BLOOMQUEST: PERSONALIZED LEARNING SYSTEM BASED ON KNOWLEDGE GRAPHS AND BLOOM'S TAXONOMY.

2023-035

Project Proposal Document

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BSc. (Hons) Degree in Information Technology Specializing in Data Science

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Sri Lanka Institute of Information Technology,

Sri Lanka

February 2023

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Declaration

I hereby verify that, with the exception of the places I have listed as references, this proposal has been prepared entirely by me. I further guarantee that this material has never before been submitted to a university or other institute.

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Statement of the supervisor,

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

Signature of the Supervisor: Date:

Signature of the Co-supervisor: Date:

Research Abstract

Creating a balanced and high-quality exam for undergraduates that caters to various cognitive levels is very crucial. As a result, lecturers rely on Bloom's Taxonomy cognitive domain, a popular framework developed to assess students' intellectual abilities and skills. Despite its widespread use, many students are not aware of Bloom's Taxonomy and how it affects their learning experience. This lack of understanding can lead to students missing important opportunities for growth and development in their academic pursuits. This project is based on a personalized self-learning system that helps students to understand and apply Bloom's Taxonomy in their own learning process. And by personalizing the system according to the student may help them learn from the type and level of the content they seem to fit in. The novelty of this project is its ability to incorporate the students' own learning materials and provide various self-learning methods based on Bloom's Taxonomy. The system takes a student's study material then constructs a knowledge graph by extracting named entities and relations between the entities from material. The completed product of this project will be a full-complete web application that offers users a personalized self-learning system based on Bloom's Taxonomy. In this proposal, the implementation of sub objective, "Recommending external online study resources" is discussed. How to find the exact, relevant, and more accurate external resources for the user is mainly discussed here in this document.

Keywords: Recommending external study resources, Bloom's Taxonomy, personal learning material.

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List of Abbreviations

Abbreviation	Description
LDA	Latent Dirichlet Allocation
NLP	Natural language processing
OWL	Web Ontology Language
API	Application Programming Interface
FRE	Flesch Reading Ease

1. Research Introduction

University students face enormous pressure and stress when it comes to their academics today. Many students find themselves struggling to keep up with a wide range of subjects to cover and a huge number of assignments and exams. Some students do not have enough time to refer to all lectures, some students may not know how to study efficiently in order to achieve good grades. Many students try to do self-study to stay on the correct track. But unfortunately, students don't have a good idea about how to study effectively on their own and how they want to focus on each and every section to obtain higher results. This can lead to poor performance and even more stress. So, students need to be able to develop good self-study habits, but that can be tough to do without help.

And also, nowadays in many universities, lectures are designing exam papers based on Bloom's taxonomy. Bloom's taxonomy was developed in order to group educational objectives and goals according to a hierarchy of cognitive levels. There are six levels in the hierarchy. However, many students may not be aware of this approach and are unable to respond to questions based on Bloom's Taxonomy. As a result, students may struggle to perform well on their exams and end up with low grades for exams. It is very important for students to become familiar with Bloom's Taxonomy, as it can help them understand the type of questions being asked and how to approach them. The figure illustrates the level of unfamiliarity among university students regarding the application of Bloom's Taxonomy framework in their academic papers.

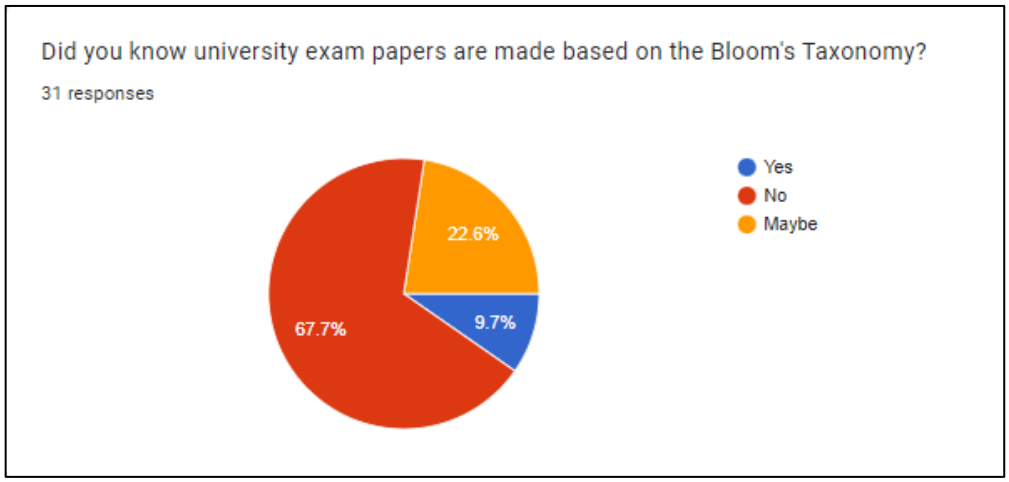

Figure 1: User awareness about Bloom's Taxonomy.

Here, we are researching a self-learning system by adding modern and advanced techniques to traditional self-learning systems. The project is based on a personalized

self-learning system that helps students to understand and apply Bloom's Taxonomy in their own learning process. The system gets the student's own study material as an input and generates questions and answers according to Bloom's Taxonomy from that material, system can measure student performance and show it in a dashboard. System provides extra study resources based on student's study material. Also, the system generates a comprehensive mind map to understand the uploaded material in a convenient way.

The major goal of this project component is to provide an online extra resource recommending system that suggests appropriate and engaging resources based on the content and reading level of the user . This approach promotes self-directed learning by giving students individualized learning opportunities based on their level of provided paper difficulty and using modern ranking methods. The aim of this project is to develop an online resource recommendation system that uses advanced technologies to recommend the most relevant and engaging resources to enhance the students' learning experience. This research component's final product is a fully completed web application that recommends extra study resources for students. The below pie chart shows how much students like to have a first-rate system for recommending online resources.

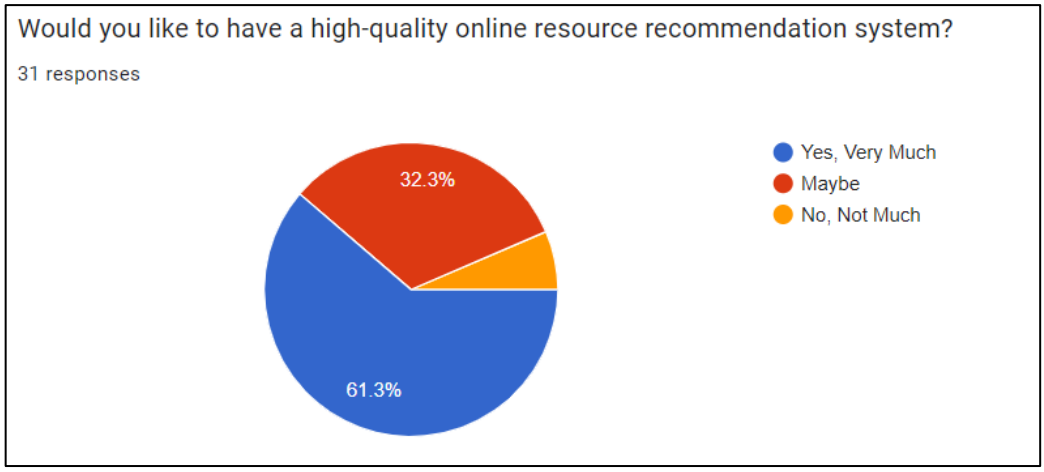

Figure 2: User Response for having for High-quality Resource Recommendation System

1.1. Research Background and Literature Review

Online resource recommendation systems have drawn a lot of attention from researchers in recent years who are investigating various technologies to propose the best resources to users. The methodologies and tools that researchers used to create online resource recommendation systems are described in the section that follows.

