DEPARTMENT: ICT

PROGRAM: INFORMATION TECHNOLOGY

RQF LEVEL: 8

SMART RESEARCH ASSISTANT

A capstone report submitted for partial fulfillment of the requirements for the award of Bachelor of Technology in Information and Communication Technology

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DECLARATION (A)

I, **NIYIBIZI Shaloom,** declare that this work entitled **"SMART RESEARCH ASSISTANT PLATFORM"** is my work. I have to the best of my knowledge acknowledged all authors or sources from where I got information. I further declare that this work has not been submitted to any university or institution for the award of a degree or any of its equivalents.

Done by: **NIYIBIZI Shaloom**
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Signed ------------------------   Date ………………………………….

DECLARATION (B)

I confirm that the work reported in this research project was carried out by the candidate under my supervision and it has been submitted with my approval as the GIP supervisor.

Name: UMUTONI Marie

Signed ------------------------   Date ………………………………….

APPROVAL

This is to acknowledge that Shaloom NIYIBIZI's dissertation, titled "**SMART RESEARCH ASSISTANT PLATFORM**", has been submitted with my approval. The dissertation meets the standards required for the degree of bachelor's technology and demonstrates a thorough understanding of Information and Communication Technology (**ICT**). I am confident Shaloom NIYIBIZI is prepared to defend her work and contribute significantly to the field.

Supervisor Name: UMUTONI Marie

Signature: .... Date...............................

HOD Name: NDIZEYE Patric

Signature: .... Date...............................

ACKNOWLEDGMENT

I, **Shaloom NIYIBIZI** dedicate this work to my supervisor, friends, mentors, and all those who have supported and inspired me along the way. Your belief, encouragement, and guidance have been invaluable, and I am grateful for your presence in my life.

I praise lord God almighty for allowing me to do this project of a smart bed for the health-care monitoring system.

Thanks, God, for the grace and wisdom he gave me to make this project. I want also to thank you. My family who has been supporting me in that helped me in the daily transport and restoration, Emotional and spiritual support.

May Almighty bless you abundantly!

ABSTRACT

The "**Smart Research Assistant**" project addresses the common challenges faced by students in academic research, such as difficulty in generating original ideas, inefficiencies in the research process, and the risk of duplicating existing work. Leveraging advanced AI technologies, the platform introduces a novel approach to revolutionize student research by providing tools that enhance research quality, foster originality, and streamline the research process. The platform's core features include an AI-powered research idea generator, an interactive chat system for engaging with research papers, and a comprehensive repository to prevent project duplication. The development process involved extensive planning, design, AI integration, and rigorous testing to ensure a seamless user experience. The results indicate that the platform significantly empowers students to undertake more innovative and efficient research, reducing redundancy and promoting collaboration. The major conclusions drawn from the study suggest that the Smart Research Assistant has the potential to transform academic research by fostering a culture of originality and pushing the boundaries of knowledge. Further recommendations include the continuous refinement of AI algorithms and the expansion of the repository to include a broader range of academic disciplines.

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LIST OF SYMBOLS, ACCRONYMNS AND ABBREVIATIONS

- **AI:** Artificial Intelligence
- **API:** Application Programming Interface
- **BTech**: Bachelor of Technology
- **AWS:** Amazon Web Services
- **CDN:** Content Delivery Network
- **DBMS:** Database Management System
- **ICT:** Information and Communication Technology
- **IT:** Information and Communication
- **IPRC:** Integrated Polytechnic Region College
- **LLM:** Large Language Model
- **UI:** User Interface
- **UX:** User Experience
- **UAT:** User Acceptance Testing
- **QA:** Quality Assurance
- **RBAC:** Role Based Access Control
- **RP:** Rwanda Polytechnic
- **IDE:** Integrated Development Environment
- **MFA:** Multi-Factor Authentication
- **ML:** Machine Learning
- **RDS:** Relational Database Service
- **S3:** Simple Storage Service
- **DB:** Database
- **UXD:** User Experience Design
- **CI/CD:** Continuous Integration/Continuous Delivery

DEFINITION OF KEY TERMS

1. Artificial Intelligence (AI)

A branch of computer science focused on creating systems that can perform tasks that typically require human intelligence. These tasks include reasoning, learning, problem-solving, perception, and language understanding.

2. Application Programming Interface (API)

A set of protocols and tools for building software and applications. An API defines how different software components should interact, enabling systems to communicate and share data or services.

3. Cloud Computing

The delivery of computing services, including storage, processing, and networking, over the internet ("the cloud"). Cloud services are typically provided on a pay-as-you-go basis, allowing businesses to scale their resources up or down as needed.

4. Repository

A central location where data is stored and managed. In this project, the repository refers to the digital archive that houses past research projects and other related data.

5. Large language model

A large language model (LLM) is a computational model capable of language generation or other natural language processing tasks. As language models, LLMs acquire these abilities by learning statistical relationships from vast amounts of text during a self-supervised and semi-supervised training process

6. Retrieval-augmented generation

Retrieval-augmented generation (RAG) is a technique for enhancing the accuracy and reliability of generative AI models with facts fetched from external sources.

7. Smart Research Assistant

The "Smart Research Assistant" platform is an innovative project designed to transform the way students approach academic research. By integrating advanced AI technologies, the platform aims to enhance the quality, efficiency, and originality of student research projects.

CHAPTER ONE: INTRODUCTION

1.0.   INTRODUCTION

The **"Smart Research Assistant"** platform is an innovative project designed to transform the way students approach academic research. By integrating advanced AI technologies, the platform aims to enhance the quality, efficiency, and originality of student research projects. In today's educational landscape, students often face significant challenges, such as difficulty in generating original research ideas, navigating vast amounts of academic literature, and avoiding redundancy in their work. These challenges can hinder the quality and efficiency of research, leading to less impactful academic contributions.

Recognizing these issues, the Smart Research Assistant aims to revolutionize the way students approach research by leveraging advanced artificial intelligence (AI) technologies. The platform offers a comprehensive suite of AI-powered tools that assist students in every stage of their research journey—from idea generation to literature review, and from project execution to final submission. By integrating these tools into a user-friendly platform, the project seeks to enhance the quality of student research, foster originality, and reduce the duplication of work.

At the heart of the Smart Research Assistant is its commitment to empowering students to produce high-quality, innovative research that pushes the boundaries of knowledge. The platform provides access to a vast repository of past projects, helping students avoid redundancy and build upon existing work. Additionally, it features an AI-powered idea generator that helps students develop unique project concepts, and an interactive chat system that enables deeper engagement with research papers.

Overall, the Smart Research Assistant is composed to make a significant impact on the academic community by transforming the research process for students. By providing the tools and resources necessary for effective and original research, the platform supports students in producing work that is not only academically rigorous but also contributes meaningfully to their respective fields.

1.1 BACKGROUND OF THE STUDY

The landscape of Rwandan academic research has evolved significantly over the years, driven by advances in technology and the growing complexity of global challenges that demand innovative solutions. However, despite these advancements, students often

encounter several persistent challenges that hinder their ability to conduct effective and original research. These challenges include the difficulty of generating unique research ideas, the overwhelming volume of academic literature that needs to be reviewed, and the risk of duplicating existing work, which can lead to redundancy and less impactful research outcomes.

Traditionally, students have relied on manual methods for conducting literature reviews, developing research ideas, and managing their projects. These methods are not only time-consuming but also prone to errors and inefficiencies. Moreover, the total amount of information available today makes it increasingly difficult for students to identify gaps in the literature or to ensure that their work is truly original. This often results in projects that lack innovation or fail to contribute new knowledge to the academic community.

In response to these challenges, there has been a growing interest in the integration of artificial intelligence (AI) into the research process. AI has the potential to transform the way research is conducted by automating complex tasks, providing insights that would be difficult for humans to recognize, and enhancing the overall efficiency and quality of the research process. This technology can assist students in identifying research gaps, generating original ideas, and interacting with academic literature in ways that were previously unimaginable.

The **"Smart Research Assistant"** project was conceived to address these needs by leveraging AI to create a platform that supports students throughout their research journey. The platform aims to empower students by providing tools that not only enhance the efficiency of the research process but also foster originality and innovation. By offering features such as an AI-powered idea generator, an interactive chat system for engaging with research papers, semantic search, and a comprehensive repository of past projects, the Smart Research Assistant seeks to revolutionize the student research experience.

This project is built on the understanding that the future of research lies in the ability to utilize technology to overcome traditional barriers and to push the boundaries of what is possible in academic inquiry. By providing students with the tools, they need to produce high-quality, original research, the Smart Research Assistant aims to contribute to the advancement of knowledge across a wide range of disciplines.

1.3 PROBLEM STATEMENT

In Rwanda, higher education institutions such as the Integrated Polytechnic Regional Centers (IPRCs) face significant challenges in managing the submission and approval process for final year project topics. Currently, there is no centralized platform to track and manage project topics submitted by students across different campuses. Not only that here are some other challenges that students face while conducting academic research:

1. **Difficulty in Generating Original Research Ideas:** Students often struggle to identify unique and innovative research topics. This challenge is exacerbated by the vast amount of existing research, which can make it difficult to find unexplored areas or gaps in the literature.

2. **Overwhelming Volume of Academic Literature:** The total volume of available academic papers and resources can be daunting, making it challenging for students to conduct thorough and efficient literature reviews. This often leads to superficial understanding or oversight of relevant studies.

3. **Risk of Project Duplication:** Without access to comprehensive databases of past projects, students may inadvertently duplicate existing research, resulting in a lack of originality and diminished impact of their work.

4. **Inefficient Research Process**: The traditional methods of managing research projects are time-consuming and prone to error, leading to inefficiencies that can affect the overall quality and timeliness of the research.

5. **These challenges contribute to a broader problem in academia:** the production of research that lacks originality, is inefficiently conducted, and often fails to contribute significantly to the advancement of knowledge.

The **"Smart Research Assistant"** project seeks to address these challenges by developing an AI-powered platform that provides students with the tools and resources they need to conduct high-quality, original research efficiently. The platform aims to empower students to generate unique ideas, conduct comprehensive literature reviews, avoid project duplication, and streamline the entire research process. In doing so, the Smart Research Assistant seeks to revolutionize the student research experience and contribute to the advancement of academic knowledge.

