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

2023-035

Project Proposal Document

Senaweera T.I.S.

BSc. (Hons) Degree in Information Technology Specializing in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology,

Sri Lanka

February 2023

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

BSc. (Hons) Degree in Information Technology Specializing in Software Engineering

Department of Computer Science and Software Engineering,

Sri Lanka Institute of Information Technology,

Sri Lanka

February 2023

Author Details,

1. Author Name – **Senaweera T.I.S.**
2. Student ID No. – **IT20123468**
3. Research objective – Track and forecast student performance in a specific subject by combining platform-based metrics and Bloom's levels-based metrics.

Supervisor Details,

1. Supervisor Name – Mr 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 this proposal is my own work and this does not contain any material written by another person, except in places where acknowledged in the text. I assure that this document is not previously submitted for a degree or diploma in any other university.

Name	**Student ID**	**Signature**
Senaweera T.I.S	IT20123468	

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 high-quality and balanced exams for undergraduates that appeal to varied cognitive capabilities is an essential task. Bloom's taxonomy is a framework used by many university lecturers to accomplish this task and assess student performance. However, the majority of students are unaware of Bloom's Taxonomy and how it influences their learning experience. This lack of knowledge makes students struggle to understand the depth and complexity of a subject they are studying. As many university papers are created based on this framework, it is essential that a student should possess at least a basic knowledge about each level in Bloom's Taxonomy. Therefore, this presents a research problem as it raises questions about how undergraduate students can identify and understand their cognitive level as classified by Bloom's Taxonomy, and how they can develop the skills they need to advance to higher levels. To address this issue, a personalized self-study system can be implemented that guides students through the process of applying Bloom's Taxonomy to their learning. By incorporating Bloom's Taxonomy, students can identify areas where they may need to focus their efforts to achieve their learning goals. This system's primary goal is to assist students in doing self-studies with their study materials; as a secondary goal, it tracks students as they progress through Bloom's Taxonomy levels and predicts their future performance, which can help to improve self-studying in a variety of ways. Moreover, visualizing this data in a clear and understandable format provides students with a motivation factor to study and increases motivation to self-study.

Keywords: Student performance, Self-studying, Bloom's taxonomy, Statistical index, Forecasting.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

Abbreviation	**Description**
EDM	Educational Data Mining
LMS	Learning Management System
CNN	Convolutional Neural Networks
LSTM	Long Short-term Memory
ML	Machine Learning
FIS	Fuzzy Inference System
PSP	Predicting Student Performance

1. Introduction

Self-studying is very essential for university students to achieve academic success while also managing their personal life, jobs, and extracurricular activities. Many students do self-studies for hours and hours going through their study materials. Despite this, some students may still get lower grades for subjects than they anticipated. There can be many reasons for this, but through our research, we found that one of the main reasons may be that the student did not fully understand their study material and are unaware that the exam papers are made according to Bloom's Taxonomy, which is a framework for classifying objectives and goals in education. Bloom's Taxonomy separates learning objectives into six categories, ranging from low-level thinking abilities like remembering and understanding to high-level thinking skills like analyzing, evaluating, and producing. Unfamiliarity with Bloom's Taxonomy makes students focus solely on lower-level thinking abilities rather than developing higher-level thinking skills. The below figure includes data collected through a survey to show how many students are unaware of Bloom's Taxonomy.

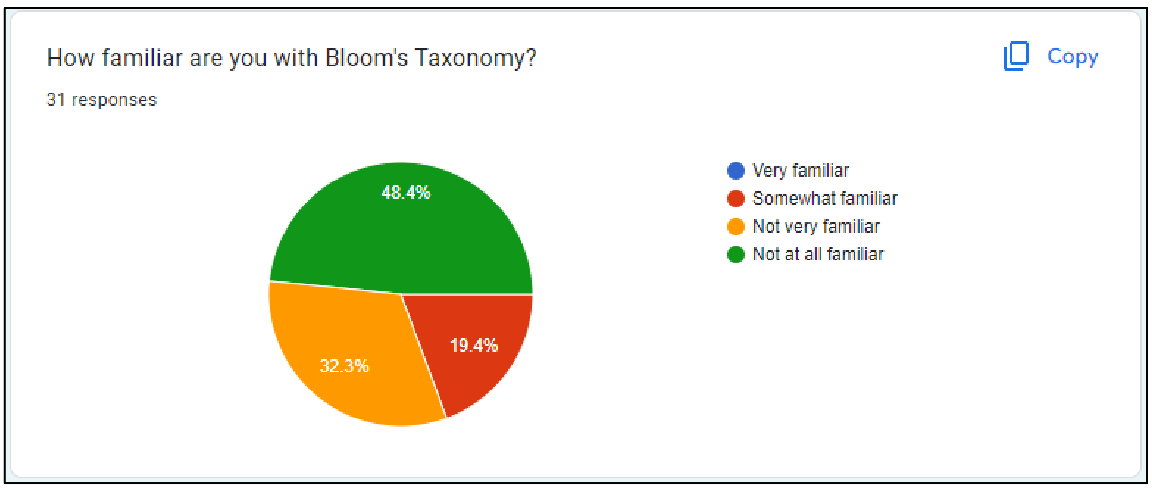


Figure 1: User responses on the awareness of Bloom's Taxonomy.