In research done by Xin Wei et al in 2021 conduct an investigation into the creation of a personalized extra learning resource recommendation system that enhances students' learning results by utilizing educational psychology theory and artificial intelligence technologies [1]. It discusses the difficulties in delivering relevant learning resources in online learning and suggests an algorithm for recommending learning resources based on LinUCB. The algorithm modifies the proportion of exploration and exploitation during recommendation using a unique exploration coefficient.

In research done by Hongtao Sun et al in 2022 proposed a learner-model-based collaborative filtering recommending approach for online study resources, which takes into account the traits and actions of learners when making recommendations in order to improve the accuracy of the content that is suggested [2]. In order to build learner models and to calculate the user similarity this paper proposed methods such as machine learning algorithms and learner modeling algorithms. The learner's evaluation of resources is revealed by how they use online learning resources, and the algorithm used to generate suggestions is based on how similar the learners are to one another and well rated regarded the resources are.

Another research done by Danyang Shen in 2020 proposed a neural network-based recommendation model that uses concept maps to represent knowledge points, learning behavior based on learning style scales, and Bloom's taxonomy to rank educational materials [3]. Then the score is calculated using the multilayer perceptron network based on the created embedding vectors. Studies carried out for this study's experiments showed that this recommendation model produced excellent results.

In research done by Raghad Obeidat, Rehab Duwairi and Ahmad Al-Aiad in 2019 also done research reading this topic [4]. In here, depending on commonalities in their prior course experience, a collaborative recommendation system for online courses has been developed. To identify trends among the courses, this system uses data mining techniques. Then, based on the students' behavior, clustering algorithms for the datasets use to put similar students into the same cluster.

Another research done by Gina George and Anisha M. Lal in 2019 proposed an ontology-based resource recommender system [5]. Web Ontology Language (OWL) can be use to represent ontology in a model. An ontology can serve as a database's equivalent of a XML

schema. There, feature extraction, pattern classification utilizing ontology mapping, and ontology merging are used as methodologies to uncover and enhance the discovery of sets of related learning materials.

In research done by Bhaskar Mondal et al in 2020 suggest a machine learning strategy for recommending relevant online courses depending on student performance history [6]. A new student is initially categorized using the k-means clustering technique by the framework based on their prior performance. The cluster will use collaborative filtering to suggest appropriate courses.

Another research done by Jun Xiao, Minjuan Wang, cBingqian Jiang and Junli Li in 2017 developed a personalized resource recommending system for online learning that makes use of association rules, content screening, and cooperative filtering to make suggestions for relevant learning resources to students taking online courses [7]. The authors highlight the value of personalized learning, which has grown more significant with the quick growth of online and mobile technology.

In research done by Honggang Wang & Weina Fu in 2020 developed a dynamic collaborative filtering algorithm-based strategy for recommending unique learning resources [8]. The authors suggest using dynamic k-nearest-neighbor and the Slope One method to optimize collaborative filtering algorithms in order to address the issues of sparse data and low scalability. They also examine the network's learning resource data sparsity in considering the outcomes of neighbor selection.

In research done by Ronghua Shi, Lei Mao, Chao Hu and Sixiang Lire in 2018 provides a novel method for recommending educational resources that is based on the learner's current knowledge structure [9]. The suggested algorithm seeks to offer students individualized recommendations that are in sync with their interests while also considering their current knowledge base. The proposed method was tested in a controlled experiment by the authors, and the findings indicate encouraging gains in both the correlation score and learning process score.

Another research done by Roshan Bhanuse and Sandip Mal in 2021 focuses on a thorough analysis of deep learning-based e-learning recommendation systems (RS) and the problems with their accuracy, scalability, cold-start, and data scarcity [10]. The authors have noted that as the use of online learning materials has increased, it has become harder for students to sift through vast amounts of data for specific knowledge. The authors emphasize the significance of learning analytics (LA) and educational data mining (EDM) in the development of e-learning RS and contend that deep learning algorithms have the potential to improve RS's efficacy in individualized instruction.

1.2. Research Gap

Referring to the research papers that we found, we learned that this research has been the subject of active research in fields where researchers have worked harder to suggest quality research. A personalized online resource recommending system provides many features to improve student's knowledge based on their individual needs and preferences. Developing a web application for this kind of system could have a commercial advantage. As a research team our team members come up with novel ideas which are not included in previous research papers. We try to give a comprehensive personalized self-study system with many novel options and features.

For this research, the component that discussed in this paper is recommending online extra resources to the users according to the given content passage. According to our experience we know that when we search a lengthy query in many existing resource recommendation systems it will not support well and not give proper output as our expectation. To answer this problem, the proposed system suggests dividing long queries into small topics and executing those small query topics to retrieve resources.

Many resource recommendation systems that are currently available do not give both document type and video type resources for users separately. This proposed system provides both documents type and video type resources and users can select when they input the passage whether they want document type resources or video type resources.

The primary difference between the proposed study and previous research initiatives is that there are many of them that use common information retrieval models to measure the relevance such as bag of words. The proposed system's approach to measuring relevance involves analyzing the topics that are present in both the query and the available resources. Another main gap in our system is we analyze the reading difficulty of the user-submitted passage and suggest resources with similar reading difficulty.

Table 1: Research gap of the component.

	Paper [1]	Paper [2]	Paper [3]	Paper [4]	Proposed System
Use of user-submitted paragraphs to generate recommendation.	✗	✗	✗	✓	✓
Recommendation of resource types such documents and videos.	✗	✓	✓	✓	✓
Measure the relevance based on topics instead of common IR models.	✗	✓	✗	✗	✓
Consideration of reading level of user-submitted paragraph.	✗	✗	✓	✗	✓
Combination of relevance and reading difficulty ranking.	✗	✗	✓	✗	✓
User Can select what type of resources he/she wants.	✗	✗	✗	✗	✓

1.3. Research Problem

It is essential to create well-balanced and high-quality exams for undergraduate students, and one popular framework that many lecturers use to assess students' intellectual abilities and skills is Bloom's Taxonomy cognitive domain. However, many students are not aware of Bloom's Taxonomy and how it affects their learning experience. Because of this, students may miss important opportunities for growth and development in their academic pursuits. To address this challenge, a personalized self-learning system could be developed to assist students in comprehending and applying Bloom's Taxonomy to their own learning process.

Self-reading has become a major part of self-studying. Students may have trouble when understanding content while self-reading or possibly wish to understand more about the topics it covers. In such case people use recommending systems to search and retrieve related details. However, Students often struggle to find the right resources for self-study and may be discouraged by materials that are either too difficult or not relevant to their needs. During my investigation, I discovered that several of the existing recommendation systems are not capable of handling lengthy queries effectively, leading to erroneous or inadequate search outcomes. Additionally, when these systems receive a large number of resources, they may not rank them appropriately, causing students to refer to resources that do not contain the information they require. The below figure depicts how many users experience issues in accuracy or relevance when using existing resource recommendation systems.