1.3 PURPOSE OF THE STUDY

The purpose of the study is to design, develop, and evaluate the "**Smart Research Assistant**" platform, an innovative tool aimed at transforming the student research experience. This platform seeks to leverage advanced AI technologies to address common challenges faced by students during the research process, including the generation of research ideas, conducting thorough literature reviews, and ensuring the originality of their work. By providing a suite of AI-powered tools and a comprehensive repository of past research projects, the study aims to enhance the quality and efficiency of student research, foster innovation, and reduce the incidence of project duplication. Ultimately, the purpose of the study is to empower students to produce impactful, original research that contributes to their academic fields and pushes the boundaries of knowledge

1.4 RESEARCH OBJECTIVES

1.4.1 Main Objectives

The main objective of the "Smart Research Assistant" project is to revolutionize the student research experience by leveraging advanced AI technologies to enhance the quality, originality, and efficiency of academic research. The platform aims to empower students to produce innovative, impactful research that pushes the boundaries of knowledge while reducing redundancy and streamlining the research process.

1.4.2 Specific Objectives

The specific objectives of AI-based to streamline student research platform are to:
- ✓ Create and integrate AI modules that assist students in generating research ideas, conducting literature reviews, and interacting with academic papers.
- ✓ Build and maintain a digital repository that stores past research projects, making them easily accessible for reference and to reduce duplication.
- ✓ Design and implement a user-friendly interface that allows students to navigate the platform easily, access tools, and retrieve information efficiently.
- ✓ Enable students to interact with research papers in real-time, using AI to ask questions, summarize content, and extract key insights.
- ✓ Implement features that identify and flag potential project duplications while promoting unique and original research ideas.

✓ Utilize cloud services such as AWS for hosting, data storage, and AI processing to ensure the platform is scalable, secure, and reliable.

1.5 RESEARCH QUESTIONS

Here are adapted research questions for the AI-based streamlined student research platform:

1. What are the key challenges students face in the research process, and how can the Smart Research Assistant address these challenges to improve efficiency and reduce redundancy?

2. In what ways can an AI-powered research idea generator influence the creativity and innovation of student research topics?

3. How can the integration of an interactive chat system with research papers deepen students' understanding of academic literature and improve the literature review process?

4. What impact does access to a comprehensive repository of past projects have on the likelihood of project duplication and the originality of new research?

5. How can the Smart Research Assistant facilitate collaboration among students, and what is the effect of this collaboration on the quality and impact of research outcomes?

1.6 HYPOTHESIS

The development and implementation of the **"Smart Research Assistant"** platform will significantly enhance the quality, originality, and efficiency of student research projects by providing AI-powered tools for idea generation, literature review, project management, and collaboration, thereby reducing the likelihood of project duplication and improving student satisfaction with the research process.

1.6.1 Sub-Hypotheses

H1: AI-Powered Research Idea Generation

The AI-driven research idea generator within the Smart Research Assistant will help students develop more original and innovative research topics compared to traditional methods of idea generation.

H2: Efficiency in Literature Review

The use of AI-powered literature review tools will significantly reduce the time and effort required by students to conduct comprehensive literature reviews, leading to a more efficient research process.

H3: Reduction in Project Duplication

Access to a comprehensive repository of past research projects, coupled with AI-driven cross-referencing, will reduce the incidence of project duplication among students.

H4: Improved Understanding of Research Papers

The interactive AI-powered chat system for engaging with research papers will enhance students' understanding of academic literature, resulting in more in-depth and informed research outcomes.

H6: Increased Student Satisfaction

The overall use of the Smart Research Assistant platform will lead to higher levels of student satisfaction with the research process, as measured by user feedback and academic performance

1.7 SCOPE AND LIMITATION OF THE PROJECT

The **"Smart Research Assistant"** project encompasses the development and implementation of an AI-powered platform designed to enhance the student research experience. The scope of the project includes the following key areas:

1.7.1 Platform Development

- ✓ **User Interface Design:** Creating an intuitive and user-friendly interface that caters to the needs of students across various academic disciplines.
- ✓ **AI Integration:** Implementing advanced AI algorithms to power the core features of the platform, including the research idea generator, interactive paper chat, and project duplication detection.
- ✓ **Database Management:** Building and maintaining a comprehensive repository of past research projects, academic papers, and other resources to support student research.

1.7.2 CORE FEATURES

- ✓ **Research Idea Generator:** Developing an AI-driven tool that suggests unique and innovative research topics based on current trends, gaps in the literature, and student input.
- ✓ **Interactive Paper Chat:** Integrating a feature that allows students to engage in AI-powered conversations with research papers, providing summaries, analyses, and deeper insights.
- ✓ **Project Duplication Prevention:** Implementing a system that cross-references new research ideas with the repository to prevent duplication and encourage originality.
- ✓ **Resource Library**: Curating a diverse collection of academic resources, including research papers, articles, tutorials, and guides, to assist students throughout their research journey.

1.7.3 Target Audience

The primary users of the platform are students at various academic levels, including undergraduate, graduate, and doctoral candidates, who are engaged in research across a wide range of disciplines.

Secondary users include educators, academic advisors, and research supervisors who may use the platform to support and guide students in their research endeavors.

1.7.4 Project Phases

- ➢ **Research and Planning:** Understanding the challenges faced by students in academic research and identifying opportunities for AI to address these challenges.
- ➢ **Design and Prototyping:** Developing prototypes of the platform's features and gathering feedback from potential users to refine the design.
- ➢ **Development and Integration:** Building the platform, integrating AI technologies, and ensuring that all features work seamlessly together.
- ➢ **Testing and Evaluation:** Conducting thorough testing to ensure the platform's reliability, accuracy, and user satisfaction. Collecting feedback for further improvements.
- ➢ **Deployment and Launch:** Making the platform available to students and academic institutions, accompanied by training materials and support resources.

- ➢ **Ongoing Maintenance and Updates:** Continuously improving the platform based on user feedback, technological advancements, and emerging research trends.

1.7.5 GEOGRAPHICAL SCOPE

While initially focused on deployment in academic institutions such as IPRCs, the platform is designed to be scalable and adaptable for use in various educational contexts worldwide.

1.7.6 LIMITATIONS

The initial version of the platform may be limited in terms of the number of academic disciplines covered and the depth of AI-driven insights. These limitations will be addressed in future updates as the platform evolves.

The scope of the Smart Research Assistant project is broad yet focused, aiming to create a comprehensive, AI-powered solution that addresses the key challenges faced by students in academic research. Through this project, the platform aspires to set a new standard for research support, fostering innovation and excellence in student research.

CHAPTER TWO: LITERATURE REVIEW

2.0 INTRODUCTION

The **"Smart Research Assistant"** project sits at the intersection of educational technology, artificial intelligence, and academic research, drawing on various bodies of literature that explore the challenges and opportunities within these domains. This literature review provides an overview of key studies and theories that inform the development of the platform, highlighting the role of AI in education, the challenges faced by students in academic research, and the potential benefits of AI-driven research tools.

2.1. CHALLENGES IN ACADEMIC RESEARCH

Academic research is a complex process that requires students to engage in critical thinking, problem-solving, and creativity. However, numerous studies have identified significant challenges that students face throughout this process. According to (Pyhältö et al., 2012), students often struggle with selecting research topics, conducting comprehensive literature reviews, and managing the research process efficiently. These challenges are compounded by the ever-increasing volume of academic literature, which can overwhelm students and lead to superficial engagement with existing research(Chatzoglou et al., 2016).

Moreover, the risk of unintentional duplication of existing work is a persistent issue. (McCutcheon et al., 2017) emphasize that without access to comprehensive databases of past research, students may unknowingly replicate studies, resulting in a lack of originality and diminished academic impact. This highlights the need for tools that can assist students in identifying unique research opportunities and ensuring that their work contributes new knowledge to their field.

2.2. THE ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

Artificial intelligence has emerged as a transformative force in education, offering new ways to enhance learning outcomes and streamline academic processes. AI-driven tools have been shown to improve student engagement, personalize learning experiences, and provide valuable insights that can guide educational decision-making (Luckin et al., 2016). In the context of research, AI has the potential to assist in automating tedious tasks, such as literature reviews and data analysis, thereby freeing up time for students to focus on more creative aspects of their work.

AI's ability to process large amounts of data and identify patterns can be particularly beneficial in generating research ideas and preventing project duplication. A study by Liu et al.(Liu et al., 2018) demonstrates how AI algorithms can analyze trends in academic publications to suggest novel research topics that align with emerging areas of interest. Similarly, AI-powered tools can cross-reference new research proposals with existing studies to ensure originality and avoid duplication (Yu et al., 2015).

2.3. AI-POWERED RESEARCH TOOLS

The integration of AI into research tools is a growing area of interest, with several studies exploring its potential to revolutionize the research process. For instance, AI-powered literature review tools, such as those discussed by (Wagner et al., 2022), can significantly reduce the time and effort required to identify relevant studies, making the process more efficient and comprehensive. These tools use natural language processing (NLP) techniques to analyze vast amounts of text, providing summaries, insights, and connections that would be difficult for humans to discern manually.

Interactive AI systems, such as those explored by (Kelly et al., 2023), have also been developed to facilitate deeper engagement with academic literature. These systems allow users to interact with research papers through AI-driven chat interfaces, asking questions and receiving contextualized explanations. This interactive approach can enhance students' understanding of complex concepts and improve the quality of their literature reviews.

2.4. PREVENTING PROJECT DUPLICATION

Preventing the duplication of research is a critical concern in academia, as it ensures that resources are used effectively and that each study contributes meaningfully to the body of knowledge. Researchers like (Dibekulu, 2020) have highlighted the importance of comprehensive databases that allow students and researchers to check for existing work in their area of interest. AI can play a pivotal role in this process by automating the search for relevant studies and providing real-time feedback on the novelty of proposed research topics (Gligorea et al., 2023).

