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

2023-035

Project Proposal Document

Weerasekara N.N

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

Department of Information Technology

Sri Lanka Institute of Information Technology,

Sri Lanka

February 2023

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

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

Department of Information Technology,

Sri Lanka Institute of Information Technology,

Sri Lanka

February 2023

Author Details,

1. Author Name – **Weerasekara N.N.**
2. Student ID No. – **IT20133504**
3. Research objective – Generate a comprehensive mind map for the given study material.

Supervisor Details,

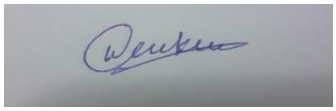
1. Supervisor Name – Dr. Prasanna Sumathipala.
2. Co-Supervisor Name – Mr. Sathira Hettiarachchi.
3. External Supervisor Name –

Group Details,

Member Name	**Student ID**
Wijayasena W.D.N.D.T. (Leader)	IT20133368
Senaweera T.I.S.	IT20123468
Weerasekara N.N	IT20133504
Colambage K.G	IT20126438

Declaration

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

Name	**Student ID**	**Signature**
Weerasekara N.N.	IT20133504	

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:

Abstract

Creating well-balanced and high-quality exams that cater to the various cognitive levels of undergraduates is crucial. To achieve this, many lecturers rely on Bloom's Taxonomy cognitive domain, which is a popular framework used to assess students' intellectual abilities and skills. However, despite its widespread use, many students are not aware of Bloom's Taxonomy and its impact on their learning experience. This lack of understanding can result in students missing vital opportunities for growth and development in their academic pursuits. To address this issue, a personalized self-learning system has been developed based on Bloom's Taxonomy, which aims to help students understand and apply it in their own learning process. The system is personalized according to the student's learning material and level of performance. It extracts named entities and relations between them from the student's material and generates a knowledge graph. This approach provides a unique opportunity for students to learn from the type and level of content that they are best suited to, ultimately leading to better performance and more effective learning. The output of this project is a desktop application that provides a fully-fledged personalized self-learning system based on Bloom's Taxonomy. The proposal focuses on implementing a personalized dynamic study plan and recommending external study resources based on the user's performance level and Bloom's Taxonomy. The system's ability to find relevant external resources for the user is critical in ensuring that they have access to a variety of study materials that are tailored to their specific learning needs. In summary, this project aims to address the lack of understanding of Bloom's Taxonomy among students and provides them with a personalized self-learning system to help them understand and apply it to their own learning process. This system can ultimately lead to better academic performance and improved learning outcomes for undergraduates.

TABLE OF CONTENT

List of Figures

List of Tables

1. Introduction

Mind Mapping is a widely recognized method for taking notes, which has proven to be highly effective in facilitating learning and self-study. This technique allows one to create visual representations of concepts and ideas in a non-linear, free-form manner that is easy to understand and remember.

Mind mapping can play a crucial role in the self-learning process for students. By allowing the mind to draw correlations and connections between many pieces of knowledge, this method promotes creativity and aids in the development of critical thinking skills. Mind mapping can help students to visualize the relationships between different concepts and ideas. Mind maps provide a graphical representation of the relationships between different topics, making it easier to understand complex information and identify connections between different concepts.

The thing is many students don't use mind maps because creating mind maps requires extra mental efforts. Only a few are creative enough to draw good mind maps and the rest don't have that creativity to draw mind maps. My point is that if every student gets a chance to summarize their work using a mind map, they could improve their memory retention significantly. This paper provides a tool that builds a mind map according to the given study material by the student. This will be helpful for the student who don't know how to create or make a mind map. Overall, mind mapping is a flexible and useful tool that may be used in a variety of contexts, including education, business, and personal growth, by people of all ages and professions.

In conclusion, Mind mapping can be a powerful way to help students understand and apply it in their own learning process. This technique can help to simplify complex information and provide a visual representation of the relationships between different concepts, making it easier for students to understand and recall the material. By using this tool, students can improve their self-studying process, which can lead to improved academic performance and success in their academic pursuits.

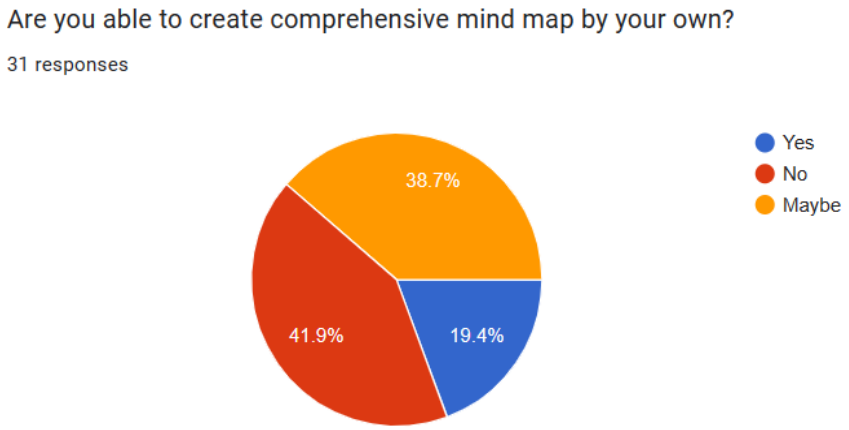


Figure 1:Responses for the ability to create a mind map

1.1 Background and Literature Review

In 2021, Yeoil, Taejin and Namgyu Kim who were Graduates in Kookmin University in faculty of Business IT have done research about Deep Learning-Based Knowledge Graph Generation for COVID-19 [1]. In order to create a knowledge network particular to COVID-19, this study suggests an Open Information Extraction (OpenIE) method based on unsupervised learning. The system uses a COVID-19 entity dictionary and a fine-tuned BERT language model to extract connecting words between entities and outperforms original BERT in terms of accuracy and score. It highlights the two methods of natural language processing - statistical and neural network - and emphasizes the benefits of using neural networks, such as the ability to efficiently expand the model.