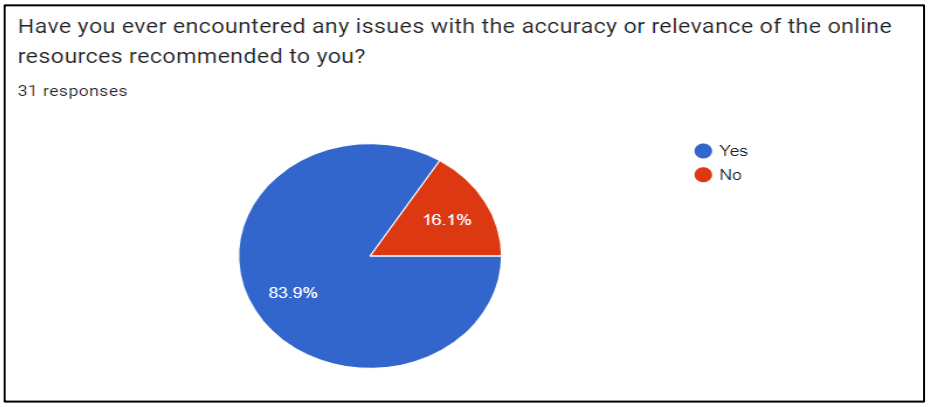

Figure 3: User responses for having issue in existing recommendation systems.

Since there are some doubts in existing recommendation systems, this paper raises the question "How to provide a method for students to retrieve more relevant and important extra online resources?". This research component will present several solutions to address these issues and establish an efficient online resource recommendation system for users.

2. Main objective and Sub objectives

The main objective of this research is to create a customized self-study platform to support undergraduate students. Unlike a typical self-study system, this platform distinguishes itself by incorporating the students' study materials and helping them evaluate their performance in a specific subject based on the various levels of Bloom's Taxonomy.

To achieve this objective, it is further divided into four sub-objectives. They are,

1. Generate a comprehensive mind map for a given study material.
2. Generate a set of questions and answers from the study material and categorize them according to Bloom's taxonomy.
3. Track and forecast student performance in a specific subject.
4. Provide online extra study resources related to the uploaded study material.

Below chart shows user feedback for having a fully fetched self-learning system consisting above objectives.

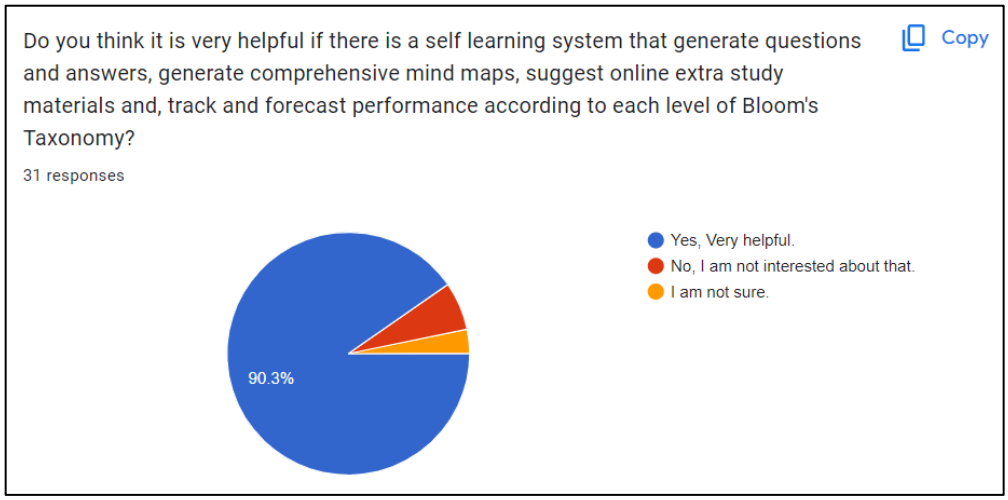

Figure 4: User response for having a self-learning system which consists of our main objectives.

The sub-objective discussed in this paper is to develop an online resource recommending system that can analyze a student's submitted paragraph and recommend educational materials that are tailored to their reading level and the specific concepts they need clarification on. Moreover, when the sub-objective dived into sections first, topic modeling algorithms were utilized to identify the most pertinent topics related to the user's query. Once the topics were identified, resources were retrieved using the Google API. These resources were then ranked based on their relevance and reading difficulty of the uploaded material to provide users with the most useful resources. Finally, related online

resources were suggested to expand the user's knowledge on the topic. Overall, this approach provides a comprehensive and personalized recommendation system for users seeking online resources.

2.1. Functional Requirements and Non-Functional Requirements

Functional requirements outline the operation of the system's parts and their interactions with the user. The major functional requirements for this software component are listed below,

1. User should be able to upload text paragraph that he/she refer to the web application.
2. User should be able to select which type of resources that wants to display. (Text or Video)
3. System should be able to recommend online resources to the user.
4. Users should be able to refer to the suggested online resources.
5. Application should be able to save suggested online resources in a database.

In a system, non-functional requirements are essential to ensuring that a system satisfies user expectations and quality standards for its performance, usability, Accuracy, security, and other features outside of its functional capabilities,

1. Performance: The system should be able to process and rank recommended resources in a timely manner, to ensure a smooth user experience.
2. Usability: The interface should be designed to be intuitive and easy to use, to encourage student engagement.
3. Scalability: The system needs to be built to handle possibly numerous users and queries.
4. Accuracy: The recommendation system should be designed to provide high-quality, relevant resources to users, and minimize the inclusion of irrelevant or low-quality resources.
5. Security: The system should incorporate appropriate measures to protect user data and prevent unauthorized access.

3. Methodology

Overall system can divide into five main sub parts according to functionalities,

- Generate a set of questions and answers according to Bloom's Taxonomy.
- Create a comprehensive mind map which changes dynamically.
- Provide online extra study resources related to the uploaded study material.
- Analyze the performance level to adjust the learning experience accordingly and create a dashboard.

3.1. External Resource Recommendation System.

This section describes the methods and technologies that will be used when developing the online resource recommendation system.

The system uses leaners personal study material as the input. Learner has to select a paragraph from his/her reding material and put it in to the system that he/she wants to get a clearer idea by referring external online resources. Selected paragraph is executed in a search engine as a query. There for we have to process the query before using it in a search engine to capture the most relevant details from the given paragraph. In the query processing part, it preprocesses the paragraph by stemming and removing noisy and stop words.

I. Query Processing.

When the user input query passage to the system, it will receive by query processing section which do preprocessing, topic generating and topic compression. The topic generating section will use topic modeling algorithms to identify patterns and topics in large collections of documents. Latent Dirichlet Allocation (LDA) is use as the topic modeling algorithm for this research. [11] Aditya Anantharaman et al do research to find out what is the most relevant topic modeling algorithm. According to their observation they proposed that LDA is the best algorithm for classifying large text and documents. When creating several topics from the given passage some topics can be associated with similar concepts. To get rid of such duplication we use topic compression module. This will remove duplicate topics after taking the word distribution of every topic into account. To compare and identify similarity between topics, we can use correlation or similarity methods. In similarity methods, widely used two methods are cosine similarity method and Jaccard similarity method. [12] Research done by Lisna Zahrotun proposed that results of cosine similarity have the highest value in comparison with Jaccard similarity.

II. Resource Retrieve.

Topics that are generated from the previous part will be used here to retrieve relevant resources. Consider the top k words to create query with top keywords in each topic, this new query will be run through the search engine and retrieved resources. The system retrieves the URLs from the Google search results using the Google API.

III. Resource Ranking.

Main part for the recommendation system is to provide most relevant and accurate resources to the end user. This involves considering several factors to choose the materials that are the most valuable and pertinent. This approach ranks resources according to relevancy and measures and ranks reading difficulty of the input passage.

