for collecting, storing, and using educational data, ensuring compliance with relevant regulations (e.g., FERPA, GDPR).
- **Security:** Implement robust security measures to protect sensitive student information and prevent unauthorized access to GenAI models and data.
- **Scalability:** Design applications to scale effectively to accommodate a growing number of users and increasing data volumes, leveraging AWS's inherent scalability.
- **Cost Optimization:** Monitor and optimize AWS resource usage to manage costs effectively.
- **Teacher Training and Adoption:** Provide educators with adequate training and support to effectively integrate GenAI tools into their teaching practices.
- **Pedagogical Soundness:** Ensure that GenAI applications enhance, rather than replace, critical thinking, creativity, and human interaction in the learning process.

By strategically leveraging AWS services, educational institutions can develop powerful and innovative Generative AI applications that transform the teaching and learning landscape, making education more personalized, efficient, and engaging for all.

4. Generative AI Application for Teaching and Learning

In this paper, the access to Amazon Bedrock foundation models within an account was managed. We determine and use appropriate model identification for use within an application. We deploy a containerized application that uses generative AI foundation models to create, save, and present assignments on a given topic. We generate and save an assignment by using the generative AI-powered application. The architecture of the Generative AI application for teaching and learning is shown in Figure 1.

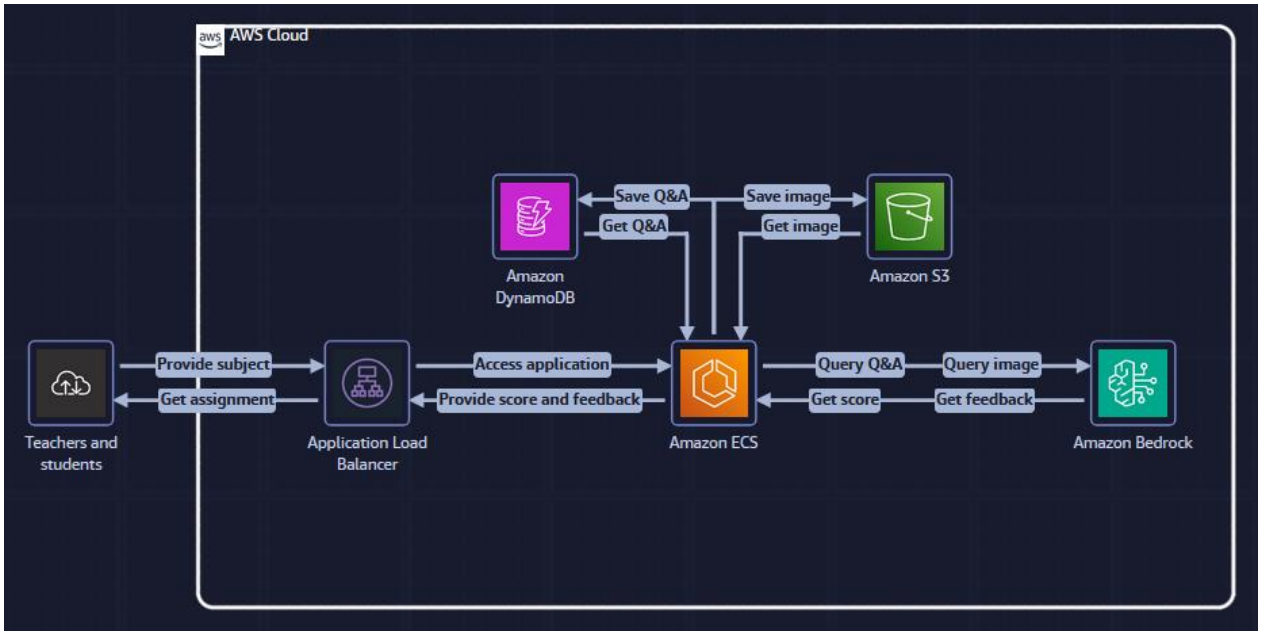

Figure 1 The Architecture of the Generative AI Application

The working process of the Generative AI application for teaching and learning is as follows:

- The application uses generative AI to help create student assignments (questions, answers, and images) based on a teacher-provided subject. Students complete assignments and receive immediate automated feedback.
- Teachers use a domain name to access a web-based application. DNS directs traffic sent to that domain name to an Application Load Balancer, which distributes incoming application traffic, increasing the application's availability.
- The application itself is hosted in a serverless, containerized manner, using Amazon Elastic Container Service (Amazon ECS) and Amazon Fargate.
- When provided with a subject, the application queries an Amazon Bedrock foundation model (FM) for a set of questions and answers. The application queries a different FM for an appropriate image.
- The application saves generated questions and answers in an Amazon DynamoDB table.
- The application saves generated images in an S3 bucket on Amazon Simple Storage Service (Amazon S3).
- Students access the assignments through the same domain name as teachers.
- The application provides the assignment of choice by retrieving the questions and answers from DynamoDB and retrieving the image from Amazon S3.
- After a student provides an answer to a question, the application accesses an Amazon Bedrock FM to determine the answer's level of correctness. The application accesses a different FM to provide feedback on how the answer could be better.

The homepage of the application is shown in Figure 2.

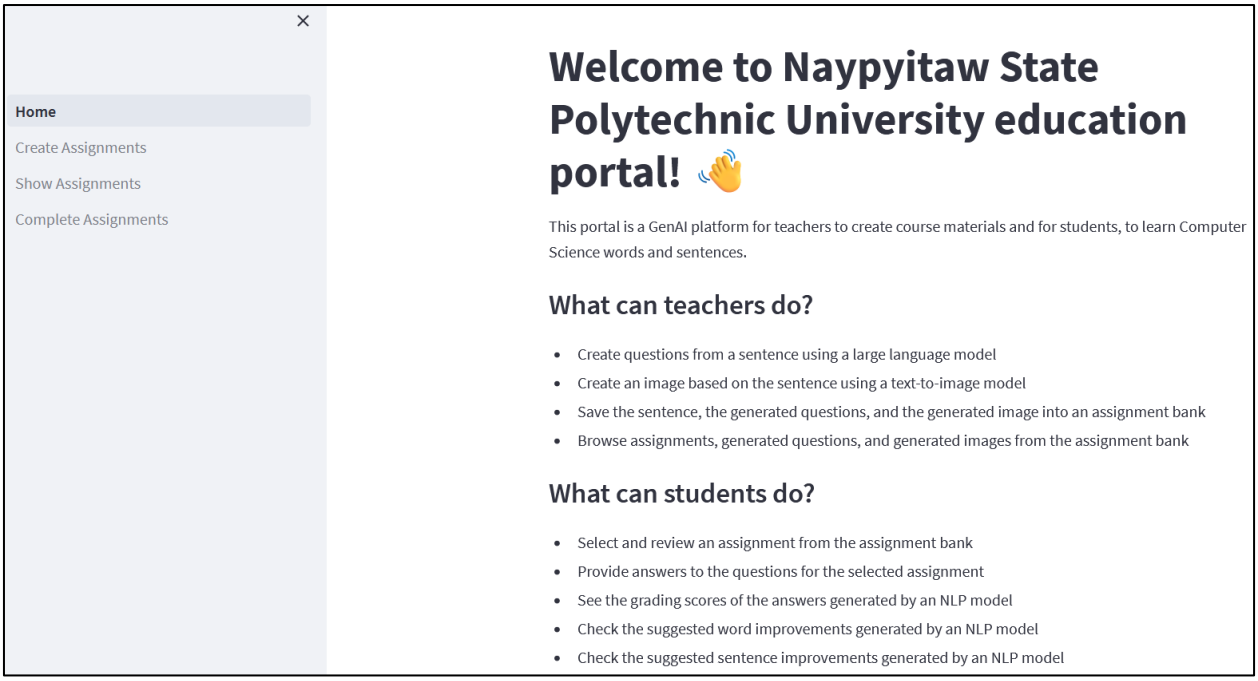

Figure 2 The Homepage of the Application

Figure 3 shows creating student assignments (questions, answers, and images) based on a teacher-provided subject.

