AI DOCUMENT ASSISTANT

24-25J-112

Project Proposal Report

PEIRIS A.R.D

B.Sc. (Hons) Degree in Information Technology Specialized in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology Sri Lanka

August 2024

Declaration of The Candidate & Supervisor

I declare that this is my work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Name	Student ID	Signature
Peiris A.R.D	IT21249266	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the Co - Supervisor

Ms. Thilini Jayalath

Date

23/8/24

Abstract

Lack of personalised attention towards students often leads to development of knowledge gaps in students. In traditional education environments, it is practically difficult to provide individualized guidance as there is a greater student count. This study aims to develop an AI Document Assistant that can be integrated as a third-party service to any Learning Management System.

Most research are focused on the role of AI in education rather than how AI can be utilised to improve a student's learning. The current study closes this gap by the development of a fully functional AI Document Assistant with a suitable Large Language Model and addressing the concerns related to AI involvement in a Learning Management System and understanding how this can improve a student's learning.

The findings of this study will contribute to understanding how AI can be effectively used to support personalized & self-directed learning. The methodology involves designing a scalable and adaptable AI Document Assistant that can be integrated as a third-party tool in various LMS platforms.

Overall, this research is likely to offer important information about using AI in education, showing both the benefits and difficulties of adding AI chatbots to LMS platforms. This will lead to more advancements in educational technology, making sure that students get the individual support they need for successful learning.

Contents

Declaration of The Candidate & Supervisor 2
Abstract 3
1. Introduction 6
1.1 Background & Literature Survey 6
1.2 Relevant Studies and Techniques to Master 8
1.3 State of the Art 9
1.4 Research Gap 10
1.5 Research Problems & Proposed Solutions 10
2. Objectives 13
2.1 Main Objective 13
2.2 Sub Objectives 13
3. Methodology 14
3.1 System Diagram 14
3.2 System Overview 15
3.3 Development Lifecycle 15
4. Project Requirements 17
4.1 Functional Requirements 17
4.2 User Requirements 17
4.3 System Requirements 17
4.4 Non-Functional Requirements 18
4.5 Tools and Technologies 18
4.6 Wireframe 19
4.7 Work Breakdown 19
4.8 Gantt Chart 20
5. References 21

List of Figures

Figure 1 - Papers in Web of Science and Google Scholar in the last ten years..... 6
Figure 2 - Overall, how well did you understand this lecture? 7
Figure 3 - User Interaction & Components..... 14
Figure 4 - RAG Architecture..... 14
Figure 5 - Tentative Wireframe 19
Figure 6 - Work Breakdown 19
Figure 7 - Gantt Chart 20
Figure 8 - Turnitin Report..... 22

List of Tables

Table 1 - Research Gap 10
Table 2 - Functional Requirements 17
Table 3 - User Requirements..... 17
Table 4 - System Requirements 17
Table 5 - Non-Functional Requirements 18
Table 6 - Tools and Technology 18

List of Abbreviations

Abbreviations	Description
AI	Artificial Intelligence
LMS	Learning Management System
LLM	Large Language Model
SLM	Small Language Model
RAG	Retrieval Augmented Generation

1. Introduction

1.1 Background & Literature Survey

Learning Management Systems (LMS) are integral to the educational landscape, specifically in the context of pandemics and global emergencies, as they enable remote learning. These platforms allow educational institutions to maintain teaching, providing resources and support to students when traditional face-to-face learning is unfeasible. The significance of LMS became particularly evident during the COVID-19 pandemic, prompting schools, universities, and training organizations worldwide to transition to online education.

As technology continues to advance rapidly, Artificial Intelligence (AI) is beginning to revolutionize various fields, including education. Acknowledging the potential of AI to improve the learning experience, organizations have started to explore and implement AI within their frameworks.

The integration of AI into a LMS allows educators to deliver personalized learning experiences, and ease self-directed learning for students. This transition towards AI-integrated learning tools signifies a transformative phase in education.

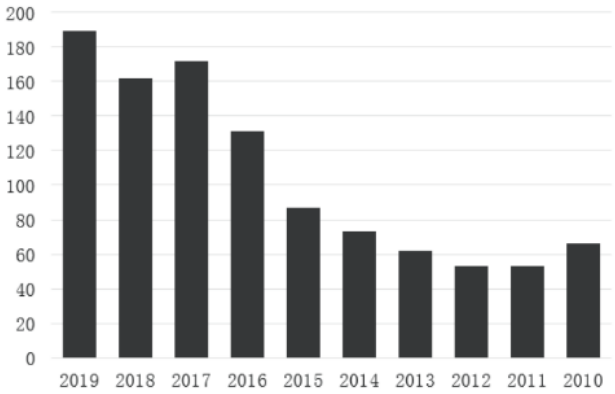


Figure 1 - Papers in Web of Science and Google Scholar in the last ten years.