2.5. IMPACT OF AI ON RESEARCH EFFICIENCY AND QUALITY

The overall impact of AI on research efficiency and quality is well-documented. AI-driven tools can streamline various aspects of the research process, from idea generation to data

analysis, leading to more timely and higher-quality outcomes (Pinzolits, 2023). By automating routine tasks and providing intelligent insights, AI allows researchers to focus on the creative and analytical aspects of their work, which are essential for producing original and impactful research.

2.6. GAPS IN EXISTING LITERATURE

While the literature provides valuable insights into the potential of AI in education and research, there are still gaps that need to be addressed. Most studies focus on individual AI tools rather than integrated platforms that combine multiple AI-driven features. Additionally, there is a need for more empirical research on the impact of AI-powered research tools on student outcomes, particularly in terms of originality, efficiency, and academic impact.

2.7 SUMMARY

The literature reviewed underscores the potential of AI to address many of the challenges students face in academic research. By integrating AI-driven tools into a cohesive platform, the "Smart Research Assistant" aims to revolutionize the student research experience, fostering originality, enhancing efficiency, and ensuring that each project contributes meaningfully to the academic community. This project builds on existing research while addressing gaps in the literature, particularly in the integration of AI technologies into a comprehensive research support system.

CHAPTER THREE: METHODOLOGY

3.0 INTRODUCTION

This methodology section provides a detailed explanation of the systematic approach employed in the development, testing, and deployment of the "**Smart Research Assistant**" platform. It outlines the various phases of the project, the strategies used to ensure the platform's effectiveness, and the tools and techniques implemented to achieve the project objectives.

3.1. STUDY AREA

The "**Smart Research Assistant**" platform was developed as a web-based application accessible globally. The primary study area was focused on higher education institutions, particularly targeting students at the undergraduate and graduate levels. The platform was designed to be scalable and adaptable to different academic environments, ensuring that students from diverse disciplines and institutions could benefit from its features.

3.2. STUDY DESIGN

The project followed an Agile software development methodology, which allowed for iterative development, continuous feedback, and adaptability to changing requirements. The study design involved multiple stages, including requirements gathering, system design, development, testing, and deployment.
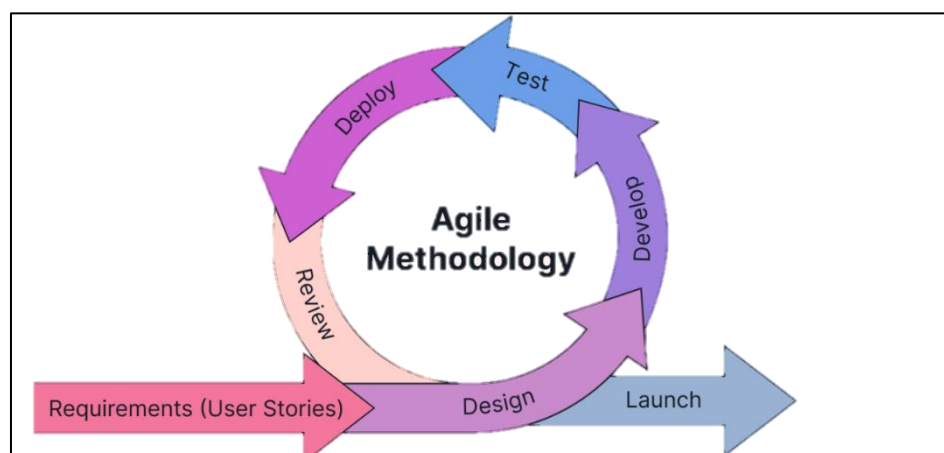

Figure 1: Agile methodology

3.2.1 Requirements Gathering

Objective: To identify and understand the needs and challenges faced by students in academic research and to define the requirements for the Smart Research Assistant platform.

Activities:

➢ **Literature Review:** Conducting a comprehensive review of existing research on AI in education, challenges in academic research, and current research tools.

➢ **Stakeholder Interviews:** Engaging with students, and academic advisors to gather insights into the specific challenges they face and the features they would find most useful.

➢ **Surveys and Questionnaires:** Distributing surveys to a broader student audience to validate the findings from interviews and to prioritize features based on user needs.

➢ **Requirements Documentation:** Compiling the gathered information into a detailed requirements document that outlines the platform's core functionalities, user roles, and system architecture.

Outcome: A clear set of functional and non-functional requirements that will guide the design and development of the platform

3.2.2 System Design

Focused on creating a robust and scalable architecture that could support the platform's core functionalities, including AI-powered tools, a comprehensive repository, and user management

Objective: To create a detailed design of the platform and develop prototypes to test with potential users.

Activities:

➢ **System Architecture Design:** Defining the overall architecture of the platform, including the database structure, AI integration, and user interface components.

➢ **Wireframing and UI/UX Design:** Creating wireframes and user interface designs that prioritize ease of use and accessibility. Ensuring that the design is intuitive and meets the needs of diverse users.

- ➤ **Prototyping:** Developing interactive prototypes of key features, such as the research idea generator, AI-powered literature review tool, and interactive paper chat.
- ➤ **User Testing:** Conducting usability testing with a sample group of students to gather feedback on the prototypes. Iterating on the design based on user feedback to improve usability and functionality.

Outcome: A refined design and prototype that are ready for full-scale development, with validated features that meet user needs.

3.2.3 Development

The platform was developed using modern web technologies, with a focus on creating an intuitive user interface and a powerful back-end system capable of handling complex queries and AI processing.

Objective: To build the platform, integrating the AI components and ensuring seamless functionality across all features.

Activities:

- ➤ **Backend Development:** Developing the server-side components, including database management, API development, and AI model integration.
- ➤ **AI Model Training and Integration:** Training AI models for the research idea generator, and interactive chat system. Integrating these models into the platform using appropriate APIs and frameworks.
- ➤ **Frontend Development:** Building the user interface based on the finalized designs, ensuring responsiveness and accessibility across devices.
- ➤ **Feature Integration:** Ensuring that all features work together seamlessly, including the repository of past projects, resource library, and collaboration tools.

Outcome: A fully functional platform with integrated AI-powered tools, ready for testing and deployment

3.2.4 Testing

Included unit testing, integration testing, and user acceptance testing (UAT) to ensure the platform met the required standards of performance, usability, and security.

Objective: To ensure the platform is reliable, secure, and meets the defined requirements.

Activities:

- ➢ **Unit Testing**: Testing individual components and features to ensure they work as expected.
- ➢ **Integration Testing:** Testing the interaction between different components to ensure that they work together seamlessly.
- ➢ **User Acceptance Testing (UAT):** Involving a group of students and educators in testing the platform to identify any issues or areas for improvement. Gathering feedback and making necessary adjustments.
- ➢ **Security Testing:** Conducting security assessments to identify and address potential vulnerabilities, ensuring that the platform protects user data and complies with privacy regulations.
- ➢ **Performance Testing:** Evaluating the platform's performance under various conditions, including load testing and stress testing to ensure it can handle multiple users simultaneously.

Outcome: A high-quality, secure, and user-friendly platform that is ready for deployment

3.2.5 Deployment

The platform was deployed in a cloud environment to ensure scalability, reliability, and accessibility.

Objective: To make the Smart Research Assistant platform available to students and academic institutions.

Activities:

- ➢ **Deployment Planning:** Developing a detailed deployment plan, including server setup, domain registration, and data migration.
- ➢ **Platform Launch:** Deploying the platform to the production environment and making it accessible to users.
- ➢ **Training and Documentation:** Providing training materials, user guides, and support resources to help users get started with the platform.
- ➢ **Marketing and Outreach:** Promoting the platform to academic institutions, students, and educators to encourage adoption.

Outcome: A successful launch of the Smart Research Assistant platform, with initial user onboarding and engagement.

3.2.6 Monitoring, Maintenance, And Continuous Improvement

Objective: To ensure the platform remains up-to-date, relevant, and continues to meet user needs.

Activities:

- ➢ **Monitoring and Analytics:** Continuously monitoring platform performance, user engagement, and AI accuracy. Collecting data on user interactions to identify areas for improvement.
- ➢ **User Feedback and Support:** Providing ongoing support to users and actively seeking feedback to address issues and improve the platform.
- ➢ **Regular Updates:** Implementing regular updates to the platform, including bug fixes, new features, and AI model improvements based on emerging research and user needs.
- ➢ **Scaling and Expansion:** Scaling the platform to support more users and expanding its features based on feedback and technological advancements.

Outcome: A continuously evolving platform that remains relevant, effective, and aligned with the needs of its users.

3.3. STUDY POPULATION

The study population primarily consisted of students from higher education institutions, including undergraduates, postgraduates and graduate. Additionally, educators and academic researchers were included to provide insights into the platform's potential for supporting teaching and research activities.

User Personas:

Undergraduate Students: Looking for help in selecting research topics and conducting literature reviews.

Graduate Students: Seeking advanced tools for managing and conducting comprehensive research projects.

Educators and Researchers: Interested in the platform's ability to support academic research and provide educational resources.

3.4. STUDY SAMPLE

A representative sample of users was selected for the initial testing and feedback phases. The sample included students from various disciplines, ensuring that the platform could cater to a wide range of research needs. The sample was also stratified by academic level to assess the platform's effectiveness across different stages of academic research.

Sample Size: Approximately 100 users were selected for beta testing, including a mix of undergraduates, postgraduates, and faculty members.

Selection Criteria: Participants were chosen based on their involvement in active research projects or their need for research assistance, ensuring that the feedback received was relevant and actionable.

3.5. SAMPLING STRATEGY

The sampling strategy involved purposive sampling to select participants who were actively engaged in research activities and could provide meaningful feedback on the platform's functionality. Snowball sampling was also used, where initial participants were encouraged to refer peers who could benefit from the platform and provide additional insights.

Recruitment Channels: Participants were recruited through academic networks, online forums, and direct outreach to universities and research institutions.

Diversity Considerations: The sample was designed to include a diverse range of academic disciplines, ensuring the platform's tools were tested across various research contexts.

3.6. DATA COLLECTION METHODS AND PROCEDURES

Data collection was an ongoing process throughout the development and testing phases, with a focus on gathering qualitative and quantitative data to inform platform improvements.