As a university student, having a way to track the performance level according to Bloom's taxonomy would be very helpful to identify areas where you have excelled and areas where you need to improve. This allows students to set achievable objectives for themselves and monitor their progress in achieving those goals. This component of the research provides students with a way to track and forecast their performance in a specific subject by combining platform-based metrics and Bloom's levels-based metrics.

Platform-based metrics, such as the number of visits to the specific subject page, total time spent on a single Q and A session and duration of interactions using the system provide quantitative data that can be used to track student performance. On the other hand, Bloom's levels-based metrics focus more on the cognitive processes involved in learning and can give information about how well a student is understanding the study material. By combining these metrics, students can gain a more holistic understanding of their performance. Moreover, forecasting future performances and having these details in a visualized manner gives students motivation factor to increase self-studying and work harder toward achieving the set goals.

1.1. Background and Literature Review

Predicting students' academic performance has been a popular research area among researchers and educators. Forecasting a student's success in a specific subject or course can assist instructors in developing more effective teaching tactics, identifying at-risk students, intervening proactively, and eventually improving student results.

Various traditional statistical techniques have been used to predict student performance over the years. However, recent advances in machine learning and data analytics have opened novel possibilities for modelling predictions in education, allowing researchers to develop more precise and reliable models capable of quickly and efficiently analyzing large amounts of data. Among these research, they have revealed that platform-based data can be a highly effective way of predicting student performance due to the vast amount of information that they offer about students' interactions with educational resources and materials. By analyzing this data, valuable insights into student behaviour and learning patterns can be gained to support students better.

Research done by Silvia Gaftandzhieva et al [1], has used educational data mining (EDM) methods, in predicting students' final marks based on Moodle activities in the Learning Management System (LMS) and participation in lectures sessions that were delivered via Zoom. To predict final marks, they have applied different machine learning and statistical techniques to the dataset. The dataset utilized is made up of 105 number of students who studied the Object Oriented Programming course at the University of Plovdiv from the academic year 2021 to 2022. The findings of the study demonstrate that the final grades of students are remarkably associated with their online activities, as well as their participation in lectures. And the Random Forest algorithm has outperformed the other three algorithms with a 78% accuracy rate.

Abdulaziz et al [2] conducted another study, which involved using platform-based metrics from an online Learning Management System (LMS). The metadata they have used is the number of views of the content of the course, the amount of student visits received to the course etc. A new model of deep learning was developed using the Convolutional Neural

Networks (CNN) algorithm and Long Short-term Memory (LSTM) algorithm to predict student performance. The researchers have used records of 35,000 students with seven features which are platform-based, for seven courses making the total size of the dataset to be 1,715,000. The mentioned model has been able to do the predictions with a precision score of 94.2% using the seven platform-based features.

In paper [3], through the use of LMS interaction data and machine learning (ML) models, Kiran et al focused on forecasting student performance in mixed-media educational settings. The authors highlighted that in order to achieve fundamental values that contribute to strategic goals and economic wellness in tertiary educational institutions, student attrition plays an important role. They emphasize that identifying at-risk students is a manual process and requires a lot of time and that it is better to identify struggling students early in order to offer them timely and effective support. The authors investigate the use of currently available ML approaches to identify at-risk students more quickly and effectively from a publicly available dataset gathered via student LMS interaction. The novel approach used in the study is it may encourage prompt engagement in the learning process, such as enhancing students' academic development. The findings demonstrate that the 85% accuracy of the random forest algorithm could assist teachers in implementing different educational techniques to enhance students' learning. The work shows the importance of employing ML approaches to predict student performance in blended learning contexts and offers implications for future research paths.

In a study conducted by Ajibade, Ahmad, and Shamsuddin [4] using EDM to predict student performance, they highlighted the need of incorporating behavioural data derived from student interactions with the LMS platform. The study showed that the accuracy of the predictive model improved significantly when behavioural or platform-based features were included. The proposed model achieved 84.2% accuracy with behavioural features, while it only reached 72.6% without these features. The results also suggest a strong correlation between students' behaviour in the LMS platform and their academic performance.

Another study in the paper [5], shows how most studies using neural networks have focused on predicting performance based on student scores, without considering the use of the LMS data. As a result, this study made an effort to forecast 3518 university students' performance using artificial neural networks. The study examined the contributions of various variables taken from the LMS. According to the study, their model has been able to show a high accuracy rate of 80.47%. These findings suggest that artificial neural networks can be effective in predicting student performance, with a focus on specific variables related to the use of LMS.

Research done by Tamada M et al [6] have used seven machine learning algorithms to detect high risk students studying two years long course at a high school. They have used registration data as well as records from the LMS. They discovered that student interactions with surveys on the LMS platform were the most relevant element in predicting student achievement and that starting grades were the most important variable. The results revealed that the Random Forest algorithm outperformed the other seven algorithms tested.

While it is undoubtedly true that platform-based metrics play an important role in predicting student performance, it is essential not to overlook the significance of having a standard metric in place to evaluate a student's level of understanding. This is because relying solely on platform-based metrics may not provide a complete understanding of a student's abilities and limitations. A standardized test or placement exam can help to provide a more holistic view of a student's academic capabilities and be used in conjunction with platform-based metrics to make more accurate predictions of their overall performance. It is also worth noting that the use of a standard metric can help to ensure consistency in performance predictions across different courses or educational institutions, facilitating more meaningful comparisons and analyses. As such, it is imperative to consider both platform-based metrics and standard metrics when attempting to predict student performance.