The application of AI algorithms and systems in education are gaining increased interest year by year. Figure 1 shows the rising number of papers published in the topics ‘‘AI’’ and ‘‘Education’’ from Web of Science and Google scholar since 2010.

	NESB	ESB
Understood very well	9	34
Understood fairly well	68	58
Did not understand a lot	22	8

Notes: this question not asked in first questionnaire administered (Unit 1).
NESB $N = 174$; ESB $N = 216$.
Differences between groups significant at 0.001 level of confidence.

Figure 2 - Overall, how well did you understand this lecture?

During research done by Denise Mulligan & Andy Kirkpatrick in Curtin University of Technology, through a questionnaire they found out that

- 22% of English speaking the students they surveyed did not understand the lecture they were taught,
- 68% understood quite fairly
- 9% completely understood.

These statistics, as illustrated in Figure 1.1.2, highlight the existence of considerable knowledge gaps among students especially during the presence of a language barrier. Such gaps often arise when students' doubts remain unaddressed, leading to a partial understanding of the subject matter.

While reviewing the existing body of research, it became evident that most of the available literature primarily addresses the broader applications of Artificial Intelligence (AI) within education. These studies extensively explore AI's potential to enhance learning experiences, personalize education, and improve student outcomes. However, there is a notable gap in the literature when it comes to the specific application of AI for developing a document assistant within a Learning Management System (LMS).

Although general discussions on AI's role in education provide valuable insights, they often do not address the unique challenges and requirements associated with integrating a document assistant into an LMS. This project seeks to bridge this gap by focusing on the design and implementation of an AI-powered document assistant that leverages LLMs with RAG to enhance student learning through targeted information retrieval and contextually relevant responses.

1.2 Relevant Studies and Techniques to Master

To successfully implement the AI-powered Document Assistant using LLM APIs and Retrieval-Augmented Generation (RAG), it is crucial to master a set of relevant studies and techniques that align with the project's objectives.

The project will leverage transformer-based language models like GPT, accessed through an API, to process and generate language. Although model training is not part of the scope, a solid understanding of how these models' function is essential.

Central to this project is the use of Retrieval-Augmented Generation (RAG), which combines retrieval mechanisms with generative models to deliver accurate and contextually relevant information. The individual must be proficient in the RAG architecture, particularly in how it retrieves documents from a vector database and integrates this information into the generated responses.

The project will also rely heavily on a vector database to facilitate efficient similarity searches. Integrating these vector databases with the RAG framework is critical to ensuring that the system can quickly and accurately pull relevant information in response to user queries.

Furthermore, the project will utilize the Langchain framework to manage the interaction between the LLM and the external data source. Therefore, the individual must learn how to integrate RAG and vector databases, allowing the system to deliver sophisticated, contextually aware responses tailored to the educational content.

Finally, the project will adhere to software development best practices and ensure seamless interaction between the LLM, Langchain, and the retrieval components. The individual will also prioritize testing and debugging practices to maintain the system's reliability and efficiency, ensuring smooth operation as the system scales.

By learning these studies and techniques, the project will be well-positioned to develop an innovative and effective AI-powered Document Assistant, significantly enhancing the learning experience within the LMS.

1.3 State of the Art

The state of the art in integrating AI with Learning Management Systems (LMS) involves several advanced technologies that significantly enhance educational tools. Transformer-based language models offering powerful capabilities for natural language understanding and generation. These models are accessed through APIs, allowing for sophisticated interactions and personalized learning experiences without the need for extensive model training.

Additionally, Retrieval-Augmented Generation (RAG) represents a major advancement by combining retrieval-based methods with generative models. RAG improves response accuracy by retrieving relevant documents from vector databases and integrating this information into the generation process. This approach ensures that responses are grounded in factual data, making AI interactions more reliable and contextually relevant. The use of vector databases for efficient similarity searches further enhances the system's ability to provide precise and timely information. Overall, these state-of-the-art technologies enable more effective and tailored educational tools, pushing the boundaries of what is possible in AI-powered learning environments.