Surveys and Questionnaires: Used to gather initial user requirements and feedback on specific features. Surveys were distributed online and included both closed and open-ended questions.

Interviews: Semi-structured interviews with key stakeholders (students, educators, and researchers) provided in-depth insights into user needs and expectations. Interviews were conducted via video calls and in-person meetings.

Focus Groups: Conducted to gather collective feedback and generate discussions on the platform's usability and effectiveness. Focus groups included participants from similar academic backgrounds to foster meaningful discussions.

User Analytics: Data was collected on user interactions with the platform to assess feature usage, identify pain points, and track overall user engagement. Analytics tools were integrated into the platform to monitor user behavior in real-time.

Beta Testing Feedback: During the beta testing phase, feedback was collected through integrated feedback forms and follow-up interviews, focusing on usability, functionality, and overall user satisfaction.

3.7. SYSTEM DEVELOPMENT METHODOLOGY

The system development followed the Agile methodology, emphasizing flexibility, collaboration, and iterative progress. Key phases included:

Sprint Planning: Development was organized into sprints, with each sprint focusing on specific features or components.

Development Tools: The development team used a combination of programming languages (e.g., JavaScript for the front-end and LLM and RAG for AI modules) and frameworks (e.g., React.js, Next.js, Node.js) to build the platform.

Continuous Integration and Deployment (CI/CD): The CI/CD pipeline ensured that code changes were automatically tested and deployed to a staging environment for review before being released to production.

Version Control: Git was used for version control, enabling collaboration among developers and tracking of changes throughout the development process.

User Stories: User stories were created to capture specific user requirements and guide development. Each user story was linked to specific features or functionalities, ensuring that user needs were addressed in the platform design.

3.8. SYSTEM TESTING AND QUALITY ASSURANCE

Testing was an integral part of the development process, ensuring that the platform met the necessary quality standards.

Unit Testing: Each component was tested individually to ensure it performed as expected. Automated unit tests were written to cover various edge cases and scenarios.

Integration Testing: Ensured that different components of the platform worked together seamlessly. This phase involved testing interactions between the front-end, back-end, and database.

User Acceptance Testing (UAT): Conducted with a select group of users to validate the platform's functionality and usability. UAT provided final approval before the platform was launched.

Security Testing: Focused on identifying and mitigating potential security vulnerabilities, including data breaches and unauthorized access.

3.9. IMPLEMENTATION AND DEPLOYMENT

The final phase involved deploying the platform to a production environment and ensuring its availability to users.

Cloud Deployment: The platform was deployed on a cloud service provider (e.g., vercel) to ensure scalability, reliability, and global accessibility.

Monitoring and Maintenance: Post-deployment, the platform was continuously monitored for performance issues, and regular maintenance was scheduled to address any emerging bugs or enhancements.

User Training and Onboarding: Comprehensive user guides and training sessions were provided to help users get started with the platform and fully leverage its features.

3.10. ETHICAL CONSIDERATIONS

Ethical considerations were a key aspect of the project, ensuring that user data was handled responsibly and in compliance with relevant regulations.

Informed Consent: Participants in surveys, interviews, and focus groups provided informed consent, understanding the purpose of the study and how their data would be used.

Data Privacy: All user data was anonymized and stored securely, with access restricted to authorized personnel only.

Ethics Approval: The project received ethics approval from the relevant institutional review board, ensuring that all research activities were conducted in accordance with ethical standards.

CHAPTER 4: SYSTEM ANALYSIS, DESIGN AND IMPLEMENTATION

4.0 INTRODUCTION

The "**Smart Research Assistant**" platform's development is a multi-faceted process that involves detailed system analysis, careful design, and methodical implementation. Each phase is crucial for ensuring that the platform effectively meets the needs of its users and achieves the project's objectives.

4.1. SYSTEM ANALYSIS

4.1.1 Requirements Analysis

➢ **Functional Requirements:**

- **AI-Powered Research Idea Generator:** The platform should provide an AI-driven tool that suggests research topics based on trends, gaps in the literature, and user preferences.

- **Interactive Research Paper Chat**: A feature that allows users to interact with research papers via an AI-powered chat interface, helping them understand complex concepts.

- **Project Repository:** A comprehensive database of past research projects that students can access to avoid duplication and draw inspiration.

➢ **Non-Functional Requirements:**

- **Scalability:** The system must be capable of handling a growing number of users and large volumes of data without performance degradation.

- **Security:** The platform must ensure data privacy and security, particularly given the sensitive nature of academic research data.

- **Usability:** The interface should be intuitive and user-friendly, with a focus on accessibility for students with varying levels of technical expertise.

4.1.2 Stakeholder Analysis

1. Students:

Primary User: Undergraduate and graduate students conducting academic research. who will benefit from AI-driven research tools, reducing time spent on routine tasks and enhancing the quality of their research.

Functionality:

- **Dashboard Access:** View recent projects, quick actions, and notifications.
- **AI Research Assistant:**
  - ✓ Chat, ask and get answer to the past project.
  - ✓ Chat with research paper (any research document)
  - ✓ Get project ideas based on user preferences.
- **Idea Originality Check:** Input research topic title and/or description to get relevant project.
- **Project Repository:**
  - ✓ View detailed project information and download pdf and code.
  - ✓ Comment and like on the project
- **Settings and Support:** Update profile information and notification preferences.

2. Faculty

Secondary User: Professors, lecturers, and academic advisors who oversee student research use the platform to guide students, assess progress, and ensure academic rigor.

Functionality:

- **Dashboard Access:**
  - ✓ View notifications related to student projects and feedback.
  - ✓ Manage users
  - ✓ Accept or reject student project

AI Research Assistant: search for project plagiarism.

Settings and Support: Update personal settings and preferences.

4.1.3 FEASIBILITY STUDY

Technical Feasibility: The project is technically feasible given the current state of AI and cloud-based platforms. Available technologies like large language model (LLM) and retrieval augmented generative (RAG) can support the platform's functionalities.

Economic Feasibility: The project is economically viable, with potential funding from educational institutions and government grants aimed at improving academic outcomes.

Operational Feasibility: The platform aligns with current academic processes and can be integrated into existing research workflows with minimal disruption.

4.2. SYSTEM DESIGN

4.2.1 System Architecture

Three-Tier Architecture:

Presentation Layer: The user interface, developed using web technologies (HTML, CSS, JavaScript, React, Nextjs, Tailwindcss), provides access to the platform's features. It is designed to be responsive, ensuring usability across various devices.

Application Layer: This layer hosts the core functionalities of the platform, including AI models for research idea generation, literature review, and interactive chat. It is implemented using a combination of OpenAI and vercel AI for AI development and Node.js for server-side logic.

Data Layer: A robust database management system (DBMS), such as PostgreSQL to stores user data, research papers, and project details Pinecone for vector storage Upstash Redis for data cashing. The data layer also includes an index of past research projects, which is regularly updated.

4.2.2 DATABASE DESIGN

Entity-Relationship Diagram (ERD):
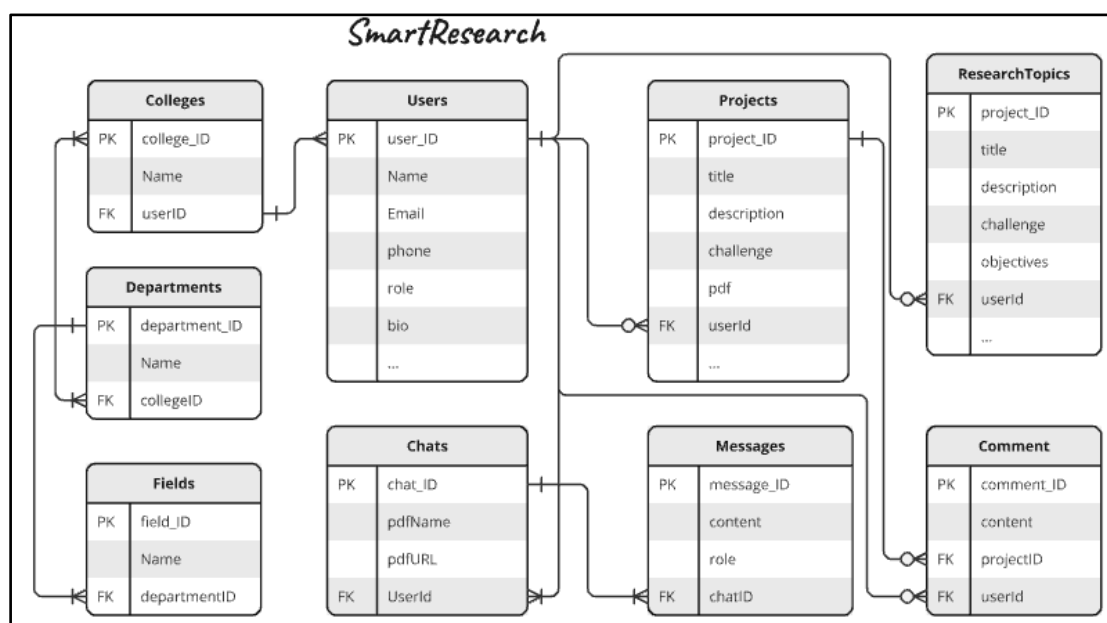
Figure 2: Entity relationship diagram

Entities:

Users: Store information about students, and facilities.

ResearchTopics: Store AI-suggested and user-generated research ideas.

Chats: Store Academic papers analyzed by the AI for literature reviews and chat interactions.

Projects: Store Past and current research projects stored in the repository.

college: Store comment and feedback to the projects.

Relationships:

Users to Projects: One-to-many relationship, as users can create multiple projects.

Projects to Comment: one-to-many relationship, as projects have multiple papers.

Users to Chats: One-to-many relationship, as users can chats on multiple paper.