To address this, a study done by Dr. G. N. R. Prasad [7], has used Bloom's taxonomy as a tool to assess student performance and to gather information about their level based on Bloom’s taxonomy. The researcher has given a computer-based assessment to students to evaluate critical thinking skills. In this literature review, a question paper was given using each level of Bloom's taxonomy, and the results of student performance were evaluated through online testing.

V.B. Deshmukh et al [8] conducted another study in which they used a fuzzy logic-based model to evaluate a student's performance at different Bloom's levels. The model has been purposed to be used in evaluating the performance of third-semester Electronics and Communication Engineering students in their Network Analysis course, using a Mamdani Fuzzy Inference System (FIS). The model is designed to analyze various factors and provide a comprehensive evaluation of student performance in this particular course. Furthermore, the study emphasizes the importance of identifying students’ strengths and weaknesses according to each level in Bloom’s Taxonomy.

[9] This study addresses predicting student performance (PSP) utilizing individualized forecasting approaches that consider the sequential effect of PSP. The existing PSP prediction literature primarily focuses on classic techniques such as linear regression and logistic regression. This study proposes a new approach that uses historical information of individual students to forecast their own performance and incorporates the "student effect/bias" and "task effect/bias" into the models. The results reveal that the proposed approach performs well and is significantly faster than the current PSP methods. This

research contributes to the educational data mining field by providing a more accurate and personalized approach to PSP prediction, which could replace some current standardized tests and save students' time and effort.

Jie Xu et al [10] conducted a study to track undergraduate students and predict their performance during the degree program. They suggest a novel method using machine learning, addressing three key challenges they identified. The proposed method utilizes a bi-layered structure and an approach driven by data based on latent factor models and also probabilistic matrix factorization to identify course relevance. The dataset used is data collected from undergraduate students at the University of California, Los Angeles for over three years. The proposed method has been able to show excellent performance through a thorough stimulation done using the mentioned dataset.

1.2. Research Gap

According to the above literature review, predicting students' performance has been a topic of great interest and extensive research in the field of education. Many researchers have invested their time and effort in exploring various factors that can affect students' academic performance. It has been widely acknowledged that predicting students' performance can provide valuable insights to educators and policymakers. By identifying at-risk students and providing them with additional support, dropout rates can be reduced, and academic achievement can be enhanced. Thus, researchers continue to investigate and develop effective methods for predicting students' academic performance.

Most of the discussed research studies predict students’ academic performance for the convenience of university decision-makers or higher education providers [1],[2],[3]. The studies mentioned in the literature review are primarily concerned with predicting two things: the final grade a student will receive for a subject or course, and whether the student will successfully complete the course or program without dropping out prematurely. Furthermore, few studies have used a standard metric such as Bloom's Taxonomy to assess student performance [7], [8]. And studies like [9], only use an individual student's historical data in predicting or forecasting their own performance.

Based on this, it appears that none of the studies mentioned have developed systems or tools that individual students can use to predict their own academic performance. Instead, these studies are focused on providing insights and predictions to educators and decision-makers within the university or higher education provider.

As a result, the presented literature reveals a research gap, that there are no methods or tools exist for students to forecast their own academic achievements. This emphasizes the need for a tool that students can utilize to improve their academic performance and get aid in reaching their academic goals.

The primary difference between this proposed project and other research is that it focuses on forecasting performance by determining the student's level based on Bloom's taxonomy. Then, platform-based and Bloom's levels-based metrics will be used to forecast the performance for the convenience of students.

Table 1: Research gap.

Characteristic	Paper [1]	Paper [2]	Paper [3]	Paper [7]	Proposed Research Project
Use platform engagement metrics.	✓	✓	✓	✗	✓
Identify the Bloom's level.	✗	✗	✗	✓	✓
Forecast student performance.	✗	✗	✗	✗	✓
Visualization of performance.	✗	✗	✗	✗	✓
Focused on students.	✗	✗	✗	✗	✓

1.3. Research Problem

Self-studying is very essential when it comes to achieving good grades. It is a learning style in which students take care of their own studies outside of the classroom and without direct supervision. Students are expected to take responsibility for their education by actively seeking knowledge outside of the classroom, especially when they study at university. It can help students to be more independent and self-reliant, which is an important skill to have in the professional world. However, self-studying can be difficult for many university students, especially for those who have trouble managing their time or staying focused. These students require personal assistance in order to be motivated to overcome difficulties and do self-study.

The current educational system fails to provide students with this kind of personalized learning experience. This raises the research question of “How to provide a method for students to track and forecast their performance in a specific subject according to a standard metric used in the education sector?”

One potential solution to this issue is the development of a system that tracks students' progress using Bloom's taxonomy framework. It is a widely used framework, especially in universities for categorizing educational goals into six cognitive complexity levels: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. This system tracks student progress across each level of Bloom's taxonomy, providing students with a better understanding of their strengths and weaknesses in different areas of cognitive development. This will enable them to focus their efforts on areas where they need improvement.