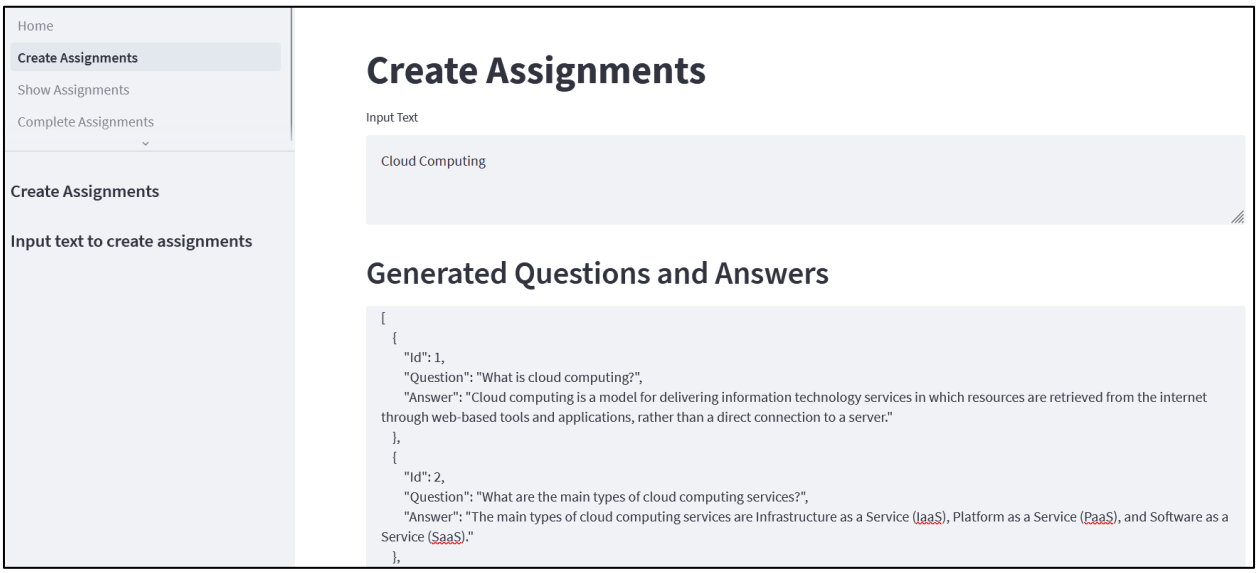

Figure 3 Creating Student Assignments based on Teacher-Provided Subject

Figure 4 shows saving generated questions and answers in an Amazon DynamoDB table and saving generated images in an Amazon S3 bucket respectively.

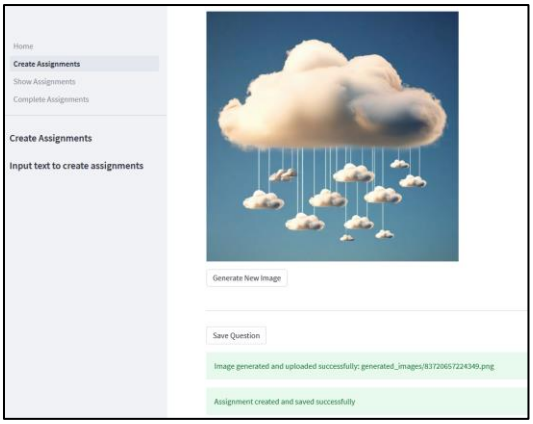

Figure 4 Saving Generated Questions, Answers and Images

Figure 5 shows the assignment chosen by students by retrieving the questions and answers from DynamoDB and retrieving the image from Amazon S3.