4.2.3 USER INTERFACE DESIGN

User Flow Diagrams: Detailed diagrams show how users will navigate through the platform, ensuring that each feature is easily accessible and intuitive.
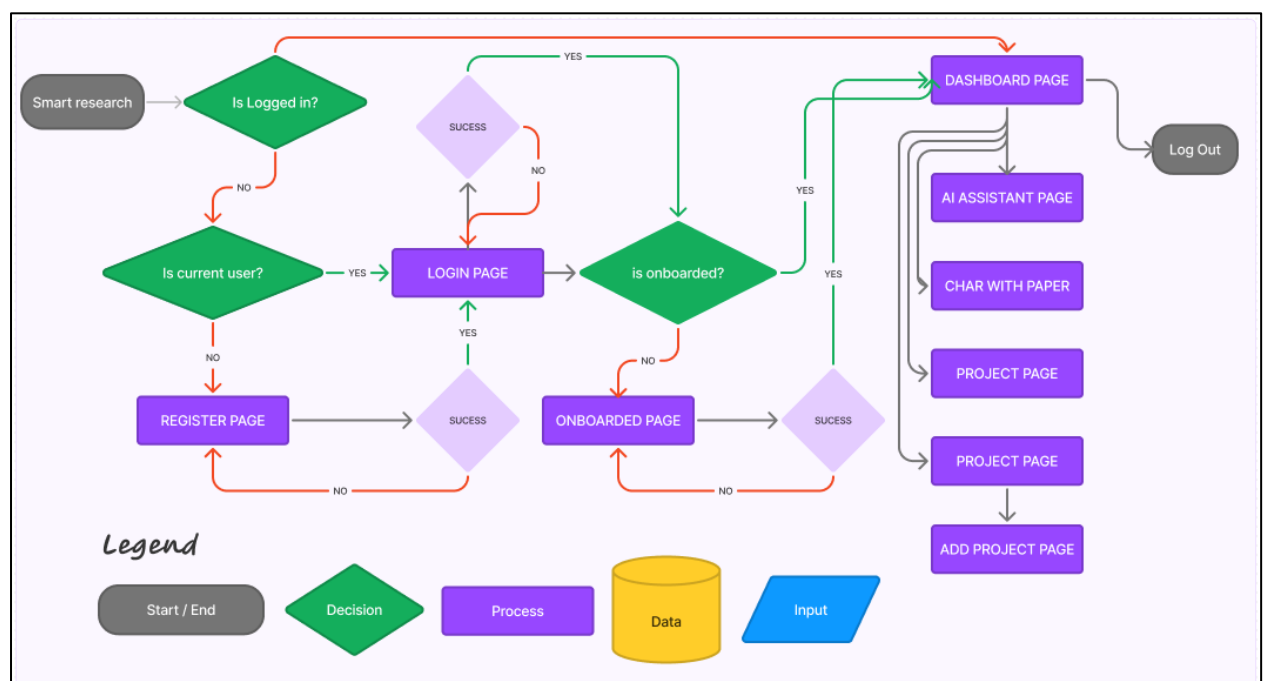
Figure 3: Student flow diagram
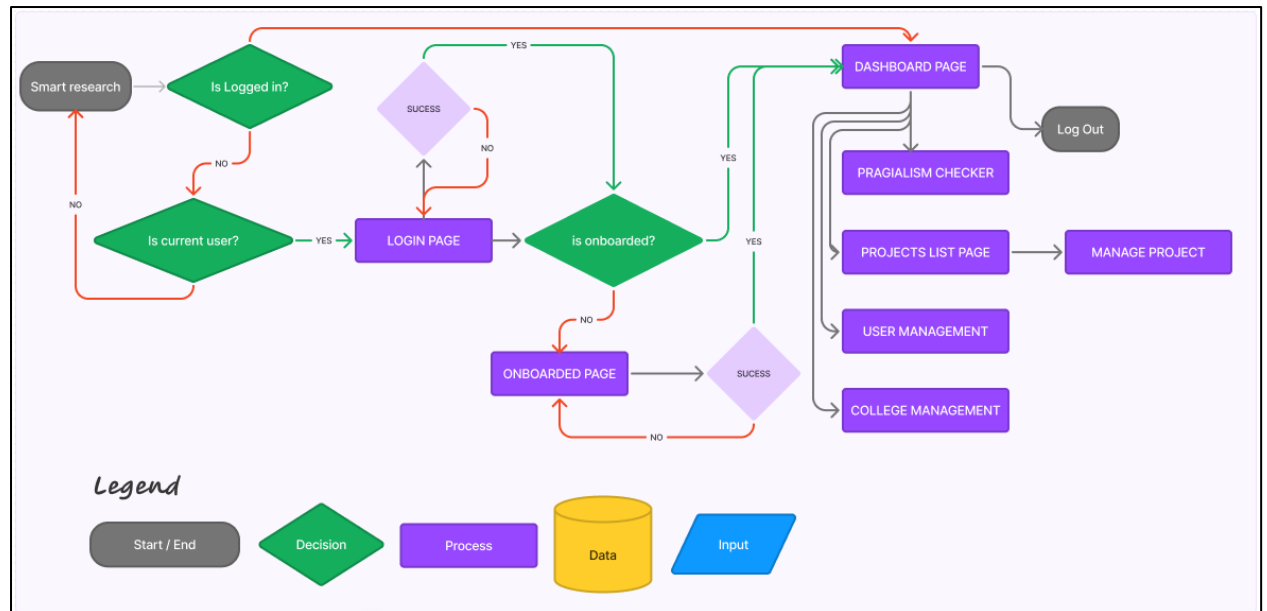
Figure 3: Faculty flow diagram

interface: provides an overview of how users interact with the platform, the key components of the interface, and the user experience (UX) considerations that were taken into account during the design process.
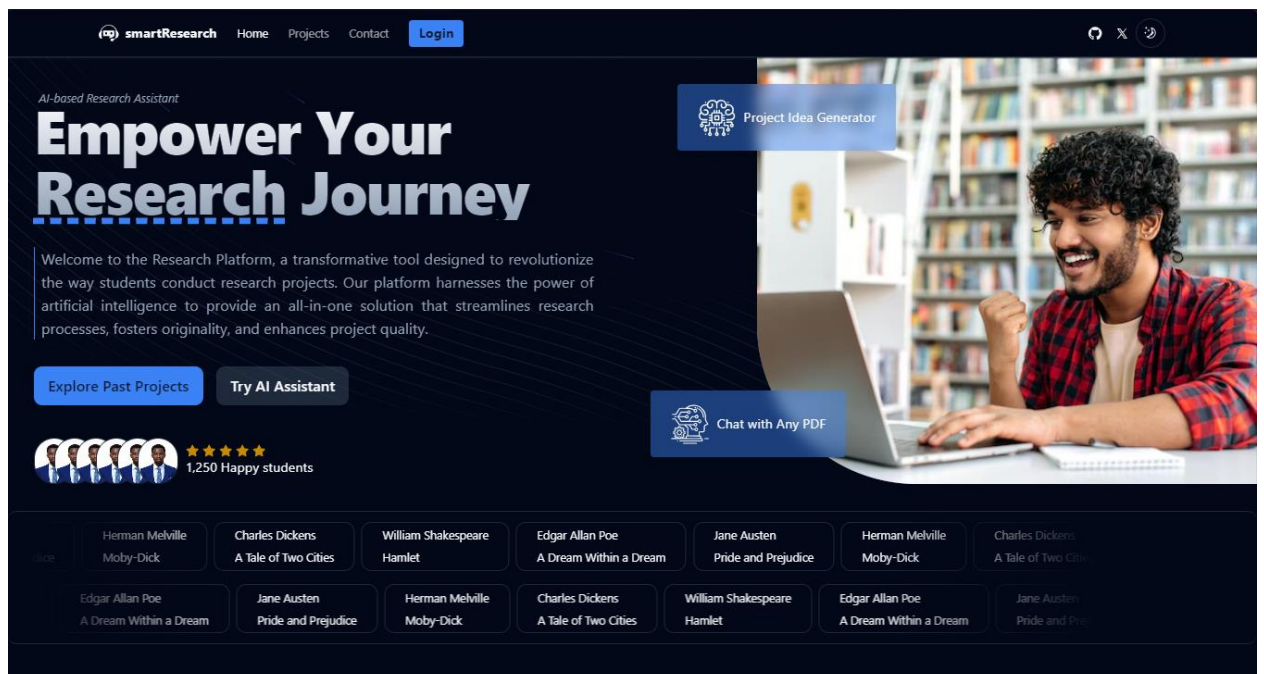
Figure 4: Home page hero section
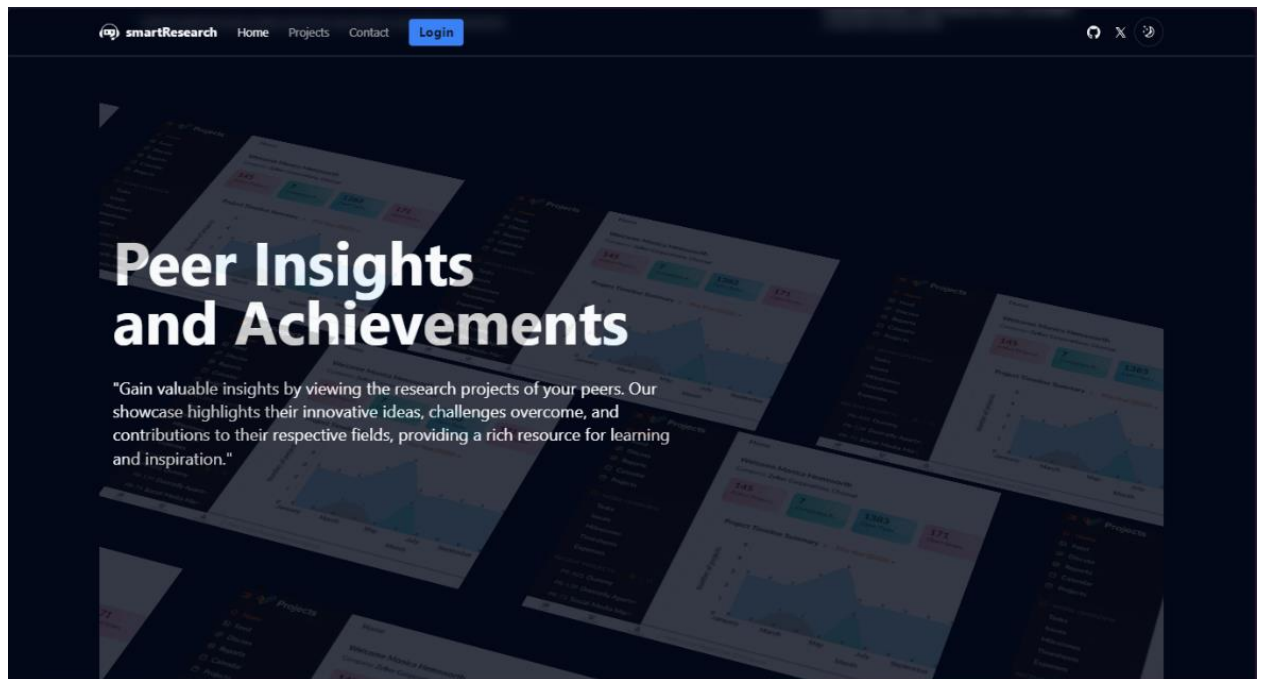
Figure 5: Home page project section