Traditional search engines use term similarity instead of topic similarity when matching documents to a query. Then the retrieved resources should be rank again according to their topic similarity not only to the topic query but also to the whole query passage.

Table 2: Comparison of term-based ranking and topic-based ranking.

Term-Based Ranking	Topic-Based Ranking
Ignores the underlying topics and context of queries.	Consider underlying topics of documents and queries.
May retrieve irrelevant or less relevant results.	Can provide more accurate and relevant search results.
Cannot handle ambiguous queries effectively.	Can handle ambiguous queries and long-tail queries better.
May not work well for long-tail queries.	Can capture the meaning and intent of a query more effectively.

Overall, topic-based ranking can provide more accurate and relevant search results.

To improve the learning outcome, it is important to not only rank the resources according to their relevance to the query passage, but also consider their appropriateness for the reader. One way to ensure appropriateness is to evaluate both the passage entered by the user and the extra study resources that suggested. Flesch Reading Ease (FRE) will be used to estimate the reading difficulty. It takes two parameters such as average sentence length and the number of syllables per word in order to calculate the reading difficulty. The higher the FRE score, the easier the text is to read.

Finally, retrieved and well ranked resources that relevant to the user given content will be displayed to the user in an interface. Users are able to select the resource type as they need ,whether it is a document type or video type.

Figure below displays the general architecture between the elements of “Personalized online extra resource recommendation system” objective of the research.

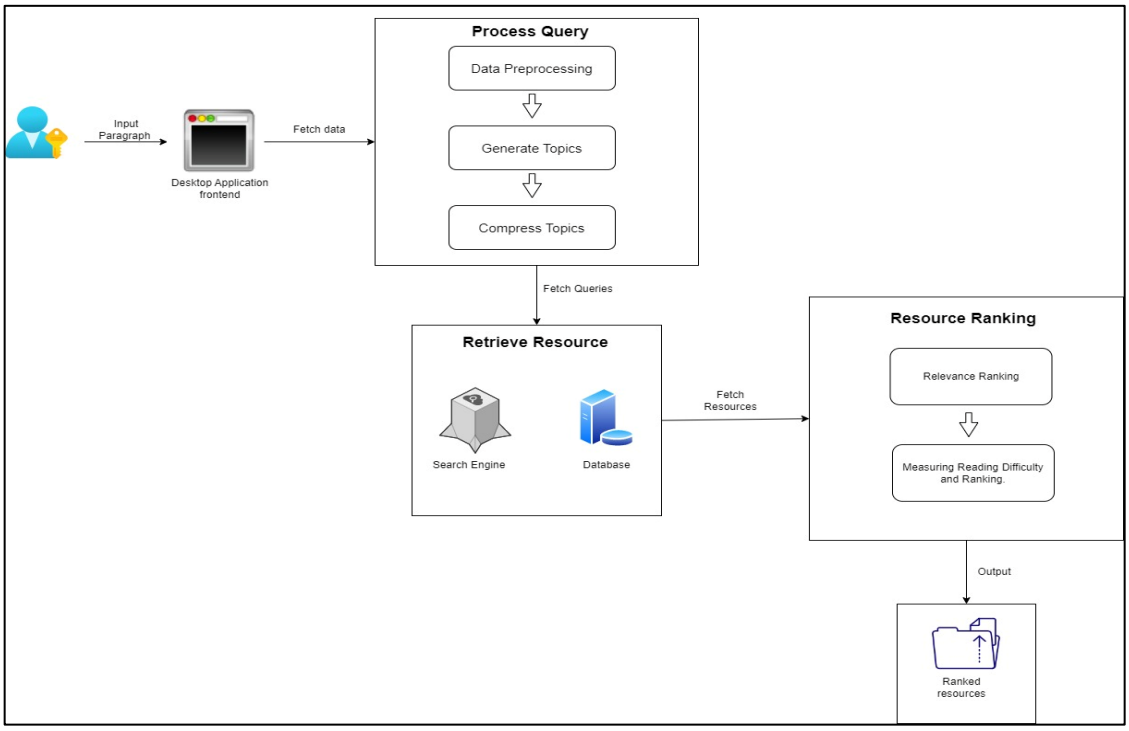

Figure 5: High level architecture of personalized online extra resource recommendation system.

3.2. Overall System Diagram

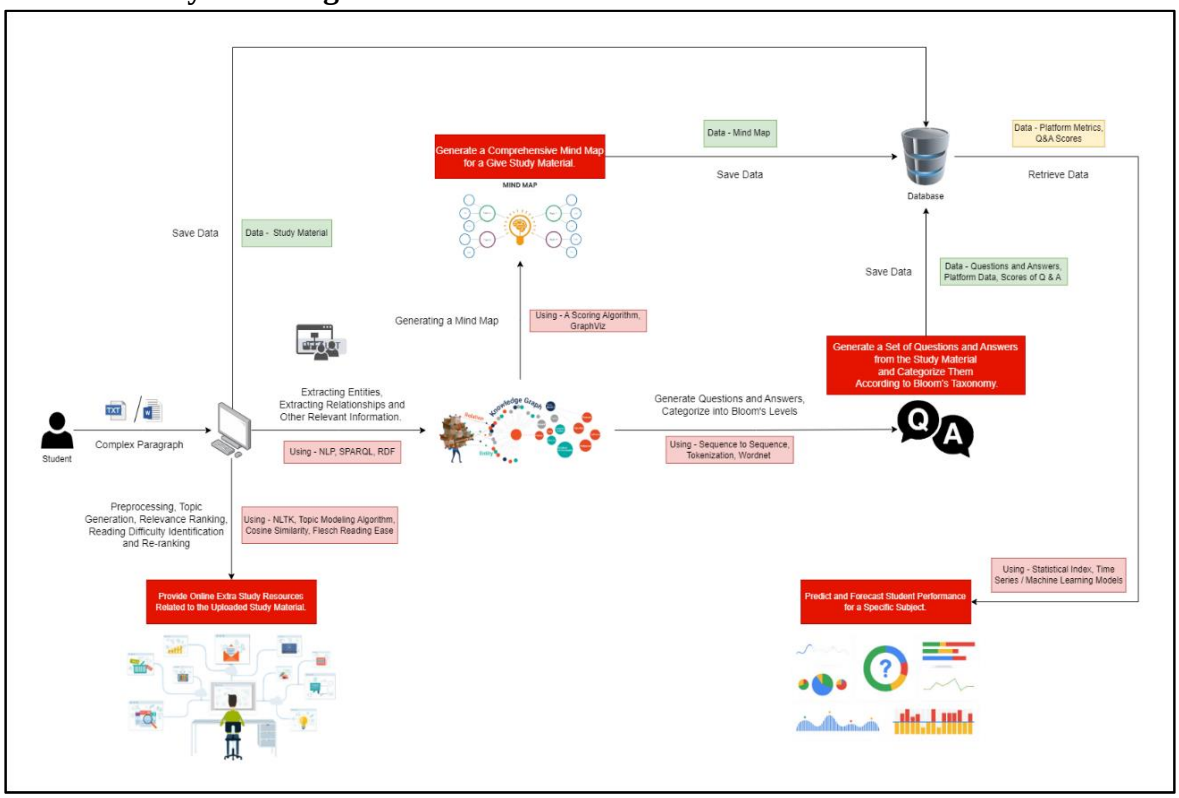

Figure 6: High level architecture of the overall system.