1.4 Research Gap

Research Paper	[1]	[2]	[3]	[4]
Focus	Provide an overview of the research on AI applications in LMS	Explore the different possibilities of using AI in education and its use in education.	Determine the factors that influence the level of motivation and efficiency among students attending higher education institutions.	Emphasizes significant challenges and critical factors that educators need to handle diligently.
Methodology	Follows Kitchenham's [1] approach to SLR. Kitchenham [1]	Applying cluster analysis, specifically the k-means algorithm, to group sales data and identify patterns,	Reviewing relevant literature, conducting surveys or interviews with educators.	Drawing from extensive systematic literature reviews.
Findings	The LMS most used for implementing AI solutions in education is Moodle.	Benefits of personalized learning AI offer	Most learners have shown a positive response to the applications of artificial intelligence.	Numerous benefits of integrating AI chatbots in education
Research Gap	Does not address concerns and Document Assisting and suitable LLM	Does not address concerns and Document Assisting and suitable LLM	Does not address Document Assisting and suitable LLM	Does not address Document Assisting and suitable LLM

Table 1 - Research Gap

1.5 Research Problems & Proposed Solutions

Model Suitability - Selecting the most suitable Language Model for enhancing educational experiences within an LMS involves evaluating factors such as model accuracy, responsiveness, and integration capabilities. Key considerations include the model's ability to understand and generate educational

content, its performance in handling domain-specific queries, and its adaptability to the LMS's requirements.

While Small Language Models may be ideal for more narrowly defined tasks, such as customer support or specific, repetitive inquiries, they often lack the breadth and depth necessary for the diverse and complex needs of educational environments. SLMs typically require extensive model training on specific subjects to perform effectively in specialized domains, which can be resource-intensive and time-consuming. In contrast, LLMs, like those offered by ChatGPT, come pre-trained on vast datasets encompassing a wide range of topics. This enables LLMs to handle the multifaceted nature of educational content with minimal additional training, making them more capable of generating rich, context-aware responses across various subjects. As education involves a broad scope of topics and a need for nuanced understanding, LLMs are the preferred choice for this project, offering a more scalable and efficient solution.

As of today, OpenAI's ChatGPT, Google's Gemini, and Anthropic's Claude represent the leading Large Language Models in the AI industry. When evaluating these models based on factors such as available documentation for development, wide usage, pricing, and integration capabilities, ChatGPT stands out as the most efficient and contextually robust option.

ChatGPT excels in providing comprehensive and contextually rich responses due to its extensive training data and advanced capabilities. It offers well-documented APIs that facilitate seamless integration with various platforms and tools, including Langchain and vector databases.

This integration is particularly enhanced by the Retrieval-Augmented Generation (RAG) functionality within our system, which allows for more domain-specific and contextually relevant interactions by combining context-rich information stored in the vector database. This capability is crucial for enhancing educational experiences within an LMS.

Additionally, ChatGPT's widespread adoption and mature ecosystem support its versatility and reliability, making it a strong candidate for creating an AI Document Assistant.

Integration Concerns - Integrating AI chatbots into a Learning Management System (LMS) presents several concerns. One major issue is ensuring compatibility between the AI system and the LMS's existing infrastructure, which may involve dealing with different data formats, APIs, and security protocols. Additionally, maintaining data privacy and compliance is critical. Ensuring that the AI chatbot can handle diverse queries effectively while providing accurate and contextually relevant responses is another challenge.

To address these concerns, the system can incorporate data removal functionalities before sending any student query to the Language Model, ensuring that no personal information, such as emails and phone numbers, is exposed during processing. Integration issues can be mitigated by developing the AI chatbot as a microservice, allowing it to be easily plugged into or unplugged from the LMS without disrupting the broader system. This modular approach not only simplifies integration but also enhances flexibility and scalability, enabling the system to adapt to changing requirements and technologies.

Impact on Learning - The integration of a document assistant into an LMS has the potential to significantly improve student learning performance. By providing instant access to information and personalized support, the document assistant can help students clarify doubts, explore topics in greater depth, and receive tailored guidance based on their individual learning needs. This can lead to enhanced understanding, better retention of material, and increased engagement with the learning content.

Research has shown that personalized teaching is much more effective than teaching an entire class. The problem is that the teacher is unable to adapt his teaching to the whole class, on the other hand, individual teaching of each pupil is particularly unworkable.[5]

In summary, this project aims to advance the current state of AI in education by developing an AI Document Assistant that can seamlessly integrate into existing LMS platforms, providing personalized learning support in a way that is both scalable and user-friendly. This approach not only builds on previous research but also introduces innovative solutions to the challenges of integrating AI into traditional educational systems.