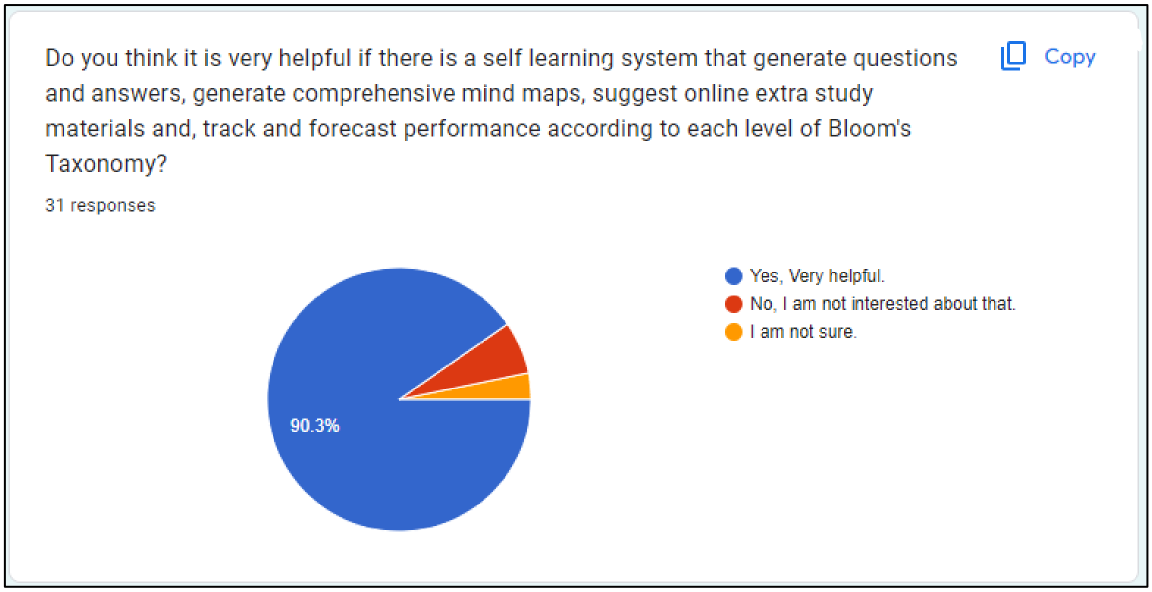


Figure 2: User responses on having a self-study help system.

Moreover, the system will generate a statistical index that can be used to forecast student performance. Then, to motivate students to improve their performance, use graphs and charts to visualize their progress. When students are able to see how their efforts are directly affecting the improvement in their performance, it will provide them with a motivation factor to be more committed to their learning goals. By presenting data in this way, students can track their progress over time and gain a better understanding of their performance across different levels of Bloom's taxonomy.

In summary, the proposed system will address the gap in personalized learning experiences by providing students with a tool to track their progress, forecast their performance, and visualize their data in a clear and understandable format. Thereby, giving students a more personalized and effective learning experience.

2. Objectives and The Sub Objective

The primary objective is to create a customized self-study system to help undergraduate students. However, rather than simply being a self-study system, the uniqueness of this system is, it takes students' study materials. It also assists them in determining their success in a specific subject based on Bloom's Taxonomy levels. 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.

The sub-objective discussed in this document is to track and forecast student performance in a specific subject by combining platform-based metrics and Bloom's levels-based metrics. Through this, students will be given insights into their performance, allowing them to identify areas of strength and weakness and take steps to improve student learning outcomes through chart visualizations. The ultimate goal is to improve student learning outcomes by providing them with a motivation factor to do self-studies.

3. Functional Requirements and Non-Functional Requirements

3.1. Functional Requirements

Functional requirements play a very important role in software development. They are the features or functions of a product. And the developers have to implement them in the system for users to complete specific tasks. Given below are some key functional requirements of the proposed self-study system,

1. Users should be able to create a "Subject Page" for each subject they want to study.
2. Users should be able to upload their study materials to a particular subject page via the application.
3. The system should be able to generate a set of questions and answers for a given study material and categorize them according to each level of Bloom's Taxonomy.
4. The system should be able to retrieve relevant platform-based data and Bloom's taxonomy-based data of each student for analysis.
5. Bloom's level calculation using Q & A scores and EWMA formula.
6. The system should calculate the students' performance using the developed statistical index calculation method.
7. The system should be able to track students' performance for each level of Bloom's Taxonomy for a subject and forecast and visualize the progress in the dashboard.

3.2. Non-Functional Requirements

Specifications that define the operational capabilities, limitations of a system and the attempt to improve its functionality are the Non-functional requirements. Below are some non-functional requirements to be focused on when developing the proposed system,

1. Availability – Ability to use the system at a given time.
2. User Experience: Designed in a way that is visually appealing and engaging, while also being easy to interpret.
3. Usability: Easy to use and navigate, with a clear and intuitive interface that allows users to access the information they need quickly and easily.
4. Performance Standards: Meet specific performance standards for response time, throughput, and other metrics to ensure that it is delivering reliable and consistent results.
5. Security – Safeguards the user information and ensures the networks and resources are safe from malicious intrusion.

4. Methodology

The proposed component is to identify and track the status of each Bloom's level for a student. And construct a statistical index to predict a student's future performance in a certain subject.

4.1. Identify a Student's Current Performance Level.

A system functionality will be developed so that at the beginning a student must create a subject where the specific study material related to that subject can be added. After facing the Question paper generated from the study material uploaded, a student's performance status for each level of Bloom's taxonomy can be tracked using scores of questions.