Researchers from the University of Mexico, Ivan Lopez-Arevalo, Jose L. Martinez-Rodriguez, and Ana B. Rios-Alvarado conducted research in 2018 on an OpenIE-based method for building knowledge graphs from text. [2] This method involves the use of Natural Language Processing (NLP) and Information Extraction (IE) techniques to convert the input text into a machine-readable format consisting of RDF triples. RDF graphs are used to represent entities and relationships between them, where entities can be anything that has a unique identifier, such as a person, place, concept, or event. Relationships between entities are represented as edges in the graph, with properties that describe the nature of the relationship. By constructing a graph from these triples, Knowledge Graphs can be used to represent knowledge from multiple sources and domains and to support various applications, such as information retrieval and natural language processing.

A research study for creating mind maps from articles using machine learning was completed in 2019 by M.F. Kuroki, L.S. Riza, and Rasim at the department of computer science education at Universitas Pendidikan Indonesia. [3] For the data collection they have used articles. The topic sentence of a paragraph is chosen using the information retrieval approach, pre-processing, core NLP, and feature extraction approaches in model creation. Application development uses a stage-by-stage, linear process model. In experiments, experts choose the criteria for articles, and the application and the experts choose the topic phrases. The results are articles with topic sentences in each paragraph. With a title, subtitle, and topic sentence for each paragraph, this system creates teaching materials in the form of a mind map. The system's output is contrasted with the average values produced by two human experts, whose accuracy rate averages 53.55%. This indicates a moderate level of system correctness.

In 2013, Ayu Purwarianthi, Athia Saelan, Irfan Afif, Filman Ferdian, and Alfan Farizki conducted research on developing an autonomous mind map generator in Indonesian language at the school of electrical engineering and informatics institution in Indonesia. [4] Indonesian Mind Map Generator utilizes Indonesian natural language understanding tools such as a POS tagger, syntactic parser, and semantic analyzer to facilitate easy creation of Mind Map objects. The tools' accuracy rates for the POS tagger, syntactic parser, and semantic analyzer are 96.5%, 47.22%, and 62.5%, respectively. They were created with the aim of addressing the dearth of Indonesian language resources. The Mind Map generator also employs radial drawing visualization and an editor for modifications. In evaluation, the Mind Map object was easily understood for simple sentences by 5 respondents.

In 2020 Danilo Dessi, Franceso Osborne, Diego Recupero, Davide Buscaldi and Enrico Motta have done research on knowledge graphs creation from NLP. [5] The abundance of scientific literature makes analysis difficult, necessitating technical infrastructures for effective browsing, analysis, and research forecasting. Although knowledge graphs, which are extensive networks of entities and relationships, are useful tools, they do not explicitly represent the knowledge found in research papers. This work introduces a unique architecture that uses NLP and ML methods to extract entities and relationships from research publications and add them to a knowledge graph. A scientific knowledge network was created using the hybrid approach's accurate extraction of 109,105 triples from 26,827 abstracts. The method is universal and adaptable to any domain.

In 2011 Robert, Mirko and Mladen from university of Zagreb, Croatia has implemented a mind map generating software model by using text mining algorithm. [6] This software is compatible with desktop, laptop, PDA, and mobile devices. A web service based on SOA is advised because PDAs and mobile phones may execute slowly. The algorithms will be run by the web service, which will then produce a mind map that will be saved on a database server. All mind maps can be searched for and downloaded by users, and the database can be used to integrate mind maps and conduct additional research. This software has some kind of an accuracy related to other systems.

2. Research Gap

After going through all the above research papers, Existing automated systems for creating mind maps from text data rely on text mining algorithms[6] and machine learning approaches[3] that may not consider the domain-specific knowledge. As a result, the mind maps may be incomplete or may not accurately represent the text's intent. This research attempts to design a knowledge-based system that uses domain-specific knowledge to generate more precise and significant mind maps from text input to get over this constraint.

Comparison Criteria	Paper [3]	Paper [4]	Paper [6]	Proposed System
knowledge-based concepts	✗	✗	✗	✓
Evaluation metrics	✓	✗	✗	✓
Scoring Algorithms	✓	✗	✗	✓
Accuracy	✓	✗	✗	✓
Speed	✗	✓	✓	✓
User needs focus	✗	✗	✗	✓

Table 1 : Research Gap

3. Research Problem

"Can a knowledge-based system improve the accuracy and usefulness of mind maps generated from text data compared to existing text mining algorithms and Machine learning approaches?"

As we can see from the above papers, many of them had the problem with the accuracy of the knowledge graph that was generated. Mind map will be created for the given study material, but the thing is if you don't have the accuracy of the mind map the mind map could not be useful at all.

After doing some research about this issue, I found that knowledge-based systems accuracy is better than other approaches. In studies published in the Journal of the American Medical informatics association and Journal of Biomedical informatics found that their systems(Knowledge based) outperformed text mining algorithms in terms of accuracy.