2. Objectives

2.1 Main Objective

Facilitating self-directed learning by developing an AI Document Assistant through a chatbot interface -The primary goal of this project is to create an AI-powered Document Assistant that enhances self-directed learning within an LMS. This chatbot interface will enable students to interact with educational content more effectively, providing immediate assistance, clarifying doubts, and offering personalized support to facilitate independent learning and exploration.

2.2 Sub Objectives

To design the system for easy integration into other LMS platforms as a third-party tool - The system will be developed with a modular architecture to ensure compatibility with various LMS platforms. By adhering to standard integration protocols and providing well-documented APIs, the AI Document Assistant can be seamlessly incorporated into different learning management systems as a third-party service, broadening its applicability and usability across diverse educational environments.

Ensure scalability and adaptability - The design of the AI Document Assistant will prioritize scalability to handle increasing numbers of users and expanding data sets efficiently. Additionally, the system will be built with adaptability in mind, allowing for easy updates and modifications to accommodate evolving educational needs and technological advancements.

3. Methodology

3.1 System Diagram

Figure 3 shows a high-level diagram between the user interaction and the Retrieval and LLM Components. Once a student feels the need for additional assistance, the student will trigger the AI Document Assistance functionality, behind the scenes the document will be ingested to the RAG system and a chat interface will open. The student then can clarify doubts by querying the chatbot.

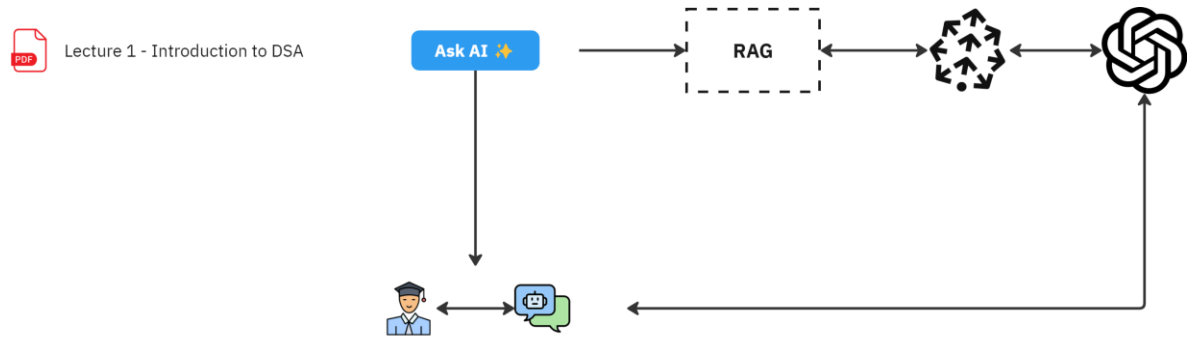


Figure 3 - User Interaction & Components

Figure 4 shows how the Retrieval component and LLM works together in order to provide a response to the user. Explained in part 3.2 System Overview.