Levels in Bloom Taxonomy :

Remembering,

Understanding

Applying

Analyzing

Evaluating and Creating

When calculating the status for each level of Bloom's, an Exponentially weighted moving average (EWMA) will be used instead of simply taking the average. By using EWMA more weight can be given to recent data and less weight to older data, which makes it more responsive to changes in the underlying data.

Sample Calculation:

Table 2: Sample percentages to calculate the "Remembering" level performance.

Session	**"Remembering" level correct answers %**
1	80%
2	60%
3	60%

To calculate the EWMA for the given data,

EWMA formula = $Y_t = \alpha * X_t + (1-\alpha) * Y_{t-1}$

alpha = 0.2

The EWMA value will be the simple moving average of the first data point is:

EWMA(1) = 80%

For the second data point :

EWMA(2) = alpha * 60% + (1 - alpha) * 80% = 68%

For the third data point :

EWMA(3) = alpha * 60% + (1 - alpha) * 68% = 64.4%

Therefore, the EWMA for the given data is:

80%, 68%, 64.4%

To calculate the average score for "Remembering", we can simply take the arithmetic mean of three EWMA scores:

(80% + 68% + 64.4%) / 3 = 70.8%

An overall level will be calculated on a scale of 0 to 100 based on two types of variables.

1. Platform-based metrics.
2. Bloom’s levels-based metrics.

Due to the unavailability of a labelled data set to train a supervised learning model, a statistical index will be generated as a way to tackle the cold start problem.

To validate the generated index value a model with a similar dataset (LMS based) will be used.

Once the system is up and running this index can be modified or updated according to the data collected from the system.

4.2. Forecasting the Student’s Performance.

The index value can be calculated daily or weekly for each student in the system for a specific subject. Once a couple of indexes are collected a forecasting method such as a time series analysis or a machine learning model can be used to predict future changes in the index.

4.3. Visualizing.

A progress bar chart visualization will be used to present the EWMA averages calculated for each level of Bloom's Taxonomy, which can be created using ReactJS and visual charting libraries such as Recharts or Victory. In addition, the final score is displayed on a gauge chart, which provides a clear visual depiction of the student's performance on the topic.

The purpose of chart visualization is to provide a clear and understandable representation of the student's performance in various areas of the subject. Students can quickly and easily see their overall performance as well as how they are performing in each level of Bloom's Taxonomy by presenting the data in a visual format. This method can assist students in identifying areas where they may need to improve their understanding and directing their efforts toward those areas.

Visualization can be tailored to specific needs and preferences by using ReactJS and charting libraries such as Recharts or Victory. This can include chart type, colour schemes, and other design elements to ensure that the visualization is engaging and simple to understand.

4.4. Component Overview Diagram.

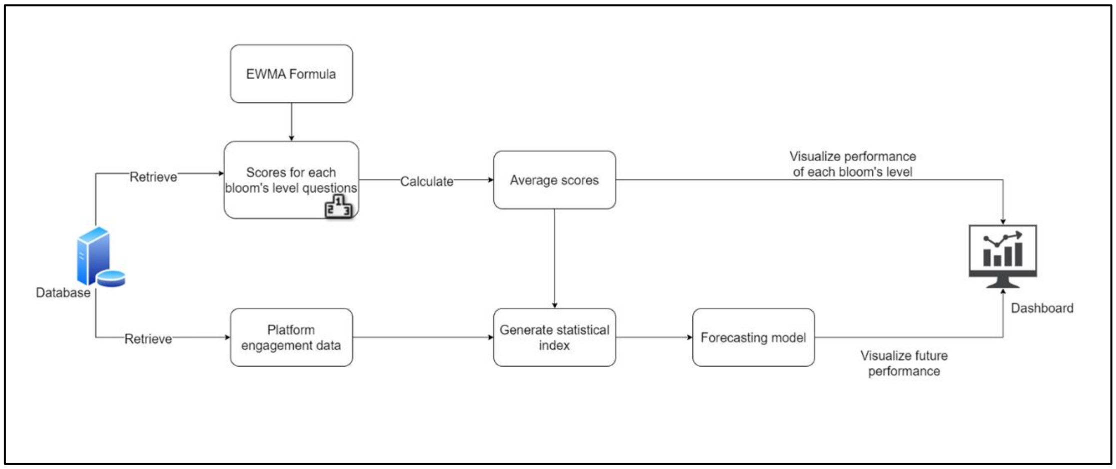


Figure 3: Component overview diagram.