3.3. Work breakdown structure

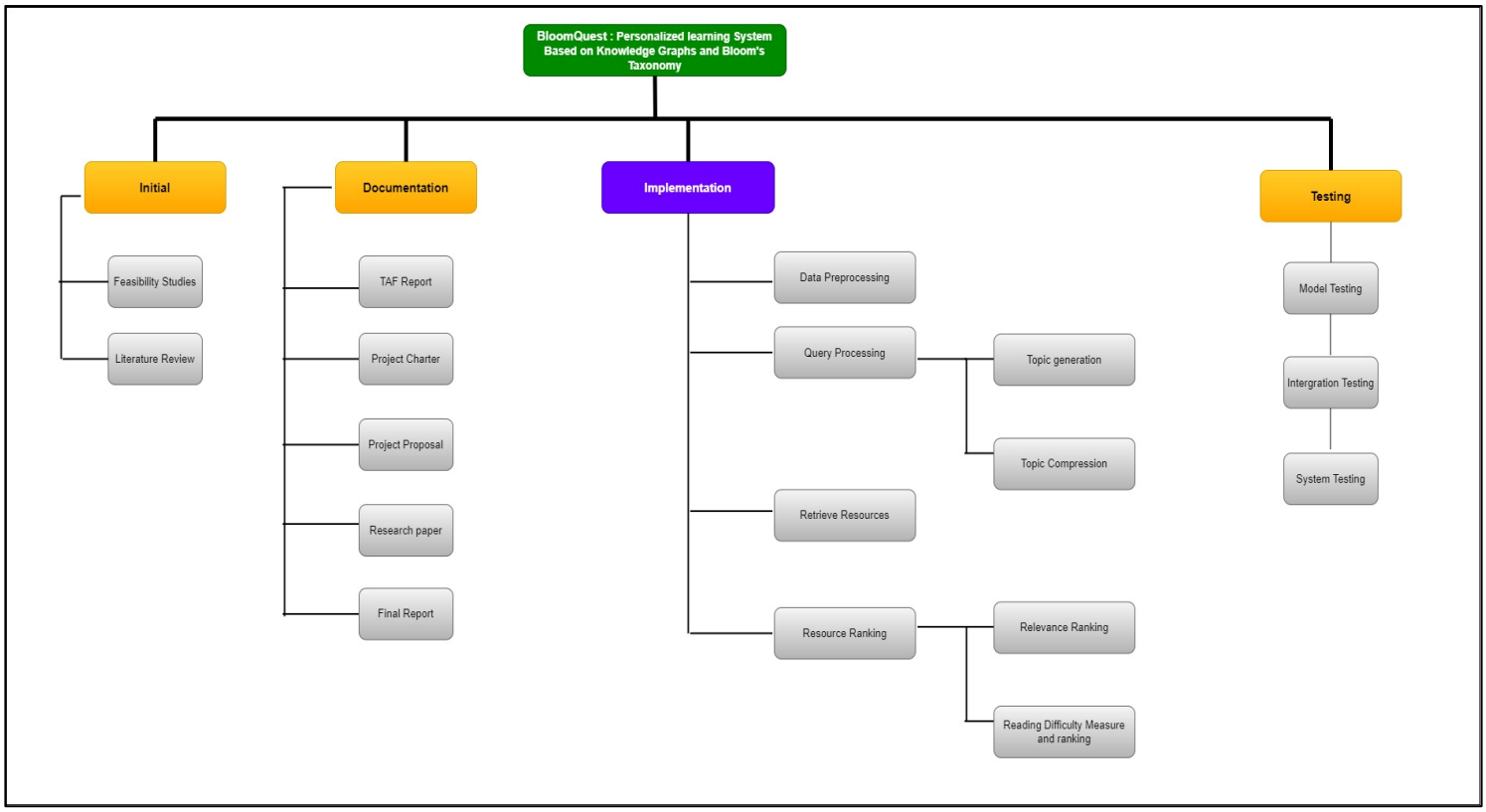

Figure 7: Work breakdown structure of the proposed component.

3.4. Test Plan

Testing will be conducting in three stages:

1. Unit Testing :

The query processing module and the resource ranking module are two examples of system components that can be tested individually for this study. It is possible to test the query processing module, by supplying sample sentences and confirming that the output topics produced by LDA are precise and pertinent .

2. Integration testing:

Integration testing can be performed by combining the individual components of the system and testing their interactions. For example, the query processing module and the resource retrieval module can be combined and tested by providing a sample query and verifying that the retrieved resources are relevant to the query and appropriately ranked based on their topic similarity and reading difficulty.

3. System testing:

System testing for the above research can be performed by testing the system as a whole to ensure that it meets the requirements and performs as expected. Testing the user interface, the system's handling of user inputs, and its capability to find and rank pertinent resources are all part of this. System testing may also involve evaluating the system's performance, security, and scalability under a variety of conditions.

4. Commercialization

The proposed online resource recommendation system has great potential for commercialization, as it presents many benefits to its users and is adaptable to various monetization models. The system is able to produce a detailed and accurate list of resources that students can use to improve their knowledge of particular topics. It can attract potential investors and generate various sources of income by offering reliable proof of its business potential.

One of the most significant benefits of this approach is its capacity to save learners time and effort when searching for appropriate information. Learners can quickly become overwhelmed by a large amount of information overload and lose valuable time looking for the right resources. By offering specialized recommendations that are suited to each learner's specific requirements, the recommendation system simplifies this procedure. The possibility for increased productivity and enhanced learning outcomes can be highlighted when marketing this advantage to both students and educational institutions.

Another benefit of the system is its potential to improve the efficacy of online learning. As the demand for e-learning platforms continues to soar, the need for effective resource recommendations becomes increasingly important. The system can provide learners with targeted and customized recommendations that align with their learning objectives, which can be an effective tool to boost user engagement and improve learning outcomes. This benefit can be marketed to e-learning platforms and educational institutions to underscore the potential for improved student engagement and academic success.

The capacity to generate revenue streams is another benefit of the system. The system can be monetized in a variety of ways, including paid subscriptions, affiliate marketing, and advertising revenue. We can attract potential investors and partners who can help us scale and monetize the product by demonstrating the system's capacity to attract and retain consumers.

In conclusion, the system for recommending online resources has the potential to be both a useful tool for students and educational institutes. And has the potential to improve learning outcomes, save time and effort, and produce revenue streams.