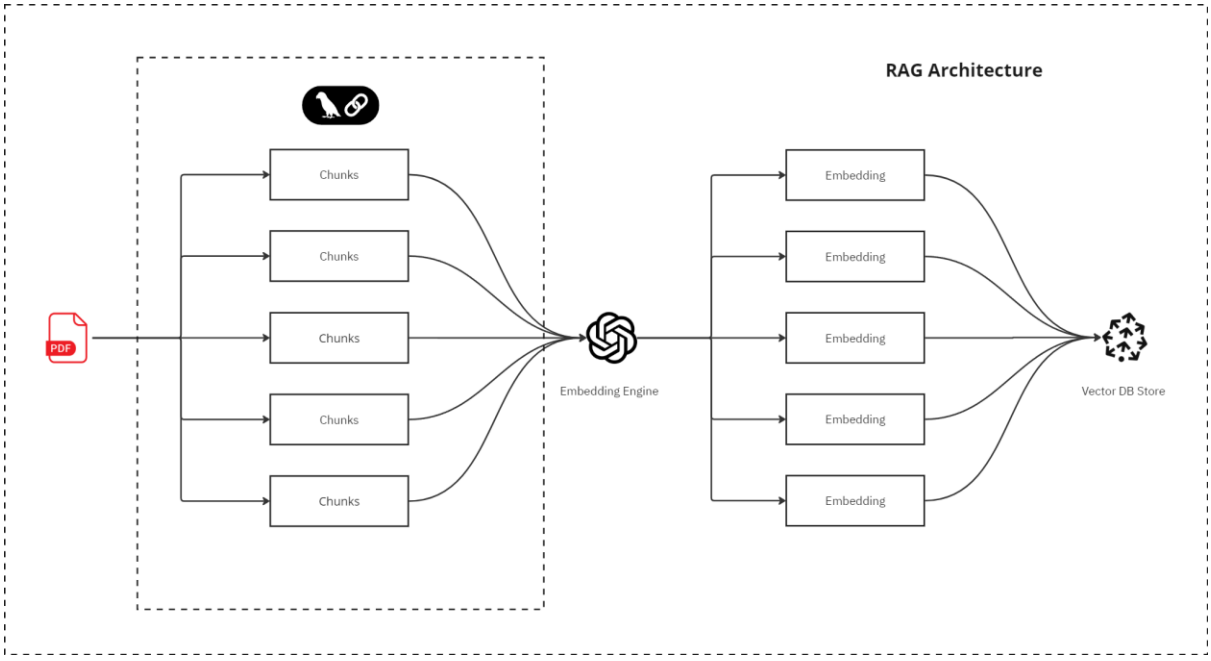


Figure 4 - RAG Architecture

3.2 System Overview

When a PDF is ingested into the system, Langchain is used to extract the text, which is then divided into smaller, manageable pieces known as chunks. These chunks represent portions of the text that are small enough to be processed efficiently while retaining meaningful context. The next step involves converting these chunks into embeddings, which are numerical representations of the text that capture its semantic meaning. This conversion is carried out by the Embedding Engine, a specialized tool designed to transform text into high-dimensional vectors, where each vector encodes the contextual meaning of a chunk.

These vectors (or embeddings) are then stored in a Vector Database, an advanced storage system optimized for searching and retrieving these high-dimensional data points.

When a student interacts with the system, the Large Language Model (LLM) queries the Vector Database to retrieve the most relevant chunks based on the student's input. This allows the LLM to generate responses that are both accurate and contextually rich, drawing directly from the source material to provide students with precise and informative answers tailored to their specific queries.

3.3 Development Lifecycle

Requirements Gathering and Analysis

Understand and document the specific requirements for the AI Document Assistant within the LMS. This includes defining the functionality of text extraction, chatbot interaction, and integration with the LMS.

Design

Design UI and focus on how the AI Document Assistant will interact with other components like Langchain.js, vector databases, and the LLM API.

Design wireframes and mock-ups for the AI Document Assistant's interface. Ensure the design is intuitive and user-friendly, allowing students to easily upload PDFs, interact with the chatbot, and view responses.

Develop an architecture diagram illustrating how Langchain.js, vector databases, and the LLM API will interact. Define how data will flow between the components and how they will be integrated into the LMS.

Plan for the handling of text extraction, including how text is parsed from PDFs, stored in vector databases, and retrieved by the LLM for query responses.

Implementation

Develop the Minimum Viable Product (MVP) of the AI Document Assistant

Implement the basic functionalities of the AI Document Assistant, including text extraction from PDFs, basic chatbot interaction, and integration with Langchain.js and vector databases.

Ensure that the AI Document Assistant integrates smoothly with the LMS, allowing students to interact with it within their existing LMS environment.

Testing

Validate the functionality and performance of the implemented features.

Functional Testing - Test each feature of the AI Document Assistant to ensure it works as expected. This includes verifying text extraction accuracy, chatbot responses, and the integration with the LMS.

Performance Testing - Assess the system's performance under different conditions, such as varying document sizes and user loads. Measure response times and ensure the system meets performance criteria.

Evaluation and Feedback

Collect feedback from students to evaluate the effectiveness of the system.

Analyse the feedback to identify common issues, areas for improvement, and any additional features requested by users.

Refinement

Make improvements based on testing results and feedback.

Deployment

Deploy it to a live environment together with the whole system

4. Project Requirements

4.1 Functional Requirements

Document Ingestion	Ensure functionality of document ingestion to the RAG component.
Text Extraction	Ability to extract text from PDF documents
Chatbot Interaction	Provide a chatbot interface that can respond to student queries based on the extracted text from the PDF.
Integration with LMS	Seamlessly integrate with the existing LMS to allow students to access and interact with the AI Document Assistant.
Query Handling	Process user queries and retrieve relevant information from the extracted text.
User Authentication	Ensure that only authorized users can access the AI Document Assistant within the LMS.