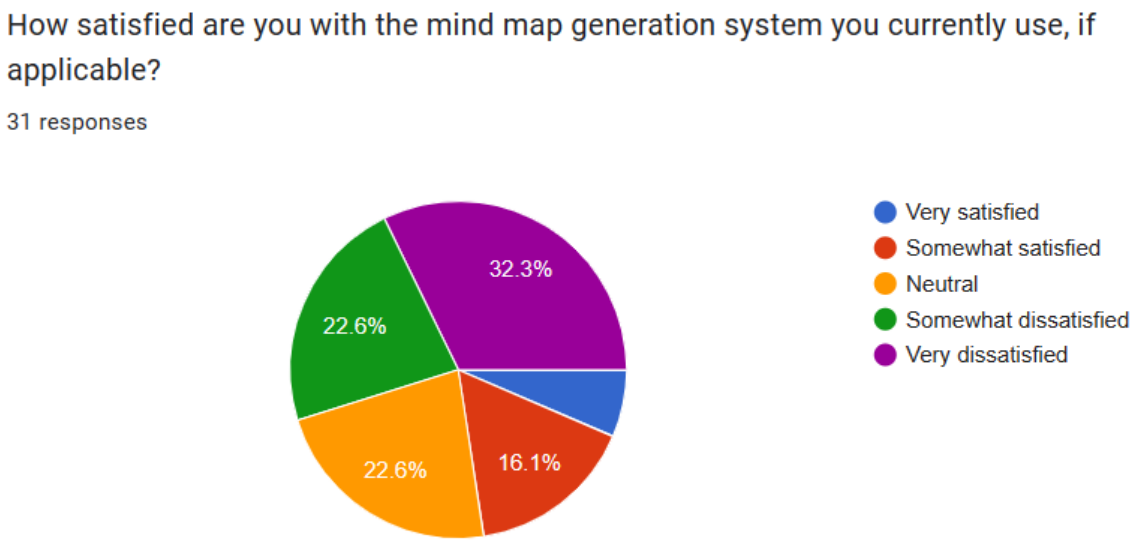


Figure 2 : Responses for the current systems

4. Main Objective

The primary goal of this project is to design and implement a knowledge-based system that can generate more precise and significant mind maps from textual data. By developing a knowledge-based system for mind map generation, this project aims to improve upon the limitations of existing text mining algorithms and machine learning approaches, which may not always capture the full semantic meaning of the input text. The proposed system seeks to address this issue by incorporating domain-specific knowledge and rules into the analysis process, which can enhance the accuracy and relevance of the generated mind maps. Additionally, the project's overarching objective is to develop a knowledge-based system that can overcome the limitations of current text mining and machine learning approaches and generate more precise and meaningful mind maps from text data.

4.1 Sub-objectives:

- To design a mind map that supports self-study and helps students to better understand and retain key concepts in a particular subject:
  The mind map will be designed to provide a visual representation of the connections between the various concepts, making it easier for students to understand and remember them. The mind map will be structured in a way that enables students to navigate through the various concepts and explore the relationships between them.

- To review existing literature on automated systems for creating mind maps from text data and identify the limitations of current approaches:
  This review will identify the strengths and limitations of current approaches and provide insights into how the proposed system can be improved. The review will also explore the different techniques used for creating mind maps, including machine learning, natural language processing, and data visualization.

- To conduct user studies to gather feedback on the usability and usefulness of the proposed system:
  .The user studies will involve recruiting participants who are studying a particular subject and asking them to use the system to create a mind map based on the material they have learned. The feedback gathered from the participants will be used to improve the system's design and functionality. The user studies will also evaluate the effectiveness of the mind map in facilitating learning and retention of key concepts.

4.2 Functional Requirements:

The characteristics and functionalities that this system must have to satisfy the needs of its users are known as functional requirements. Below main points specify what must be done by this system and how it must function in response to particular inputs or activities.

- Ability to extract and process text data from various file formats (e.g., PDF, Word).
- Ability to identify key concepts and relationships within the input text data.
- Ability to generate a visual mind map that represents the key concepts and relationships.
- Ability to allow users to modify and edit the generated mind map.
- Ability to export the generated mind map in various file formats (e.g., PNG, SVG).

4.3 Non-functional Requirements:

Nonfunctional criteria are used to determine the performance and quality attributes of this system. These standards give overall performance a higher priority than system functionality.

- Accuracy: The system should accurately represent the key concepts and relationships.
- Usability: The system should be user-friendly and easy to navigate.
- Security: The system should ensure the confidentiality and integrity of the text data and generated mind maps.

5. Methodology

5.1 System Diagram for Generating a mind map

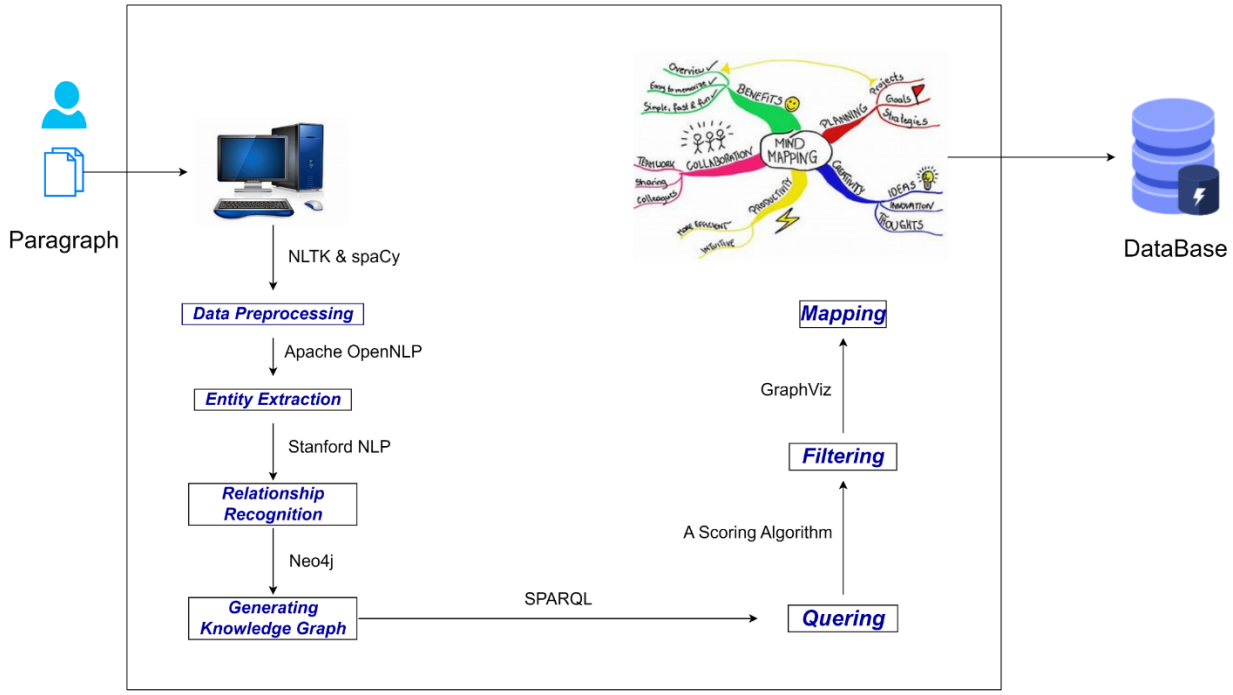


Figure 3 : System Diagram for my component

1. Text Preprocessing : Clean the text data by removing stop words, punctuations, etc.
   (Python library : spaCY)
2. Entity Recognition : Identify the name entities. (e.g.- People, Places, etc.)
   (Stanford NLP)
3. Relationship Extraction : Identify the relationships between the entities.
   (Stanford NLP, Apache OpenNLP)
4. Graph Construction : Construct the graph. (Entities as nodes, Relationships as Edges.)
   (Neo4j Tool)
5. Querying : Retrieve data from the Knowledge graph.
   (SPARQL)
6. Filtering : Include only the relevant entities and relationships.
   (A Scoring Algorithm)
7. Mapping : Map the entities and Visualize.
   (GraphViz Tool)