5. Gantt chart

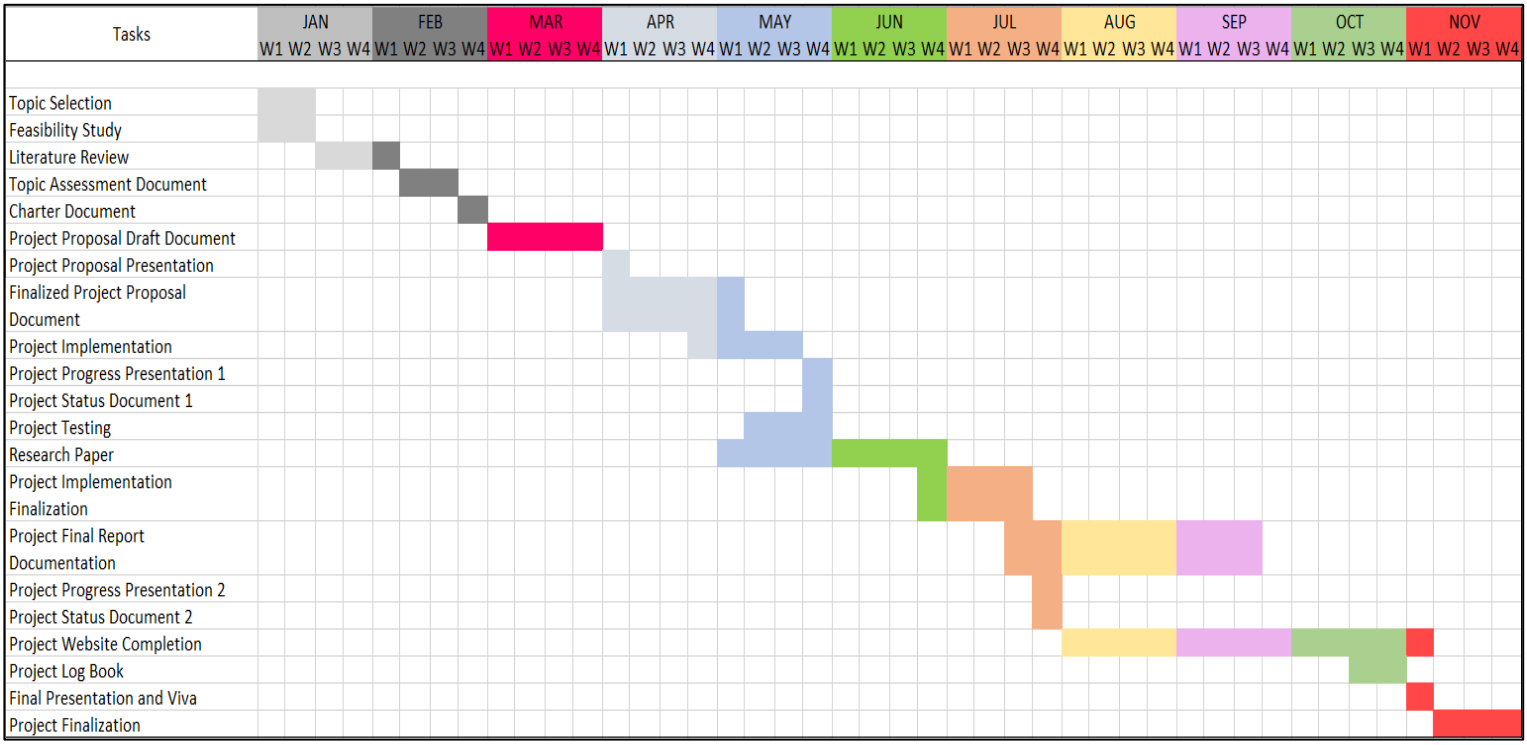

Figure 8: Gantt chart of the proposed component.

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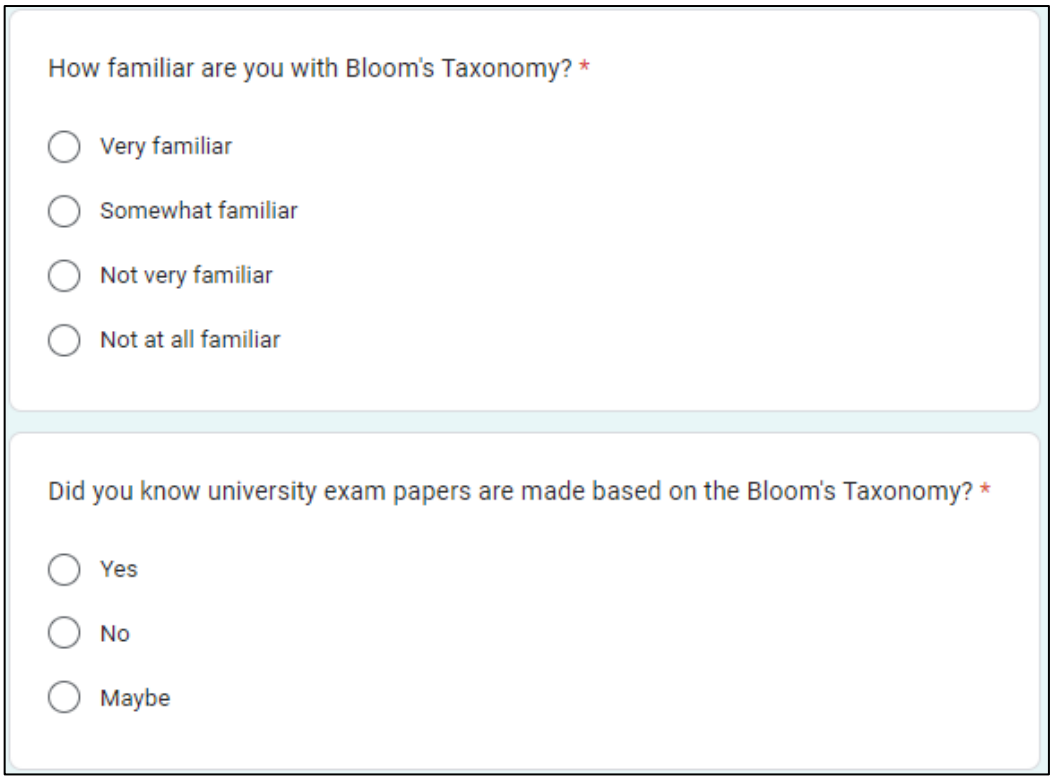
7. Appendix