Table 2 - Functional Requirements

4.2 User Requirements

Ease of Use	Interface should be intuitive and easy to navigate
Accuracy	Provided responses should be accurate and comprehensive
Responsiveness	The chatbot should provide instant responses without a significant delay.

Table 3 - User Requirements

4.3 System Requirements

Software Dependencies	Langchain, Vector Database and a LLM API

Table 4 - System Requirements

4.4 Non-Functional Requirements

Usability	Ensure user friendliness and navigation
Scalability	System should handle several users and requests at same time
Compliance	Ensure the responses are suitable for educational environment.

Table 5 - Non-Functional Requirements

4.5 Tools and Technologies

VSCode	IDE for Development
Figma	UI and Wireframe Designing
Miro	Collaborative Whiteboard
Github	Version Controlling and Collaborative Development
Jira	Project Management Tool
React	Frontend development
Node & Python	Backend development
Langchain	Framework for developing applications powered by language models
Vector Database	Store and query vector embeddings

Table 6 - Tools and Technology

4.6 Wireframe

Figure shows the tentative wireframe for the AI Document Assistant chat interface.

Figure 5 - Tentative Wireframe

4.7 Work Breakdown

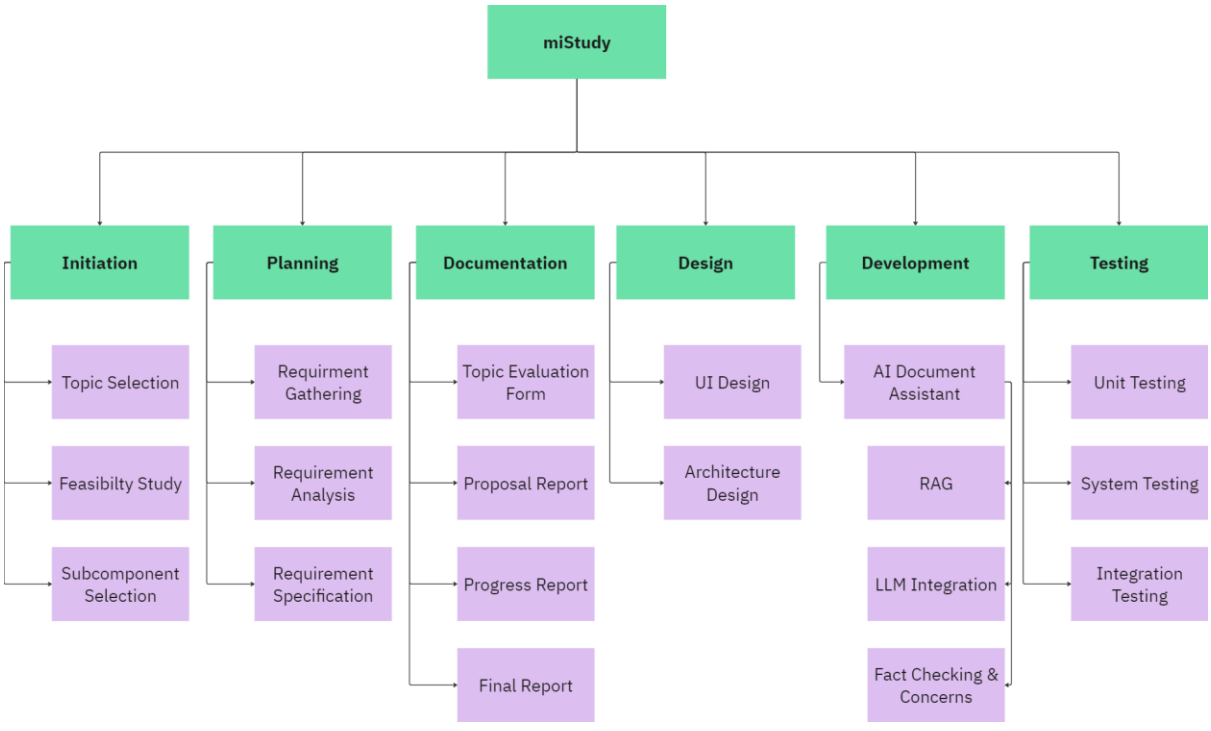


Figure 6 - Work Breakdown

4.8 Gantt Chart

No	Assessment / Milestione	Start Date	End Date	2024- 2025													
				April	May	June	July	August	September	October	November	December	January	February	March	April	May
1	Research group formation	10/04/2024	17/04/2024														
2	Supervisor selection	18/04/2024	18/04/2024														
3	Brainstorming workshop 1	20/04/2024	25/04/2024														
4	Selection of research topic	26/04/2024	30/04/2024														
5	Co-supervisor selection	20/04/2024	20/04/2024														
6	Brainstorming workshop 2	01/05/2024	07/05/2024														
7	Feasibility and background study	01/05/2024	30/05/2024														