4.5. System Overview Diagram.

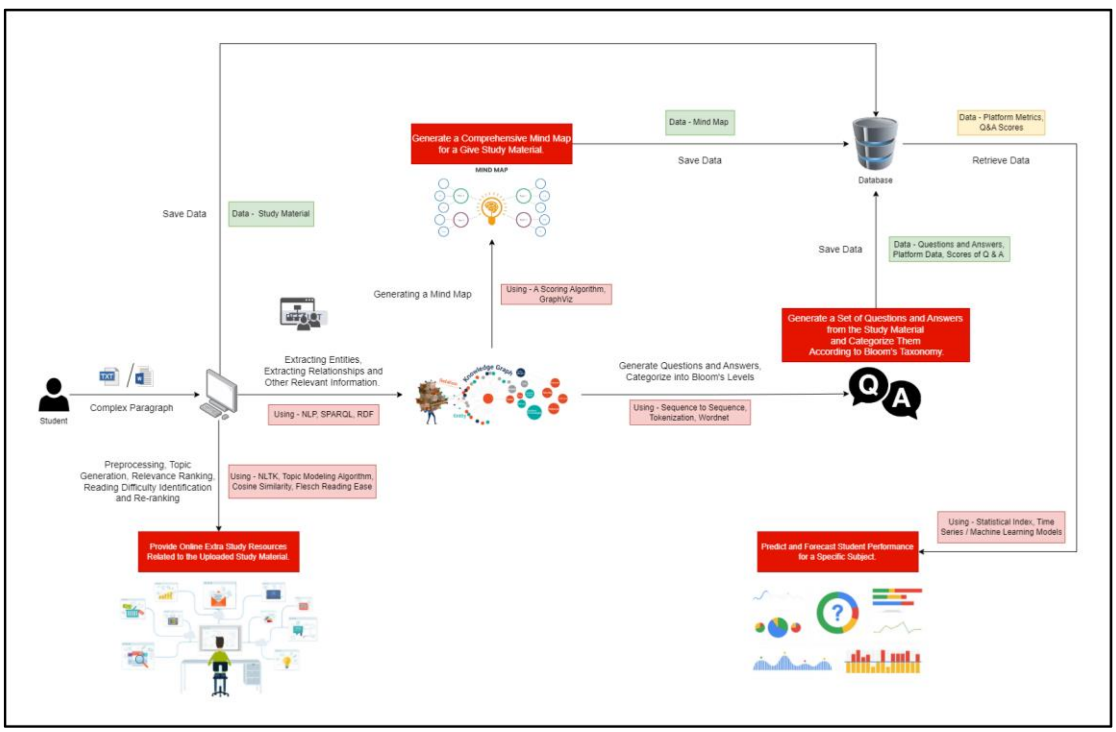


Figure 4: System overview diagram.

4.6. Work Breakdown Structure.

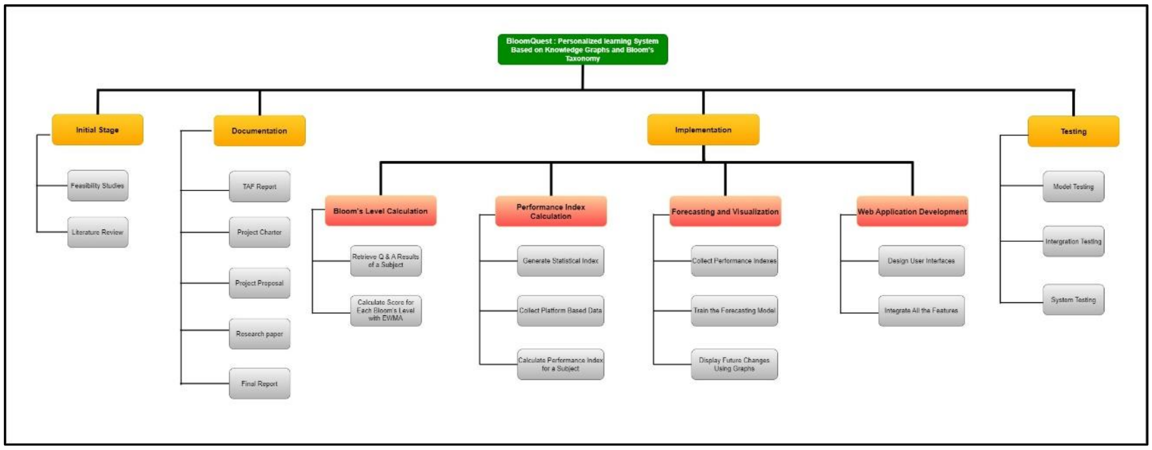


Figure 5: Work breakdown structure.

4.6. Test Plan

Having a good test plan is essential when developing a component that predicts student performance. This is because the accuracy and reliability of the predictions made by the component have a significant impact on the effectiveness of the overall system. It provides assurance to users that the system is dependable and trustworthy, which is essential in any educational setting. Overall, a thorough test strategy is required to guarantee the successful creation and implementation of an accurate and efficient student performance prediction component.

Table 3: Test plan of the component.

Test Type	Test Description
Unit Testing	Verify the correct calculation of EWMA for each level of Bloom's taxonomy.
	Verify the correct calculation of the overall level based on platform-based metrics and Bloom's levels-based metrics.
	Verify component is retrieving the correct data of each student.
	Verify the charts are visualizing the correct performance data.

Integration Testing	Verify that the system functionality developed to identify a student's current performance level is integrated correctly with the specific subject and the student's account.
	Verify that the statistical index is generated correctly, and the predicted performance is reasonable.
	Verify that the time series analysis or machine learning model used to forecast the student's performance is integrated correctly with the statistical index.
System Testing	Verify that the system is user-friendly and easy to navigate for students.
	Verify that the system provides accurate and timely performance data to students.
	Verify that the system is secure and protects the privacy of student data.