Figure 6: Login page

Figure 7: Registration page

Figure 8: Onboarding page

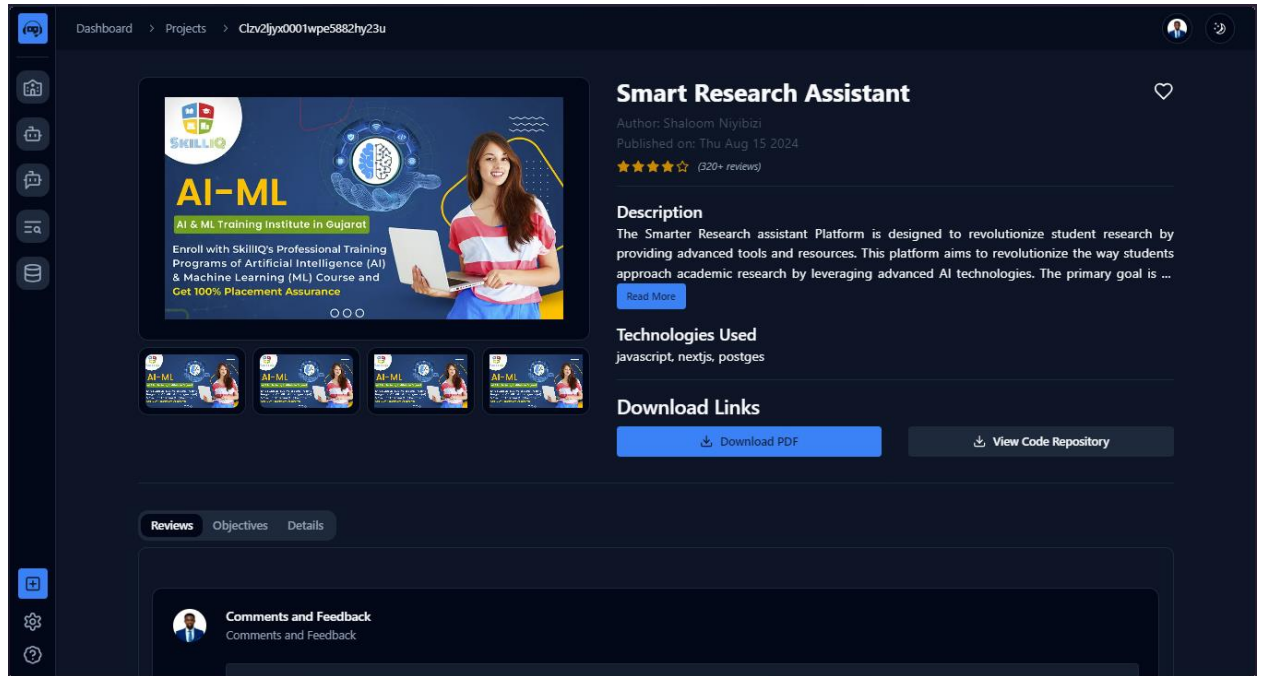*Figure 9: Add project page*

Figure 10: Projects page

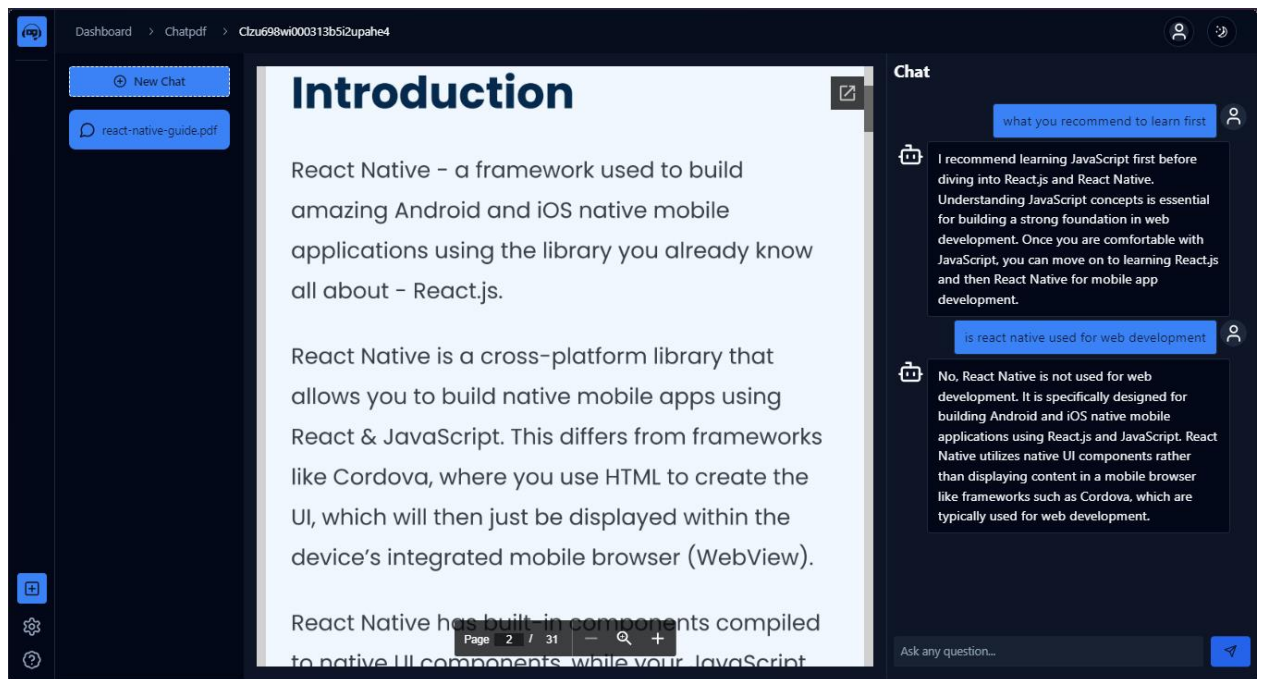*Figure 11: Single project page*

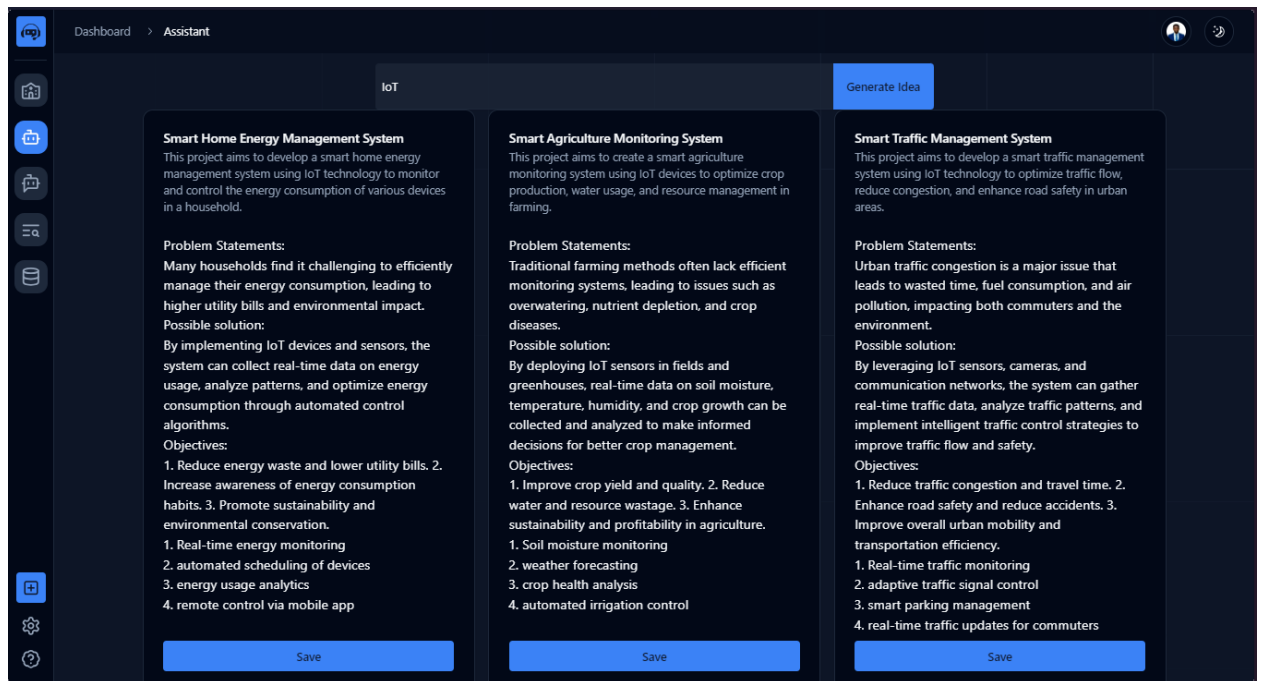*Figure 12: Chat with paper page*
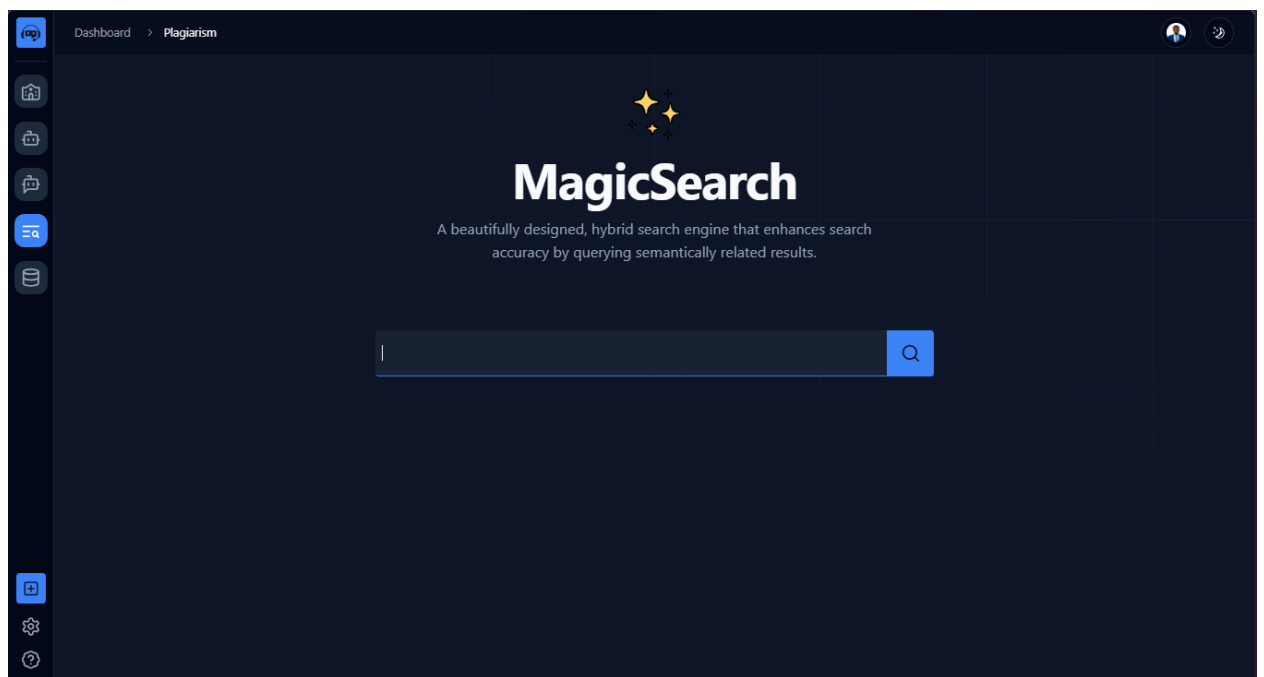
Figure 13: Idea generator page