8	Topic registration from submission	22/04/2024	22/04/2024														
9	In-depth feasibility and background study 1	01/06/2024	30/06/2024														
10	External supervisor selection	14/06/2024	13/07/2024														
11	Topic assessment form submission	24/05/2024	24/05/2024														
12	Topic assessment from evaluation	25/05/2024	30/05/2024														
13	In-depth feasibility and background study 2	01/07/2024	30/07/2024														
15	Proposal presentation	04/08/2024	09/08/2024														
16	Individual proposal report submission	15/08/2024	15/08/2024														
17	Implementation of research work(upto 50%)	01/10/2024	04/12/2024														
18	Progress presentation 1	05/12/2024	12/12/2024														
19	Prepare and submit research paper	20/10/2024	20/04/2025														
20	Implementation of research work(upto 90%)	05/01/2025	05/03/2025														
21	Progress presentation 2	05/04/2025	10/04/2025														
22	Integration of the research work	10/04/2025	15/04/2025														
23	Project completion	15/04/2025	20/04/2025														
24	System testing	20/04/2025	30/04/2025														
25	Website and final report preparation	01/05/2025	15/05/2025														
26	Final presentation	15/05/2025	25/05/2025														
27	Final report submission	26/05/2025	30/05/2025														

Figure 7 - Gantt Chart

4.8 Budget

Requirement	**Estimated Cost**
Open AI API	<= $25 (Pay-as-you-Go)

5. References

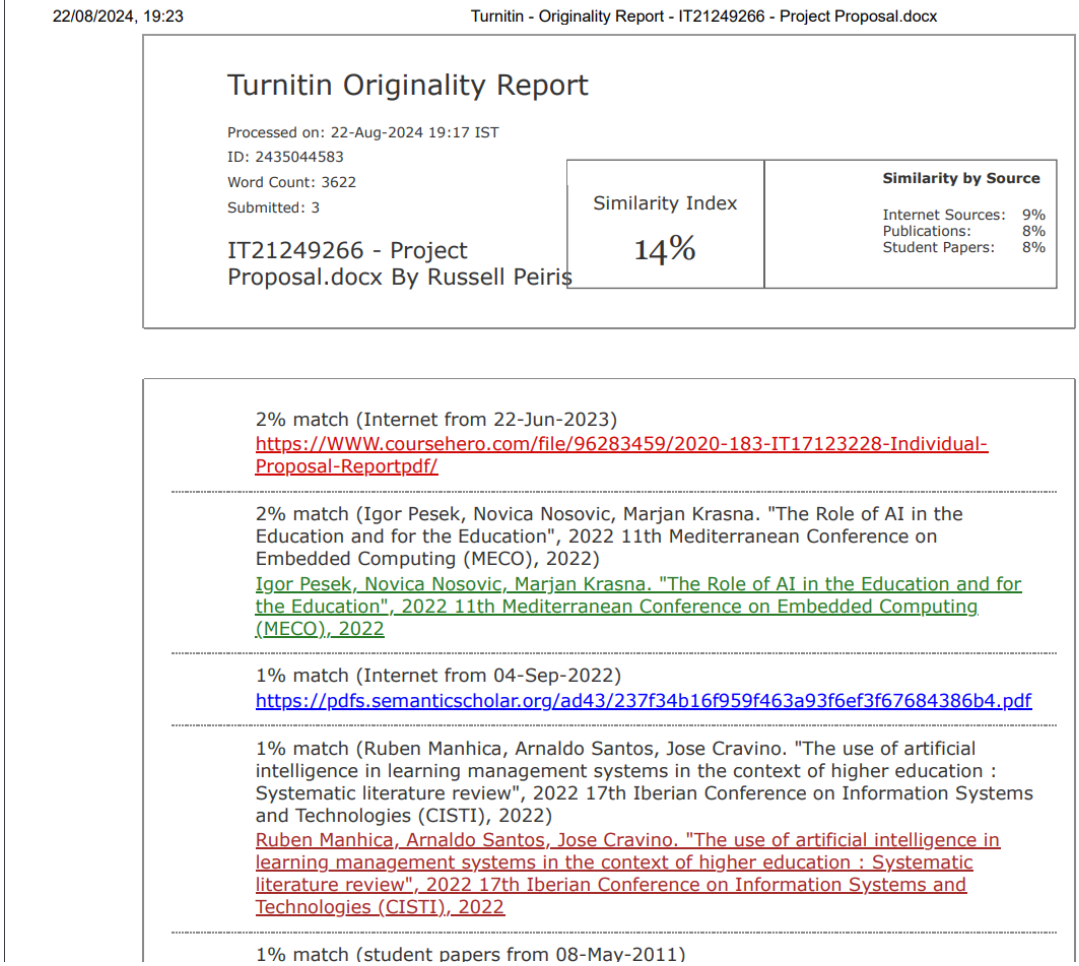
[1] R. Manhiça, A. Santos and J. Cravino, "The use of artificial intelligence in learning management systems in the context of higher education : Systematic literature review," 2022 17th Iberian Conference on Information Systems and Technologies (CISTI), Madrid, Spain, 2022, pp. 1-6, doi: 10.23919/CISTI54924.2022.9820205. keywords: {Support vector machines;Systematics;Terminology;Bibliographies;Education;Neural networks;Decision trees;Systematic Literature Review (SLR);Artificial Intelligence (AI);Higher Education;Learning Management System (LMS)},