5. Commercialization

The proposed component has a lot of potential to be commercially successful. It can bring many benefits to its users, the individual learners. With the help of this component, students can monitor their development and pinpoint their areas for growth. One unique selling point of this component is its ability to generate a statistical index that predicts a student's future performance. This feature can be marketed as an essential tool to identify potential academic challenges before they become major issues. By providing regular feedback on progress and areas of weakness, this tool can help learners improve their performance and achieve better grades.

Additionally, the proposed component's visualization features deserve attention. The usage of gauge charts and progress bar charts can offer a clear visual depiction of performance, making it simpler for students to comprehend and keep track of their progress. The ability to measure their development in an easy-to-understand manner can increase student engagement and motivation.

The business potential of this component can be realized through a subscription-based service model, which is affordable and accessible to a broad range of users. Revenue generated from subscriptions can be used to further develop the component and improve its functionality and user experience.

In conclusion, the proposed component has a good chance of being commercialized because it can enhance academic performance, provide distinctive features, and be offered as a subscription-based service to students. It is a useful tool that can be very helpful because it is centred on improving academic performance.

6. Gantt Chart

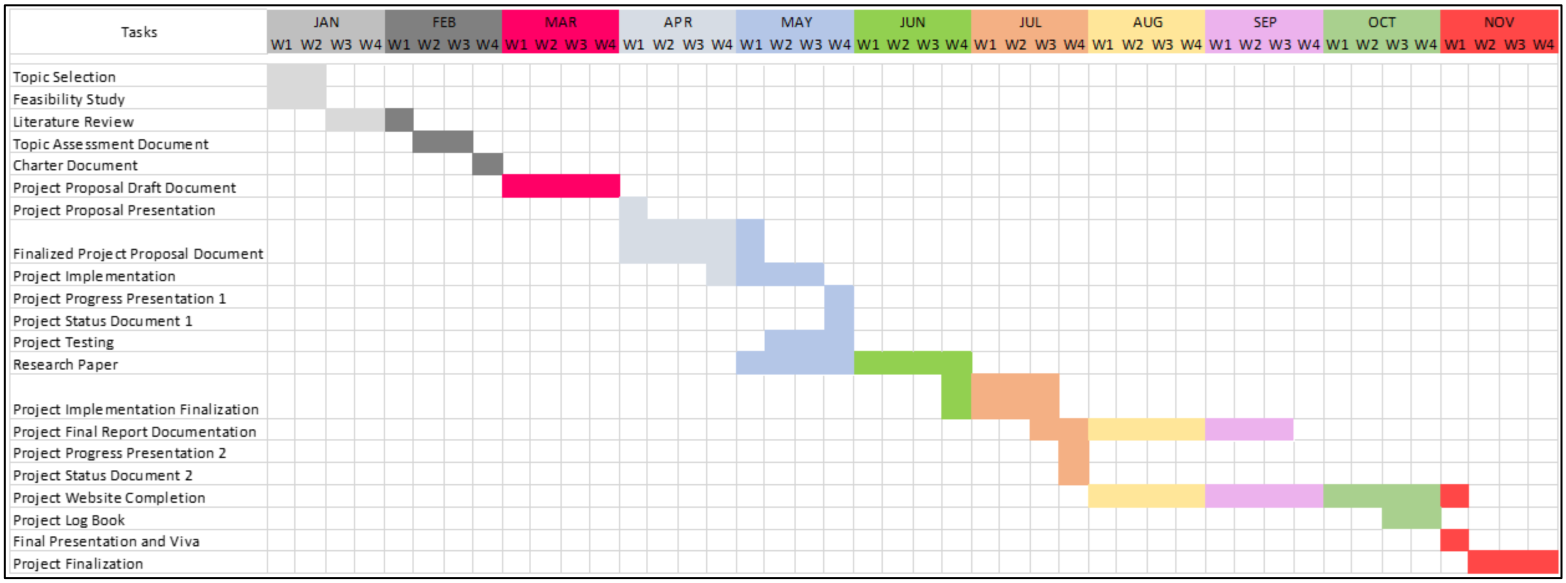


Figure 6: Gantt chart.

7. References

[1] S. Gaftandzhieva *et al.*, "Exploring Online Activities to Predict the Final Grade of Student," *Mathematics*, vol. 10, no. 20, Oct. 2022, doi: 10.3390/math10203758.

[2] A. S. Aljaloud *et al.*, "A Deep Learning Model to Predict Student Learning Outcomes in LMS Using CNN and LSTM," *IEEE Access*, vol. 10, pp. 85255–85265, 2022, doi: 10.1109/ACCESS.2022.3196784.

[3] K. Fahd, S. J. Miah, and K. Ahmed, "Predicting student performance in a blended learning environment using learning management system interaction data," *Applied Computing and Informatics*, 2021, doi: 10.1108/ACI-06-2021-0150.

[4] S. S. M. Ajibade, N. B. Ahmad, and S. M. Shamsuddin, "A data mining approach to predict academic performance of students using ensemble techniques," in *Advances in Intelligent Systems and Computing*, Springer Verlag, 2020, pp. 749–760. doi: 10.1007/978-3-030-16657-1_70.

[5] Ş. Aydoğdu, "Predicting student final performance using artificial neural networks in online learning environments," *Educ Inf Technol (Dordr)*, vol. 25, no. 3, pp. 1913–1927, May 2020, doi: 10.1007/s10639-019-10053-x.