First, we need to input a text or a paragraph to the system that contains specific subject details. After that we need to preprocess the input text using NLP techniques. In preprocessing what we are doing was we clean the text data by removing stop words, punctuation and any other irrelevant information. Once the preprocessing is done, the next step is to extract the entities from the input text. This entails locating the entities mentioned in the text and classifying them according to their category (e.g., individual, group, or location). After the extracting entity's part is over, we must extract the relationships too. Otherwise, there won't be any relationship for connect those entities. This step involves identifying the verbs and any other connecting words. For these two steps, we can also use NLP libraries such as spaCY. After these steps were over, we can construct the knowledge graph using neo4j. In the graph, Entities shown as nodes and relationships show as edges. Next, we must assign weights to the edges of the knowledge graph based on the frequency of the extracted relationship. Then we must extract the knowledge graph data by using SPARQL queries. After assigned weights to the edges, we must filter the edges based on their assigned weights. After all these steps completed, we can do the visualization, that means we can generate the mind map according to the extracted data from the graph using GrapViz tool.

5.2 Overall System Diagram

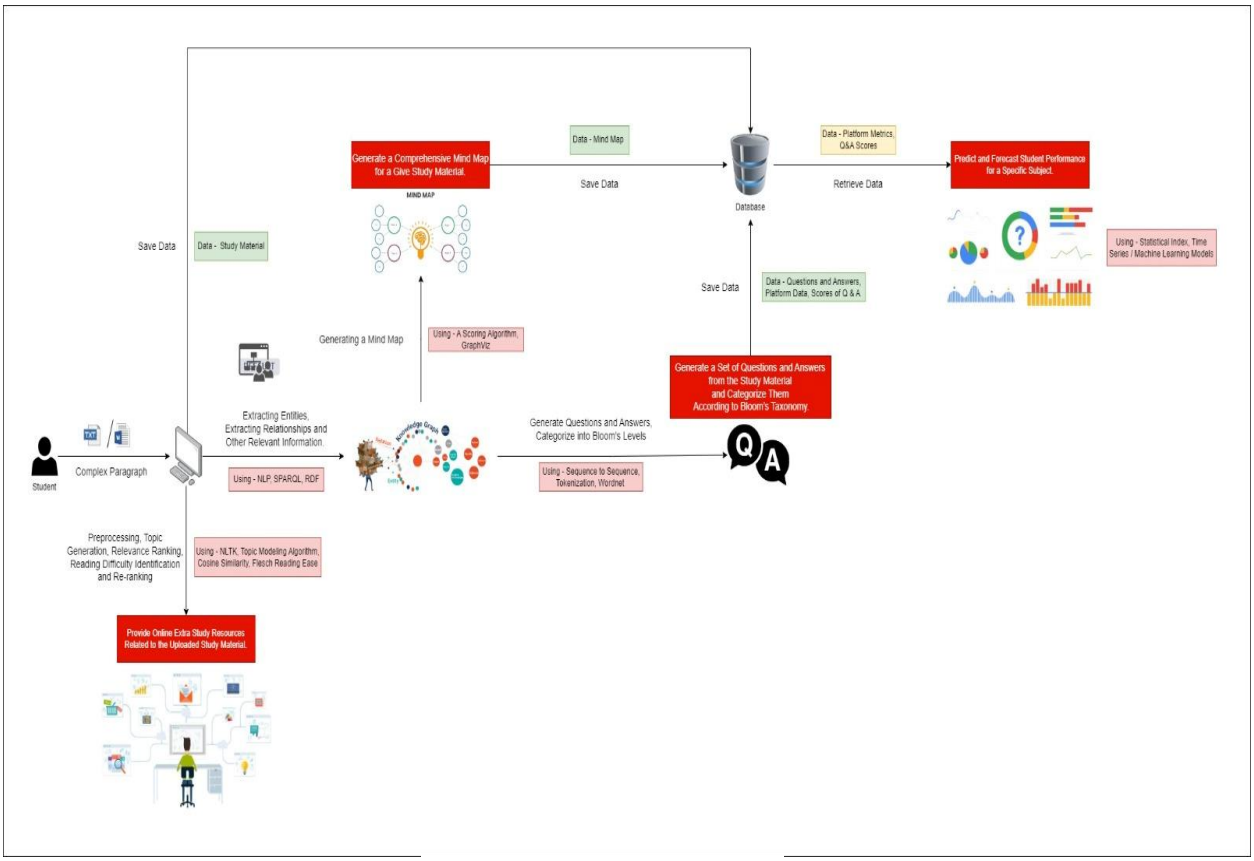


Figure 4 : Overall System Diagram

5.3 Work Breakdown Structure

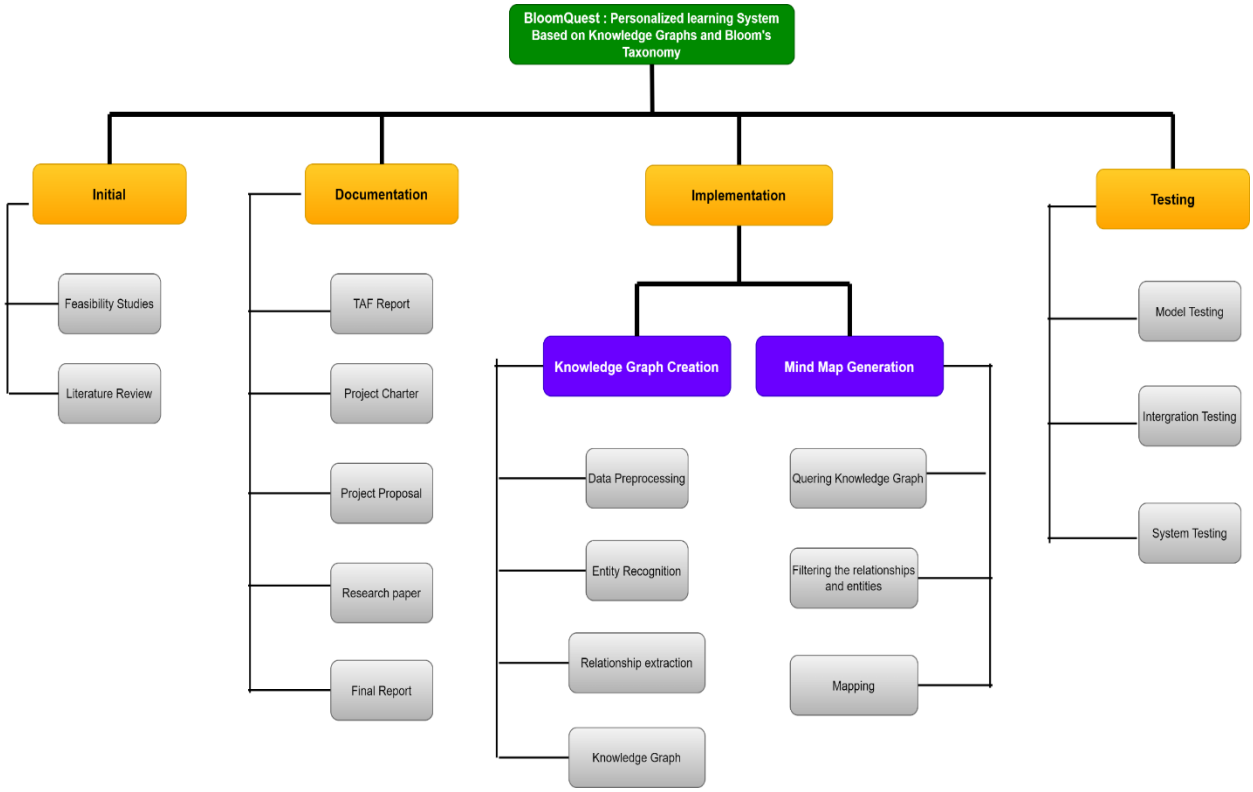


Figure 5 : WBS

5.4 Test Plan

1)Objective: The objective of this test plan is to ensure that the mind map generated using the knowledge graph accurately reflects the content of the given document.

2)Test Scenario: The test scenario will involve inputting a document into the system and verifying that the generated mind map accurately reflects the content of the document.

3)Test Cases:

a. Test case 1: Input a simple document with a single concept and verify that the generated mind map accurately reflects the concept.

b. Test case 2: Input a document with multiple concepts and verify that the generated mind map accurately reflects all the concepts.

c. Test case 3: Input a complex document with multiple sub-concepts and verify that the generated mind map accurately reflects all the sub-concepts.

d. Test case 4: Input a document with ambiguous concepts and verify that the generated mind map accurately represents the most relevant concepts.

e. Test case 5: Input a document with no clear concepts and verify that the generated mind map does not produce any misleading information.

4)Test Data:

a. Sample documents with varying complexity and structure will be used to test the system.

b. The documents will be in a variety of formats, such as plain text, PDF, and Microsoft Word.

5)Test Steps:

a. Input the sample document into the system.

b. Verify that the mind map accurately reflects the content of the document.

c. If any discrepancies are found, note them and re-test the system after any necessary modifications have been made.