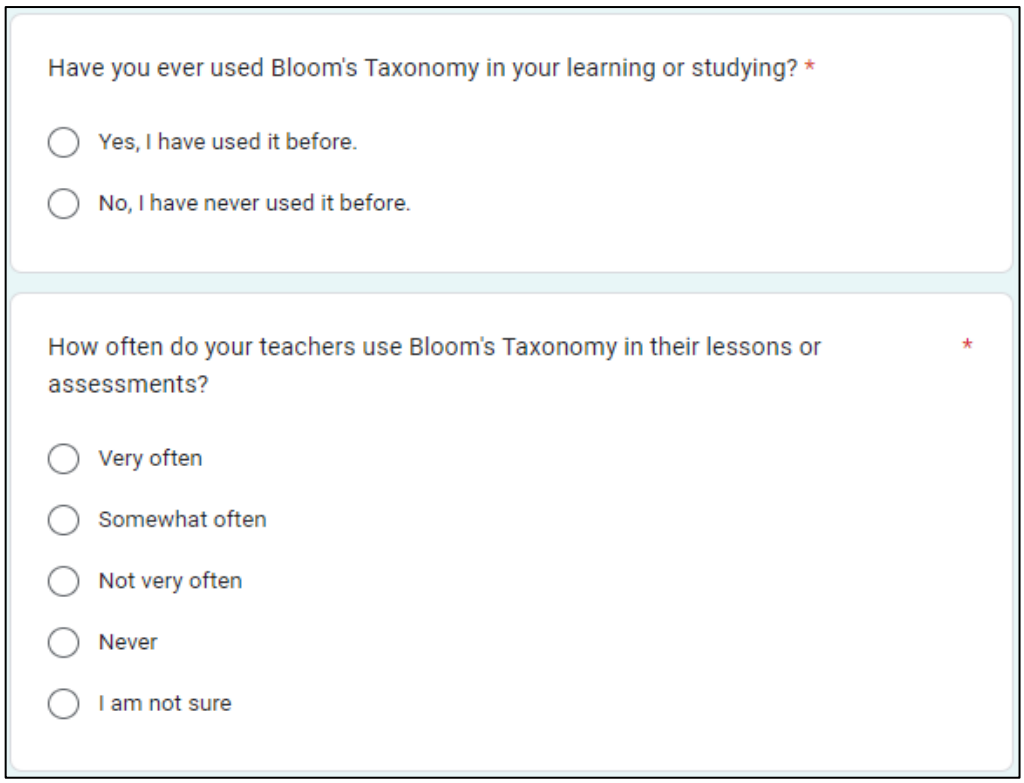
7.1. Questionnaire

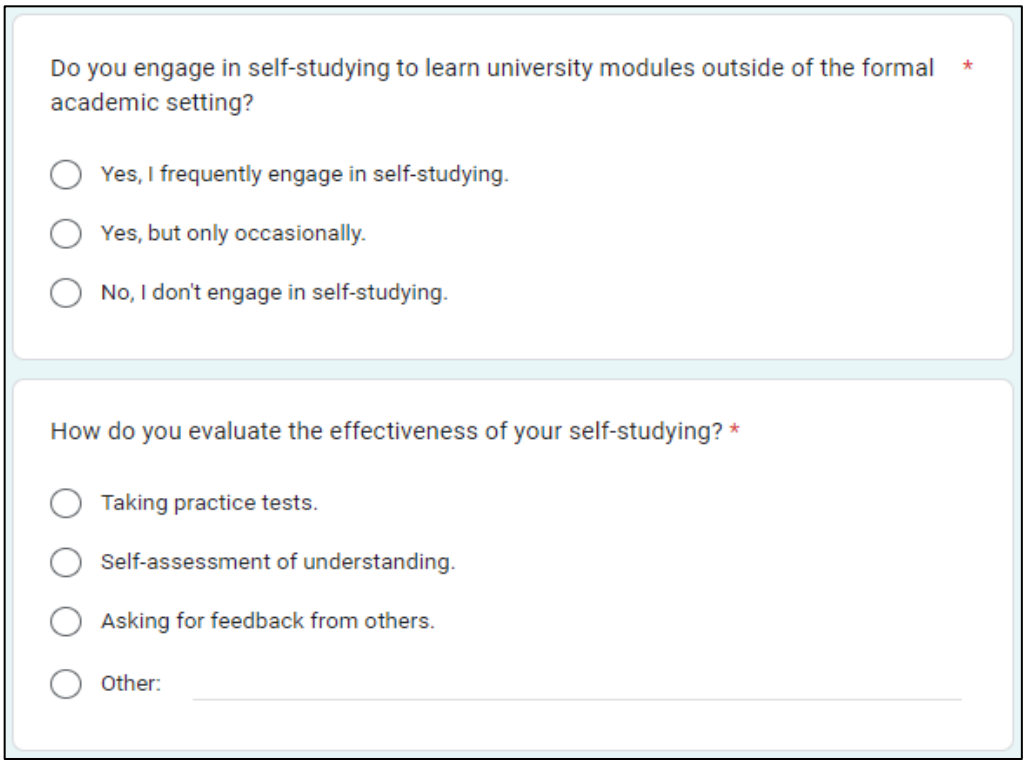
University students were given a survey with a number of questions in order to learn more about their self-study practices and familiarity with Bloom's Taxonomy. The survey's goal was to discover more about how students approach autonomous learning and their familiarity with Bloom's Taxonomy, an educational paradigm.

Link - https://forms.gle/wq6WL89q8VVt5Gsy7

Questions,




Have you ever used Bloom's Taxonomy in your learning or studying? *
Yes, I have used it before.
No, I have never used it before.
How often do your teachers use Bloom's Taxonomy in their lessons or assessments? *
Very often
Somewhat often
Not very often
Never
I am not sure


Do you engage in self-studying to learn university modules outside of the formal academic setting? *
Yes, I frequently engage in self-studying.
Yes, but only occasionally.
No, I don't engage in self-studying.
How do you evaluate the effectiveness of your self-studying? *
Taking practice tests.
Self-assessment of understanding.
Asking for feedback from others.
Other:

Have you noticed any improvements in your work or personal life as a result of self-studying? *

- ◯ Yes, I have
- ◯ No, I have not
- ◯ Maybe

Are you able to create comprehensive mind map by your own? *

- ◯ Yes
- ◯ No
- ◯ Maybe

How frequently do you use mind maps while studying? *

- ◯ Often
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

How satisfied are you with the mind map generation system you currently use, if applicable?

- ◯ Very satisfied
- ◯ Somewhat satisfied
- ◯ Neutral
- ◯ Somewhat dissatisfied
- ◯ Very dissatisfied

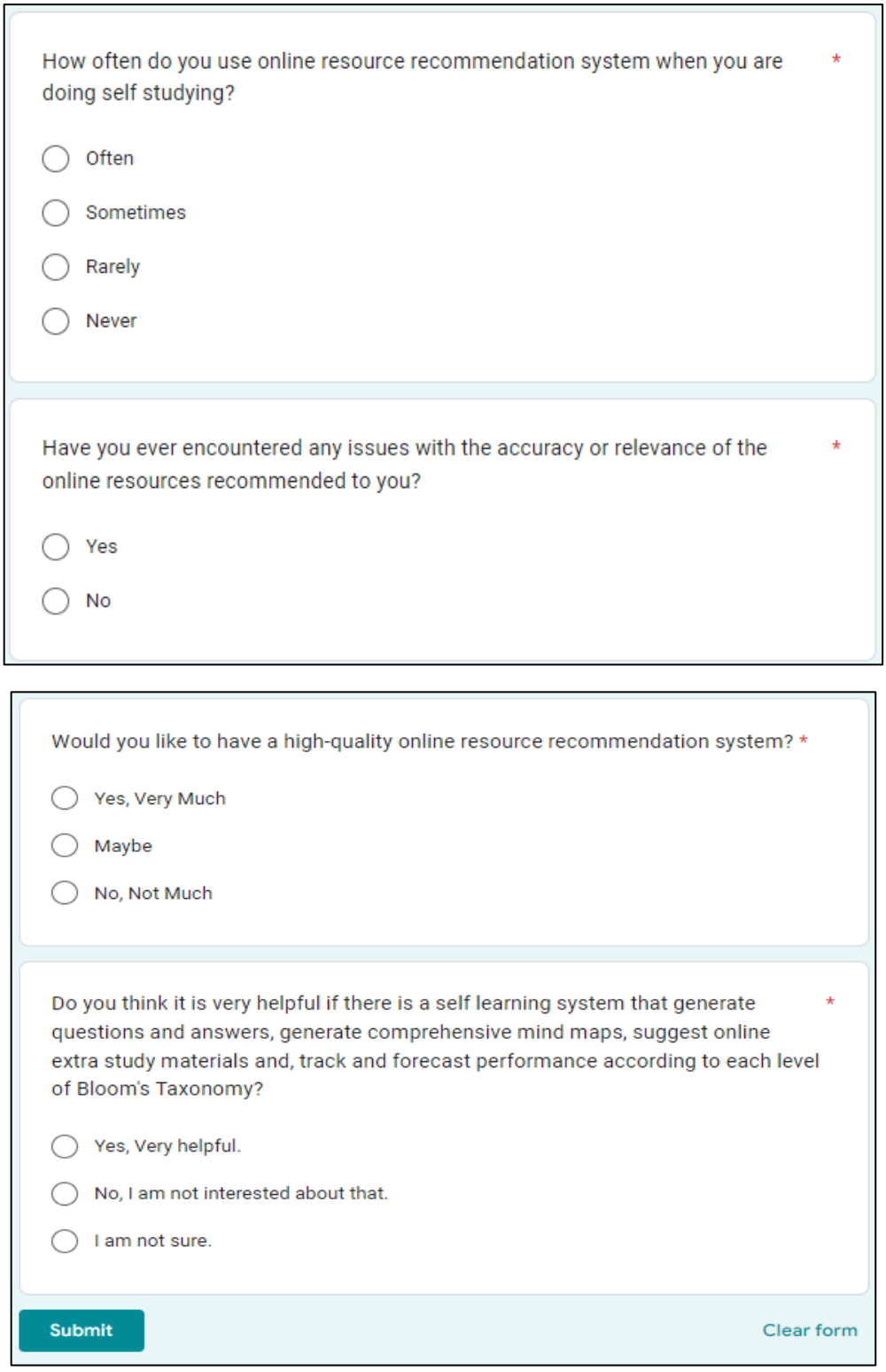


Figure 9: Questions in the questionnaire.