Figure 14: Project plagiarism checker page

4.2.4 Security Design

Data Encryption: All sensitive data, including user information and research documents, are encrypted.

Authentication and Authorization: The platform uses multi-factor authentication (MFA) and role-based access control (RBAC) to ensure that only authorized users can access specific features and data.

4.3. SYSTEM IMPLEMENTATION

4.3.1 Development Process

Agile Methodology: The platform is developed using Agile methodology, with the project broken down into sprints. Each sprint focuses on developing specific features or components, followed by testing and refinement.

Continuous Integration and Continuous Deployment (CI/CD): The development process includes automated testing and deployment pipelines to ensure that new code is regularly tested and deployed without disrupting the existing system.

Version Control: All code is managed using a version control system like Git, allowing for collaborative development and easy tracking of changes.

4.3.2 Ai Model Development

Large Language Model (LLM): is a type of artificial intelligence (AI) program that can recognize and generate text, among other tasks.
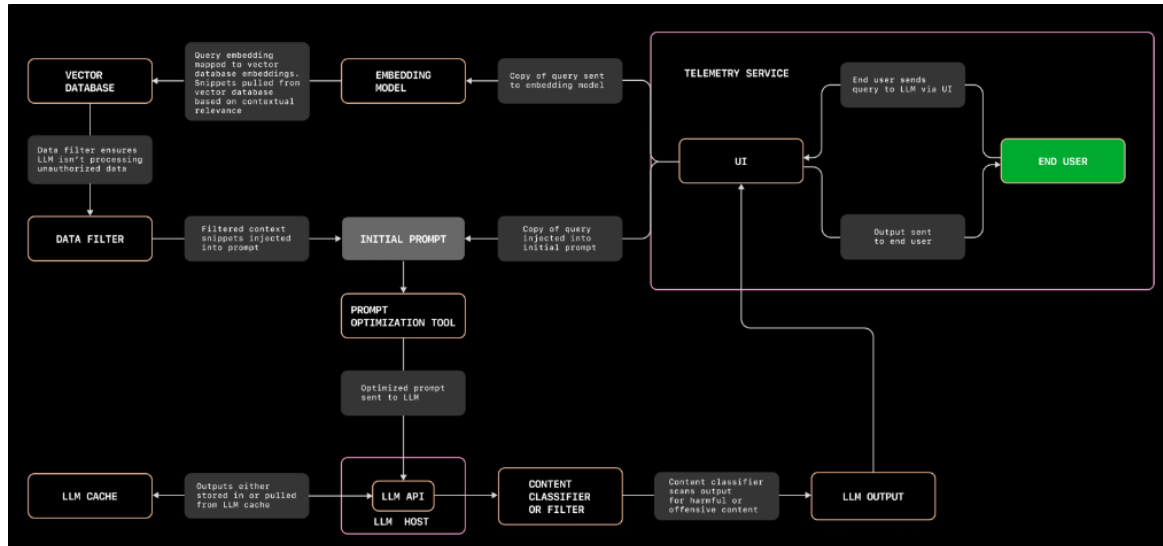
Figure 15: Large language model architecture

Retrieval-augmented generation (RAG): is a technique for enhancing the accuracy and reliability of generative AI models with facts fetched from external sources.

These algorithms are fine-tuned using data from academic publications and past research projects.
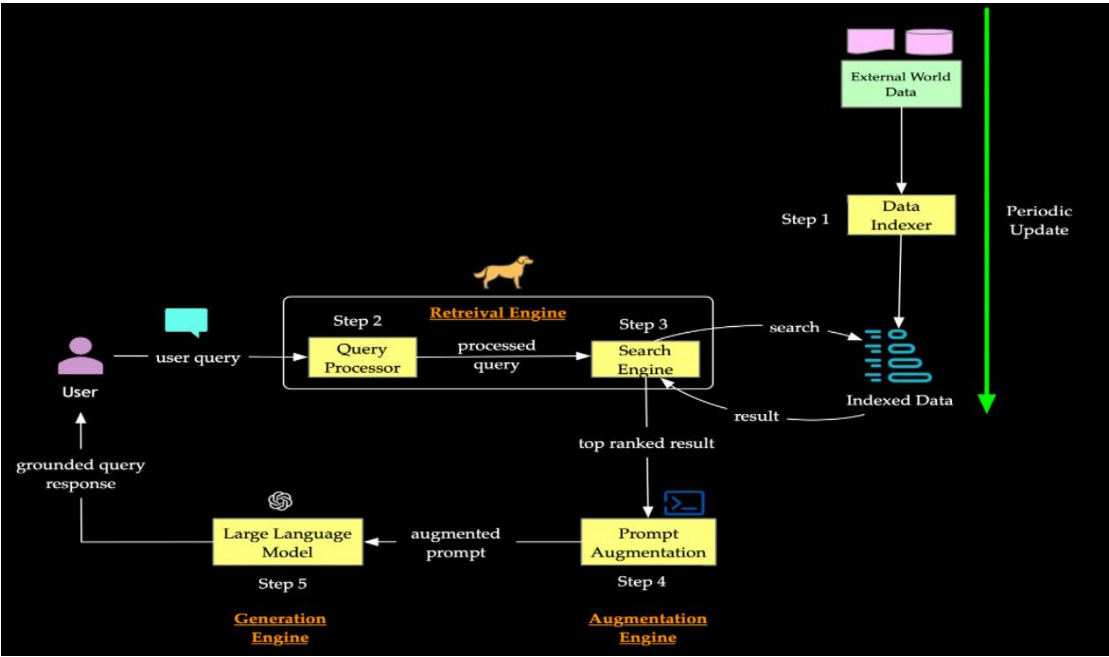
Figure 16: Retrieval argument generation architecture

Interactive Chatbot Development: The chatbot is powered by advanced RAG techniques, enabling it to understand and respond to complex queries about research papers. The chatbot is integrated with the platform's knowledge base for contextualized responses.
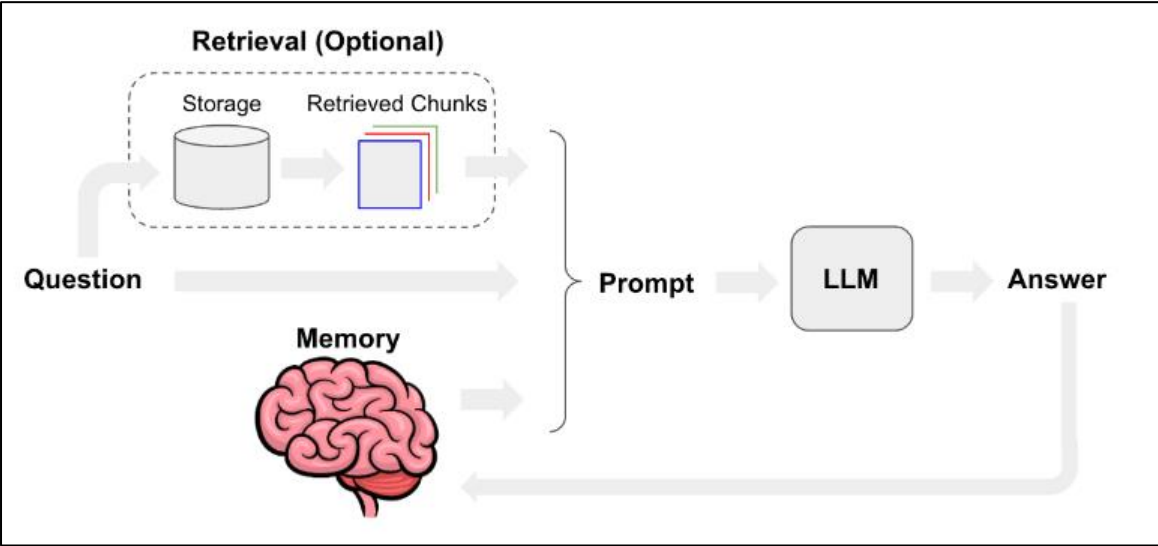
Figure 17: Chatbot architecture

4.3.3 INTEGRATION OF COMPONENTS

API Development: APIs are developed to allow seamless communication between the frontend, backend, and AI models. These APIs handle data requests, processing, and delivery of AI-generated insights.