[2] K. Souali, O. Rahmaoui, M. Ouzzif and I. El Haddioui, "Recommending Moodle Resources Using Chatbots," 2019 15th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), Sorrento, Italy, 2019, pp. 677-680, doi: 10.1109/SITIS.2019.00110. keywords: {Task analysis;Electronic learning;Databases;Machine learning;Natural language processing;Tools;Moodle, e-learning, recommender system, recommendation, e-learning chatbot, artificial intelligence},

[3] M. A. Rind, M. A. A. Qudah and P. Aliyev, "Determining the Impact of Artificial Intelligence on Modernization of Education," 2024 IEEE 1st Karachi Section Humanitarian Technology Conference (KHI-HTC), Tandojam, Pakistan, 2024, pp. 1-3, doi: 10.1109/KHI-HTC60760.2024.10482021. keywords: {Training;Learning management systems;Art;Government;Machine learning;Learning (artificial intelligence);Reflection;Artificial intelligence;applications;Education;Teaching and learning;Motivation and Effectiveness of learners},

[4] Labadze, L., Grigolia, M. & Machaidze, L. Role of AI chatbots in education: systematic literature review. Int J Educ Technol High Educ 2023

[5] I. Pesek, N. Nosović and M. Krašna, "The Role of AI in the Education and for the Education," 2022 11th Mediterranean Conference on Embedded Computing (MECO), Budva, Montenegro, 2022, pp. 1-4, doi: 10.1109/MECO55406.2022.9797189. keywords: {Technological innovation;Embedded computing;Plagiarism;Education;Learning (artificial intelligence);Transforms;Iterative methods;education;AI;ICT;benefits;competences}



Turnitin Originality Report

Processed on: 22-Aug-2024 19:17 IST
ID: 2435044583
Word Count: 3622
Submitted: 3

IT21249266 - Project Proposal.docx By Russell Peiris

Similarity Index
14%

Similarity by Source
Internet Sources: 9%
Publications: 8%
Student Papers: 8%

2% match (Internet from 22-Jun-2023)
https://WWW.coursehero.com/file/96283459/2020-183-IT17123228-Individual-Proposal-Reportpdf/

2% match (Igor Pesek, Novica Nosovic, Marjan Krasna. "The Role of AI in the Education and for the Education", 2022 11th Mediterranean Conference on Embedded Computing (MECO), 2022)
Igor Pesek, Novica Nosovic, Marjan Krasna. "The Role of AI in the Education and for the Education", 2022 11th Mediterranean Conference on Embedded Computing (MECO), 2022

1% match (Internet from 04-Sep-2022)
https://pdfs.semanticscholar.org/ad43/237f34b16f959f463a93f6ef3f67684386b4.pdf

1% match (Ruben Manhica, Arnaldo Santos, Jose Cravino. "The use of artificial intelligence in learning management systems in the context of higher education : Systematic literature review", 2022 17th Iberian Conference on Information Systems and Technologies (CISTI), 2022)
Ruben Manhica, Arnaldo Santos, Jose Cravino. "The use of artificial intelligence in learning management systems in the context of higher education : Systematic literature review", 2022 17th Iberian Conference on Information Systems and Technologies (CISTI), 2022

1% match (student papers from 08-May-2011)

Figure 8 - Turnitin Report