Responses,

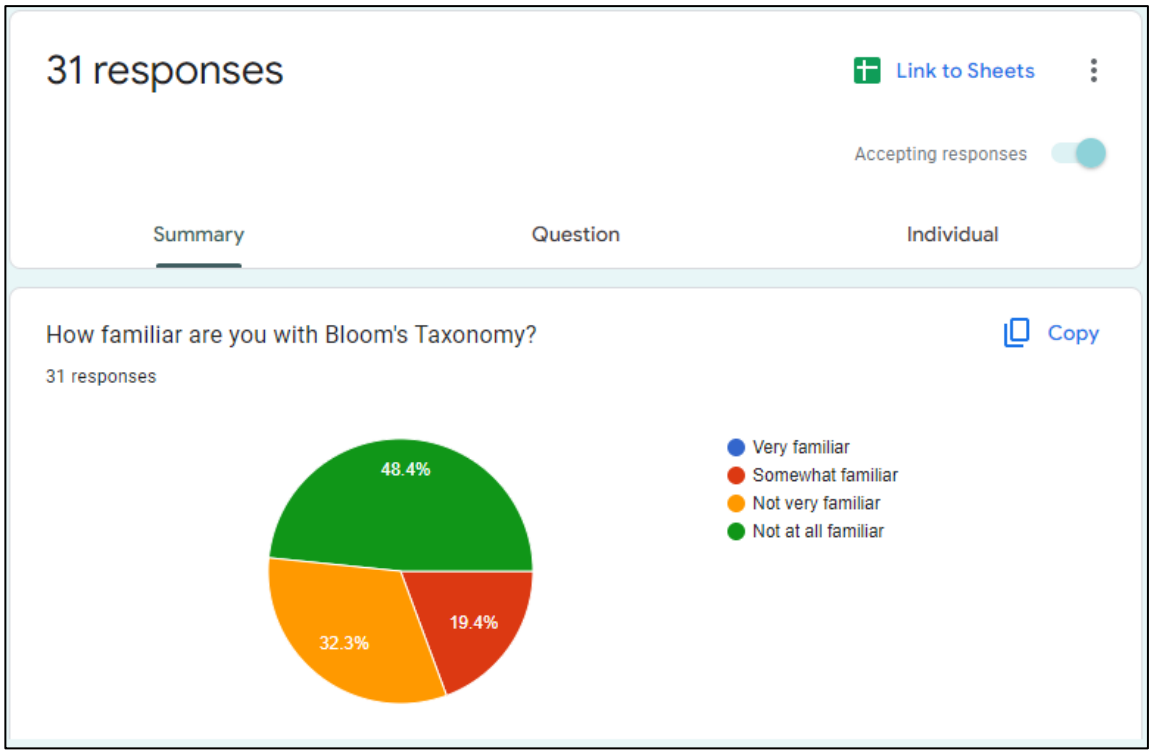


Figure 10: Responses to the questionnaire.

7.1. Plagiarism Report

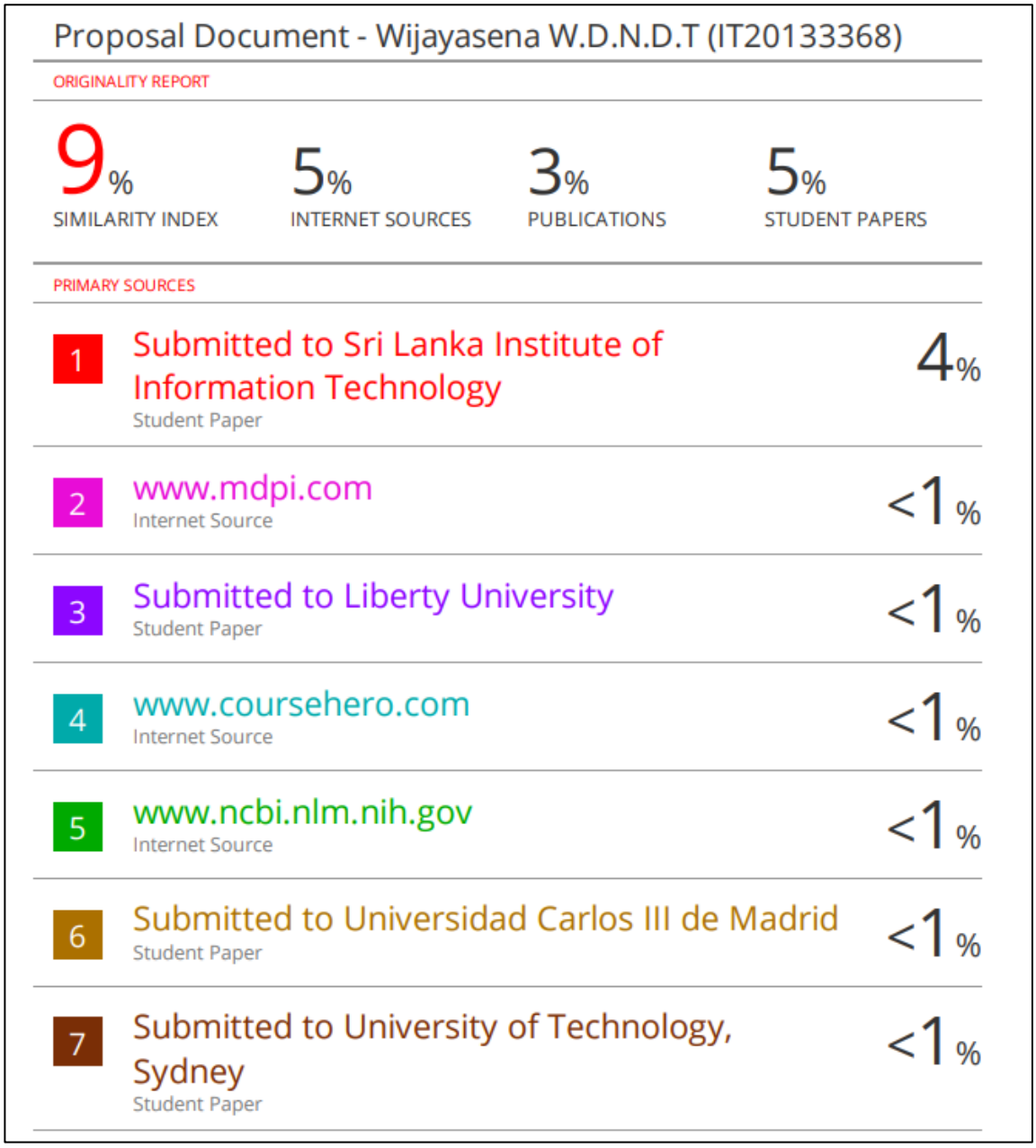


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Table 3: Plagiarism Report