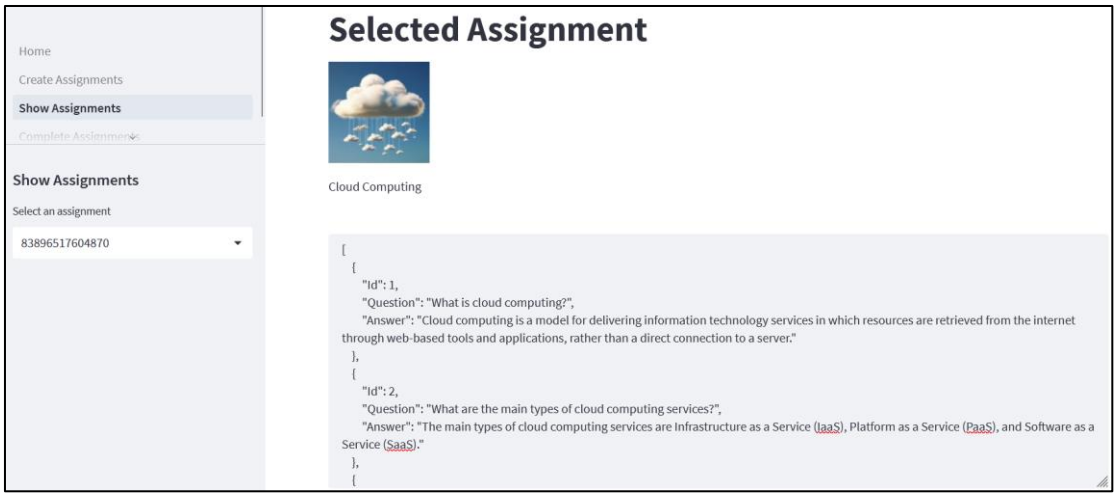

Figure 5 Displaying the Assignments chosen by Students

Providing an answer to a question and getting the score is shown in Figure 6.

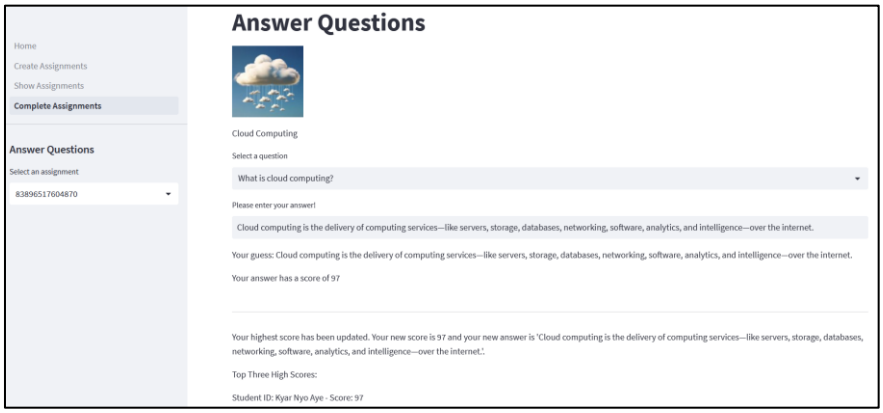

Figure 6 Providing an Answer to a Question and Getting the Score

Figure 7 shows providing feedback on how the answer could be better.

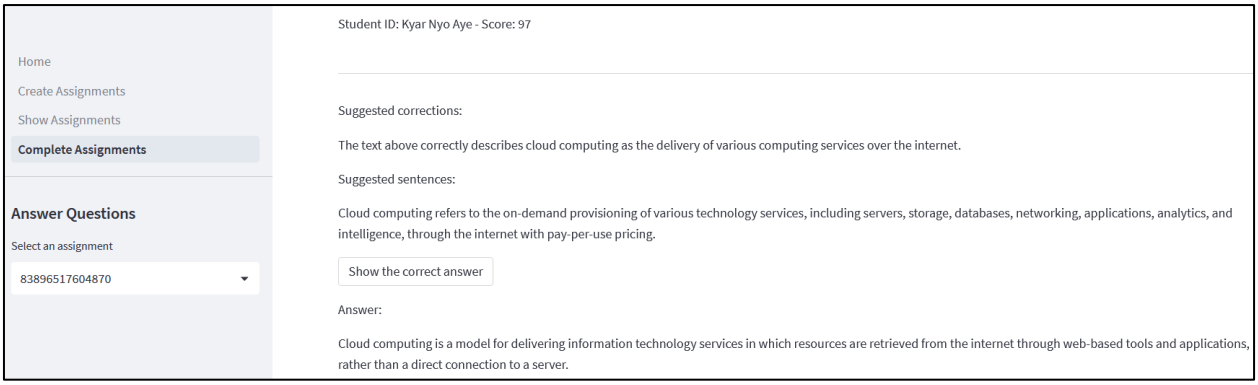

Figure 7 Providing Feedback

5. Conclusion

Generative AI has the potential to revolutionize education by making it more personalized, efficient, and engaging. As technology continues to evolve, its integration into educational practices will likely become more seamless and impactful. While generative AI offers numerous benefits, it's important to consider ethical implications such as data privacy, bias in algorithms, and the potential over-reliance on technology. Educators and developers must work together to ensure that AI applications in education are fair, transparent, and enhance the human element of teaching and learning.

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