6. Gantt Chart

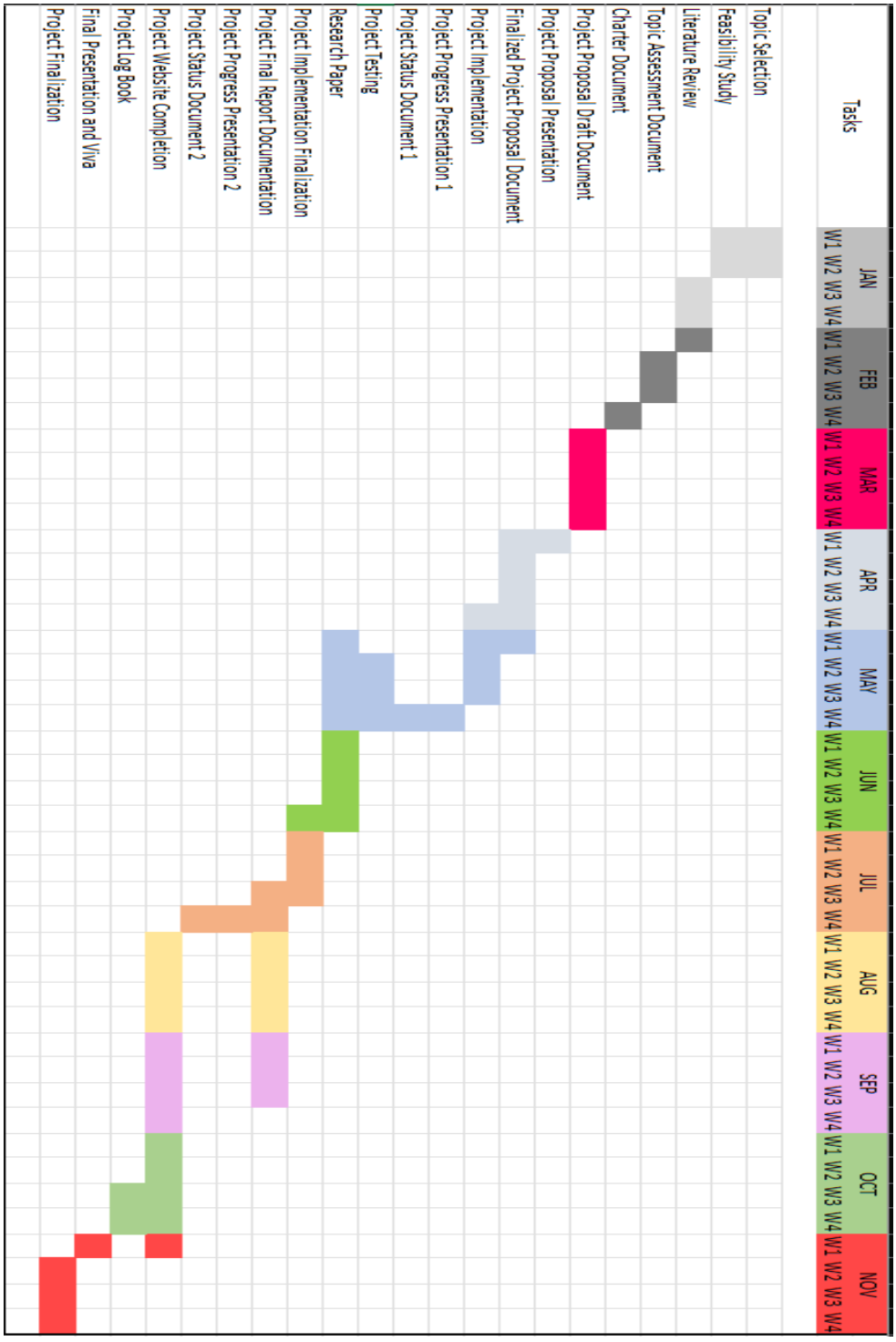


Figure 6 : Gantt Chart

7. Commercialization

The mind map generation system described above has immense potential to revolutionize the way students and professionals approach studying and knowledge retention. By inputting a text or paragraph and using NLP techniques to extract entities and relationships, the system can construct a comprehensive knowledge graph that visualizes complex concepts in a simple and intuitive manner. With the ability to assign weights to edges and filter them based on relevance, the resulting mind map is tailored to the user's needs and provides a clear and concise overview of the subject matter. This system has numerous applications, from assisting students in their studies to helping professionals prepare for presentations or meetings. By simplifying complex concepts and providing a visual representation of relationships, this system has the potential to save users time and improve their understanding of the subject matter. With the rise of remote learning and remote work, the need for efficient and effective knowledge retention tools has never been greater, making this system a valuable addition to any individual or organization's toolset.

8. References

[1]T. Kim and N. Kim, "Deep Learning-Based Knowledge Graph Generation for COVID-19," Graduate School of Business IT, Kookmin University, Seoul, Korea, 2021.

[2]Jose L. Martinez-Rodriguez, Ivan Lopez-Arevalo, Ana B. Rios-Alvarado, OpenIE-based approach for Knowledge Graph construction from text, Expert Systems With Applications (2018), doi: 10.1016/j.eswa.2018.07.017

[3] M. F. Nurrokhim, L. S. Riza, and Rasim, "Generating mind map from an article using machine learning," J. Phys.: Conf. Ser., vol. 1280, p. 032023, 2019. DOI: 10.1088/1742-6596/1280/3/032023.

[4] A. Saelan and A. Purwarianti, "Generating Mind Map from Indonesian Text using Natural Language Processing Tools," Procedia Technology, vol. 11, pp. 1163-1169, 2013.

[5] D. Dessì, F. Osborne, D. Reforgiato Recupero, D. Buscaldi, and E. Motta, "Generating Knowledge Graphs by Employing Natural Language Processing and Machine Learning Techniques within the Scholarly Domain," Knowledge-Based Systems, vol. 154, pp. 1-14, 2018.

[6] R. Kudelić, M. Konecki, and M. Maleković, "Mind Map Generator Software Model with Text Mining Algorithm," in Proceedings of the ITI 2011 33rd Int. Conf. on Information Technology Interfaces, Cavtat, Croatia, 2011