Frontend-Backend Integration: The frontend is integrated with the backend through RESTful APIs, enabling real-time data updates and interactions. The integration ensures that the platform remains responsive and efficient.

Database Integration: The database is connected to the application layer, enabling efficient data retrieval and storage. Indexing and caching techniques are employed to optimize query performance.

4.3.4 TESTING

Unit Testing: Each component of the platform, including AI models, UI elements, and backend services, is tested independently to ensure they function as expected.

Integration Testing: The platform is tested as a whole to verify that all components work together seamlessly. This includes testing user flows, data synchronization, and AI-driven features.

User Acceptance Testing (UAT): A group of students and educators test the platform in a controlled environment to validate its functionality, usability, and relevance. Feedback is collected and used for final adjustments.

4.3.5 DEPLOYMENT

Staging Environment Deployment: The platform is first deployed in a staging environment to simulate live conditions. This allows for the final round of testing and debugging before the official launch.

Production Deployment: The platform is deployed in a production environment, making it accessible to the target audience. This includes configuring the server, setting up databases, and ensuring all services are running smoothly.

Post-Deployment Support: After deployment, the development team monitors the platform for any issues and provides support to users. Regular updates and bug fixes are rolled out as needed.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS.

5.1 CONCLUSION

The "**Smart Research Assistant**" platform represents a significant advancement in the way students engage with academic research. By integrating advanced AI technologies into a user-friendly platform, the project addresses several key challenges in the research process, including topic selection, literature review, and project originality. The platform's ability to generate research ideas, assist in conducting comprehensive literature reviews, and facilitate interactive engagement with research papers positions it as a valuable tool for enhancing the quality and efficiency of student research.

Key conclusions from the project include:

✓ **Enhanced Research Efficiency:** The platform's AI-driven tools significantly reduce the time and effort required for various stages of the research process, allowing students to focus more on critical thinking and analysis.

✓ **Improved Originality and Innovation:** By providing students with project research ideas and ensuring comprehensive literature reviews, the platform fosters originality and helps students contribute new knowledge to their fields.

✓ **User Engagement and Satisfaction:** Feedback from user testing indicates high levels of satisfaction with the platform's features, particularly the AI-powered research idea generator and interactive literature review assistant.

✓ **Scalability and Adaptability:** The platform is designed to scale with increasing user numbers and can be easily adapted to accommodate new academic trends and technological advancements.

Overall, the "Smart Research Assistant" has achieved its primary goal of revolutionizing the student research process, making it more efficient, innovative, and accessible.

5.2. RECOMMENDATIONS

To further enhance the platform and ensure its long-term success, the following recommendations are proposed:

Continuous Improvement of AI Models: Regularly update and retrain the AI models used in the platform to ensure they remain accurate and relevant. This includes refining algorithms based on user feedback and emerging academic trends.

Expansion of Features: Consider expanding the platform's features to include additional tools, such as AI-driven data analysis, automated citation management, and enhanced collaboration features like real-time editing and peer review integration.

Integration with Academic Institutions: Work towards integrating the platform with academic institutions' existing systems, such as learning management systems (LMS) and digital libraries. This integration would allow for seamless access to resources and further streamline the research process for students.

Ongoing User Training and Support: Provide continuous training and support for users to ensure they can effectively utilize the platform's features. This could include webinars, tutorials, and a dedicated helpdesk.

Monitoring and Evaluation: Establish a system for ongoing monitoring and evaluation of the platform's performance, user satisfaction, and impact on research outcomes. This will help identify areas for improvement and ensure the platform continues to meet user needs.

Promotion and Outreach: Engage in active promotion of the platform within academic communities to increase adoption and usage. This could involve partnerships with educational institutions, participation in academic conferences, and targeted marketing campaigns.

Consideration for Multidisciplinary Research: Enhance the platform's capabilities to support multidisciplinary research projects, allowing students from different fields to collaborate effectively and share resources within the platform.

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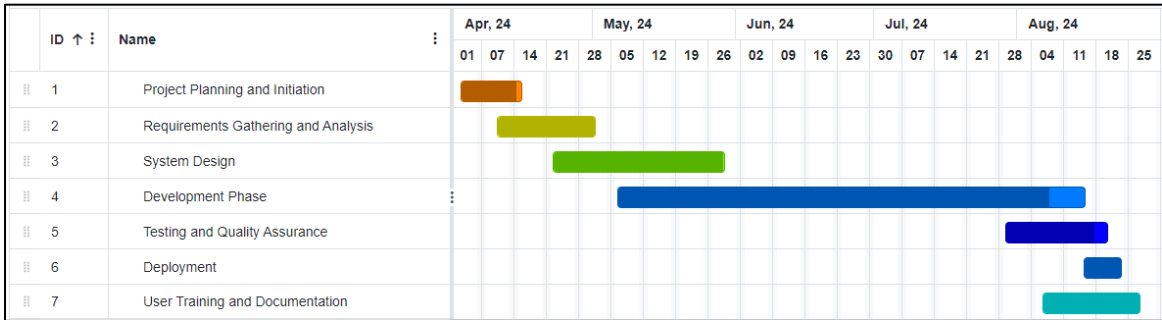
Appendices

Appendix A: Gantt chat

Figure 18: smart research Gantt chat

Appendix B: Budget

1. Personnel Costs

Role	Hourly Rate	Estimated Hours	Total cost
Project Manager	700 Rwf	300	210,000 Rwf
Front-End Developer	600 Rwf	600	360,000 Rwf
Back-End Developer	650 Rwf	700	455,000 Rwf
AI/ML Specialist	800 Rwf	400	320,000 Rwf
Database Administrator	700 Rwf	300	210,000 Rwf
UI/UX Designer	550 Rwf	200	110,000 Rwf
Project Manager	700 Rwf	300	150,000 Rwf
Technical Writer	450 Rwf	100	45,000 Rwf
Total Personnel Costs			1,830,000 Rwf

Table 1: personal cost

2. Cloud Services and Other service Costs

Service	Cost per month	Duration	Total cost
AWS S3 (Storage)	1500 Rwf	6 months	9,000 Rwf
OpenAI	16000 Rwf	2 months	32,000 Rwf
Pinecone	10000 Rwf	2 months	20,000 Rwf
Total Service Costs			61,000 Rwf

Table 2: service cost

3. Total Estimated Budget

Category	Total cost
Total Personnel Costs	1,830,000 Rwf
Total Service Costs	61,000 Rwf
Total Budget	1,891,000 Rwf

Table 3: estimation cost

Appendix C: PDF chatbot code sample

```
import db from "@/lib/db";
import { PDFLoader } from "@langchain/community/document_loaders/fs/pdf";
import { ChatPromptTemplate } from "@langchain/core/prompts";
import { ChatOpenAI, OpenAIEmbeddings } from "@langchain/openai";
import { RecursiveCharacterTextSplitter } from "@langchain/textsplitters";
import { LangChainStream, StreamingTextResponse } from "ai";
import { createStuffDocumentsChain } from"langchain/chains/combine_documents";
import { createRetrievalChain } from "langchain/chains/retrieval";
import { MemoryVectorStore } from "langchain/vectorstores/memory";
import { NextResponse } from "next/server";
import { ChatCompletionMessage } from "openai/resources/index.mjs";
export async function POST(req: Request) {
  try {
    const body = await req.json();
    const messages: ChatCompletionMessage[] = body.messages;
    const id = body.id;
    const _chats = await db.chats.findFirst({
      where: {
        id,
      },
    });
    if (!_chats) {
      return NextResponse.json({ error: "chat not found" }, { status: 404 });
    }
    const lastMessage = messages[messages.length - 1];
    const { stream, handlers } = LangChainStream({
      onStart: async () => {
        // save user message into db
        await db.messages.create({
          data: {
            content:
              lastMessage.role !== "assistant" ? lastMessage.content! : "",
            role: "user",
            chatId: _chats.id,
          },
        });
      },
      onCompletion: async (completion) => {
        // save ai message into db
        await db.messages.create({
          data: {
            content: completion,
            role: "assistant",
```

```
          chatId: _chats.id,
        },
      });
    },
  });
  const chatModel = new ChatOpenAI({
    modelName: "gpt-3.5-turbo",
    streaming: true,
    callbacks: [handlers],
    verbose: true,
  });
  const fileName = _chats.fileName;
  const loader = new PDFLoader(fileName!);
  const docs = await loader.load();
  const textSplitter = new RecursiveCharacterTextSplitter({
    chunkSize: 1000,
    chunkOverlap: 200,
  });
  const splits = await textSplitter.splitDocuments(docs);
  const vectorstore = await MemoryVectorStore.fromDocuments(
    splits,
    new OpenAIEmbeddings(),
  );
  const retriever = vectorstore.asRetriever();
  const systemTemplate = [
    `You're an AI assistant who answers questions about documents.
      You're a chat bot, so keep your replies succinct.
      You're only allowed to use the documents below to answer the question.
      If the question isn't related to these documents, say:
      "Sorry, I can't find information that not related to your document."
      If the information isn't available in the below documents, say:
      "Sorry, I couldn't find any information on that."
      Do not go off topic.
      Documents:\n\n
    {context}`,
  ].join("");
  const prompt = ChatPromptTemplate.fromMessages([
    ["system", systemTemplate],
    ["user", "{input}"],
  ]);
  const questionAnswerChain = await createStuffDocumentsChain({
    llm: chatModel,
    prompt,
  });
  const retrievalChain = await createRetrievalChain({
    retriever,
    combineDocsChain: questionAnswerChain,
  });
  retrievalChain.invoke({
    input: lastMessage.content!,
  });
  return new StreamingTextResponse(stream);
} catch (e) {
  console.log(e);
  throw e;
  }
}
```