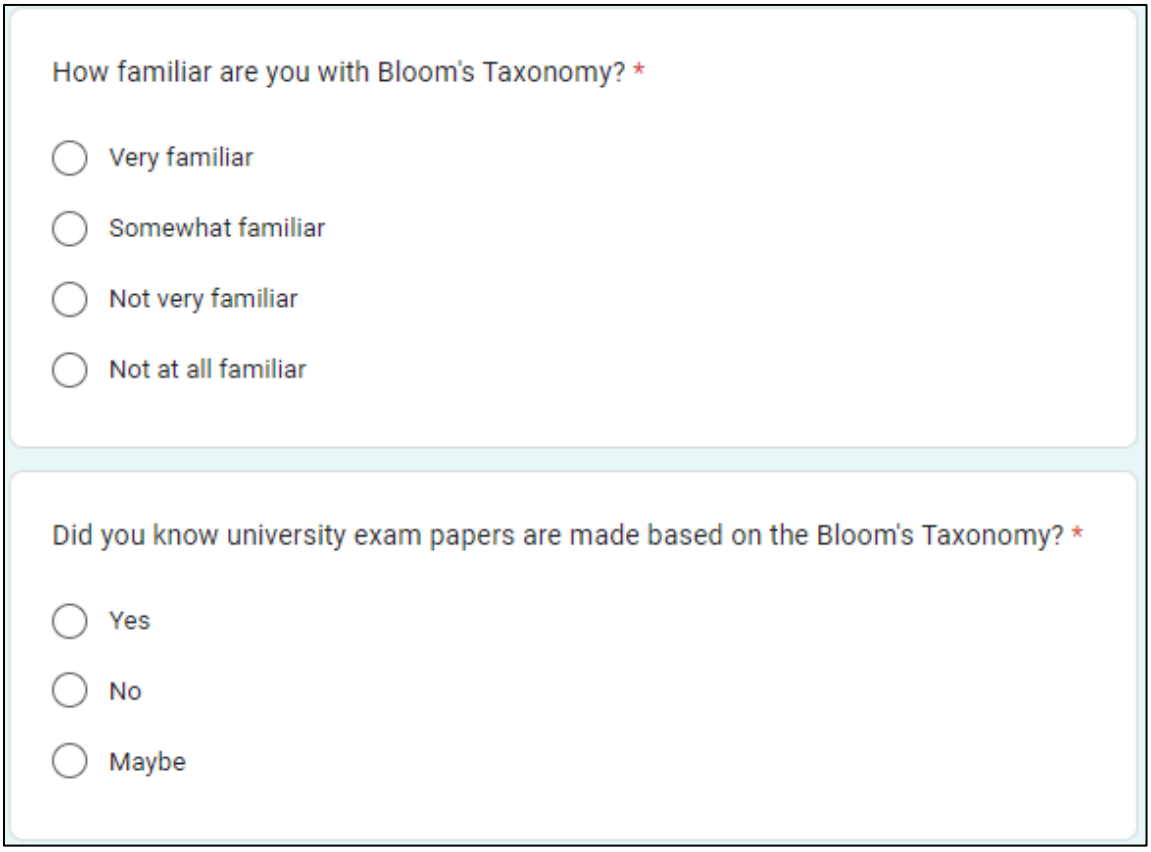
9. Appendix

9.1. Questionnaire

A survey consisting of several questions was distributed among university students to gather information on their self-study habits and their familiarity with Bloom's Taxonomy. The purpose of the survey was to gain insights into how students engage in independent learning and their level of knowledge about the educational framework known as Bloom's Taxonomy.

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: _____

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

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 often do you use online resource recommendation system when you are doing self studying? *

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

Have you ever encountered any issues with the accuracy or relevance of the online resources recommended to you? *

- ◯ Yes
- ◯ No

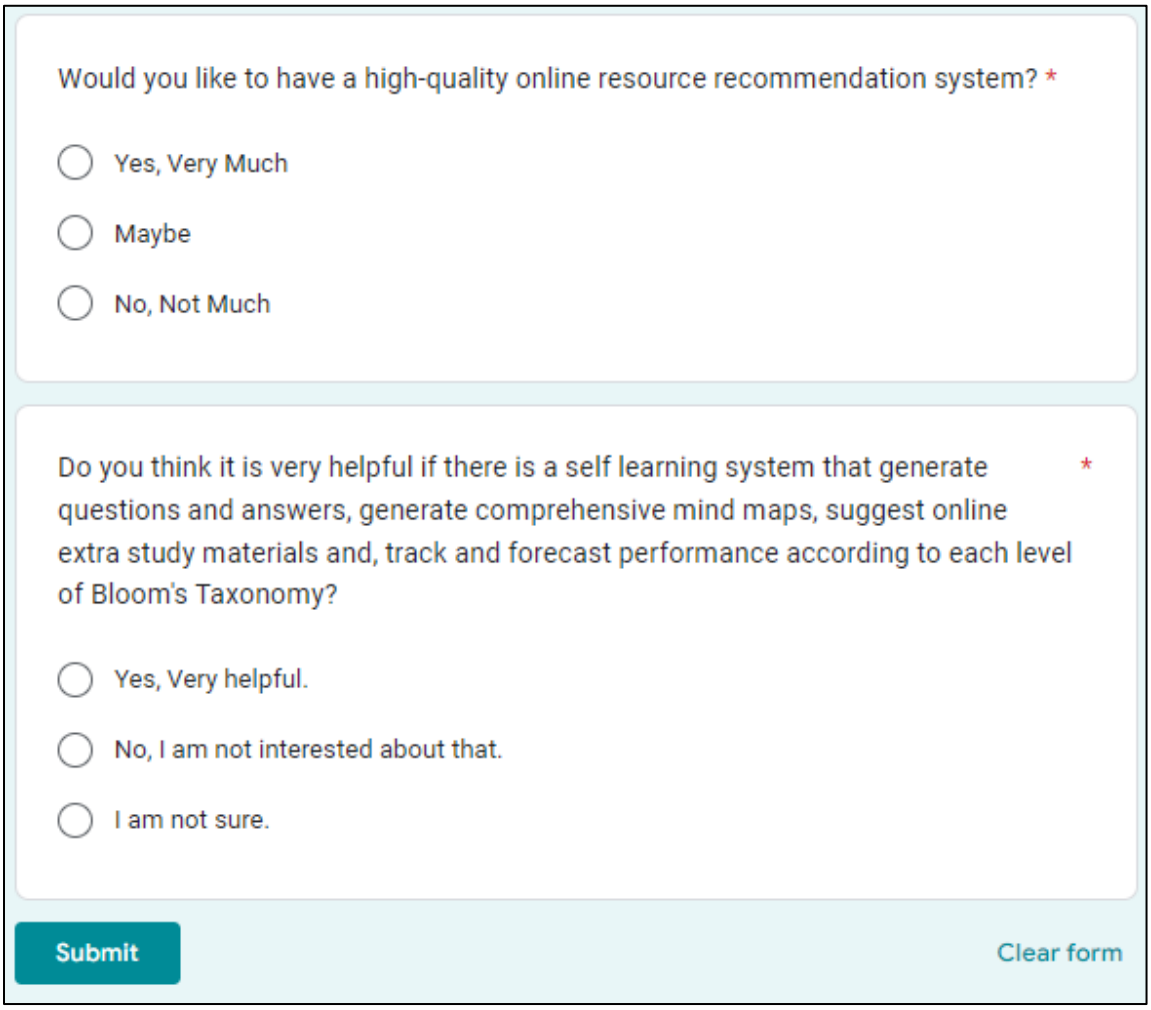


Figure 7 : Survey

Responses,

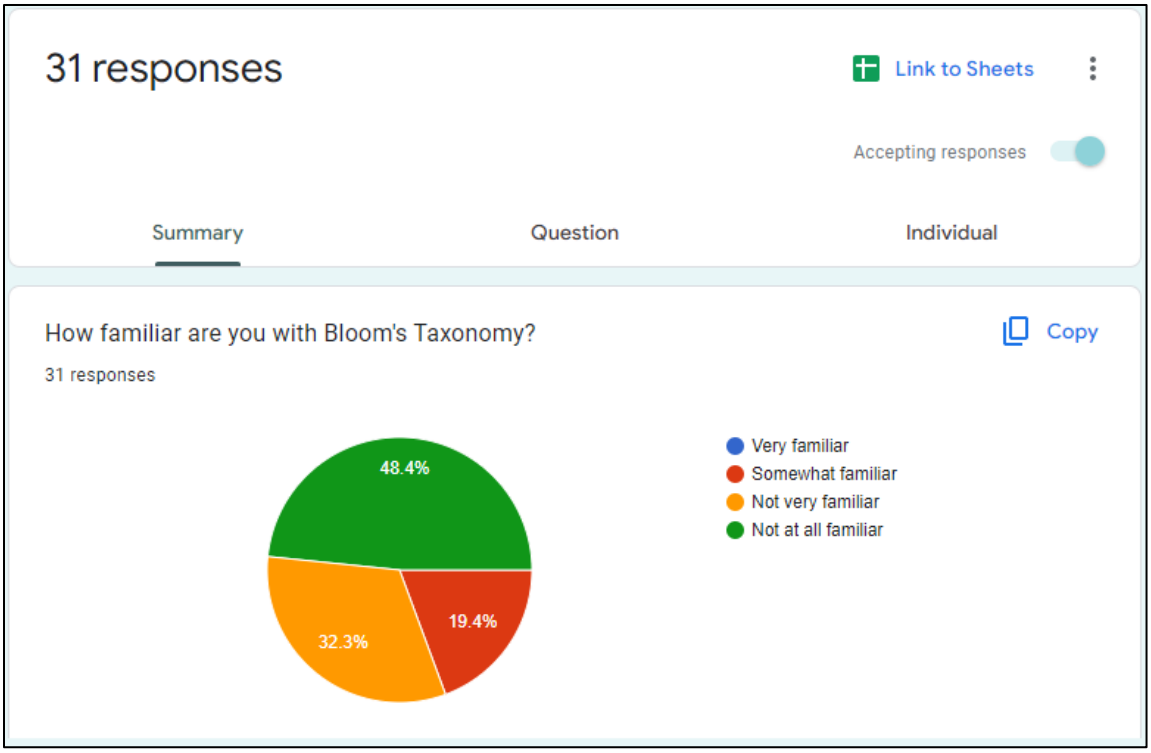


Figure 8 : Responses for the survey

9.2. Plagiarism Report

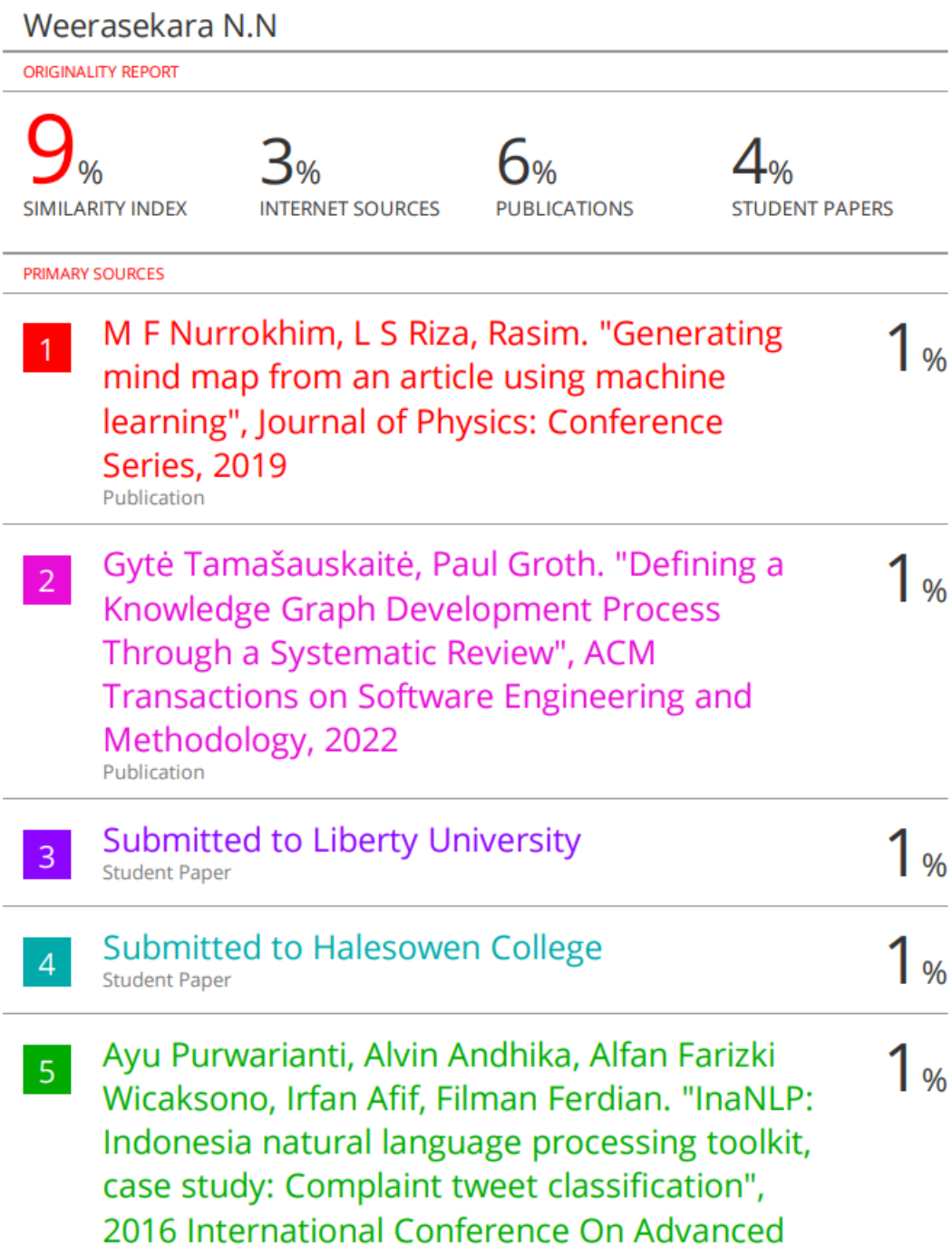


Figure 9 : Plagiarism Report