[6] M. M. Tamada, R. Giusti, and J. F. De Magalhaes Netto, "Predicting Student Performance Based on Logs in Moodle LMS," in *Proceedings - Frontiers in Education Conference, FIE*, Institute of Electrical and Electronics Engineers Inc., 2021. doi: 10.1109/FIE49875.2021.9637274.

[7] G. N. R. Prasad, "Evaluating student performance based on bloom's taxonomy levels," in *Journal of Physics: Conference Series*, IOP Publishing Ltd, Mar. 2021. doi: 10.1088/1742-6596/1797/1/012063.

[8] V. B. Deshmukh, S. R. Mangalwede, and D. H. Rao, *Student Performance Evaluation Model Based On Bloom's Taxonomy Using Fuzzy Logic*. 2018. [Online]. Available: https://www.researchgate.net/publication/325059889

[9] N. Thai-Nghe, T. Horváth, and L. Schmidt-Thieme, "Personalized forecasting student performance," in *Proceedings of the 2011 11th IEEE International Conference on Advanced Learning Technologies, ICALT 2011*, 2011, pp. 412–414. doi: 10.1109/ICALT.2011.130.

[10] J. Xu, K. H. Moon, and M. Van Der Schaar, "A Machine Learning Approach for Tracking and Predicting Student Performance in Degree Programs," *IEEE Journal on Selected Topics in Signal Processing*, vol. 11, no. 5, pp. 742–753, Aug. 2017, doi: 10.1109/JSTSP.2017.2692560.

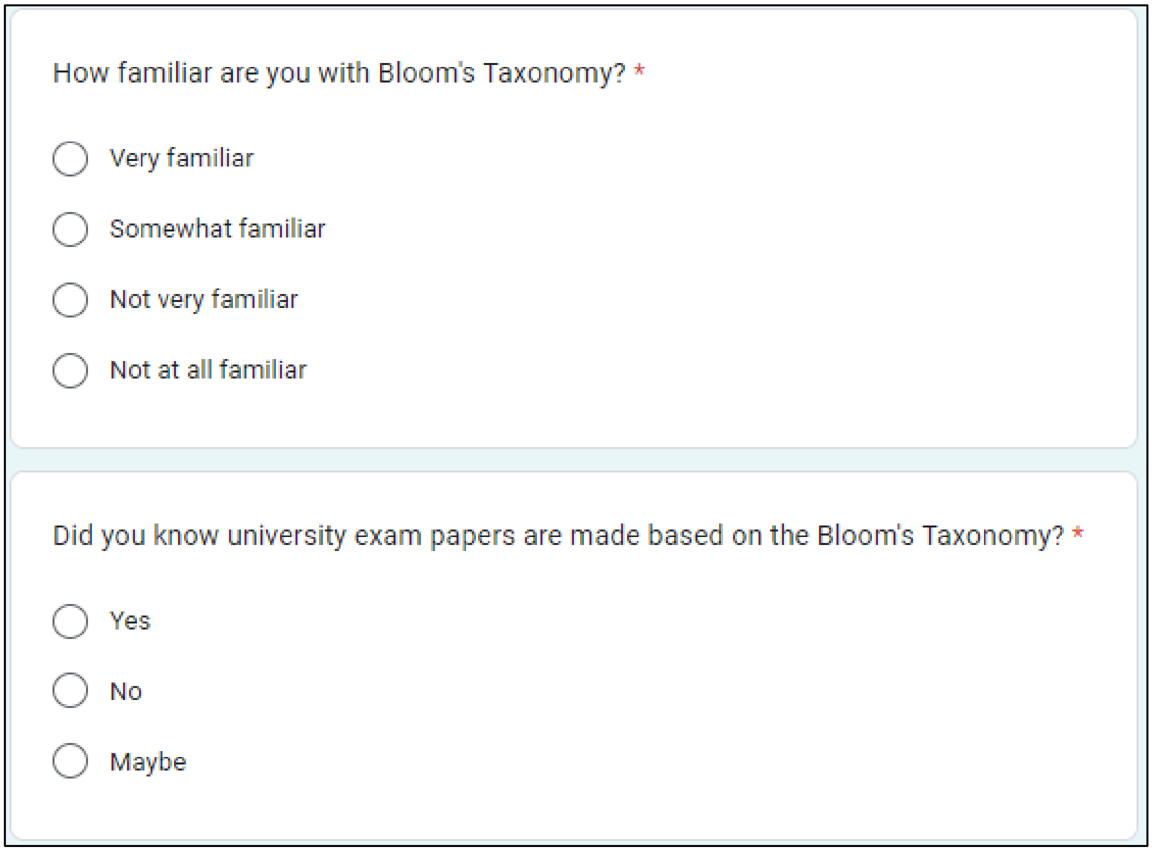
8. Appendix

8.1. Questionnaire

A survey was conducted to gather information on self-study habits and familiarity with Bloom's Taxonomy among undergraduate students. Give below are the questions and the answers to the mentioned survey questionnaire.

Link - https://forms.gle/wq6WL89q8VVt5Gsy7

Questions,


How familiar are you with Bloom's Taxonomy? *

- Very familiar
- Somewhat familiar
- Not very familiar
- Not at all familiar

Did you know university exam papers are made based on the Bloom's Taxonomy? *

- Yes
- No
- Maybe

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?

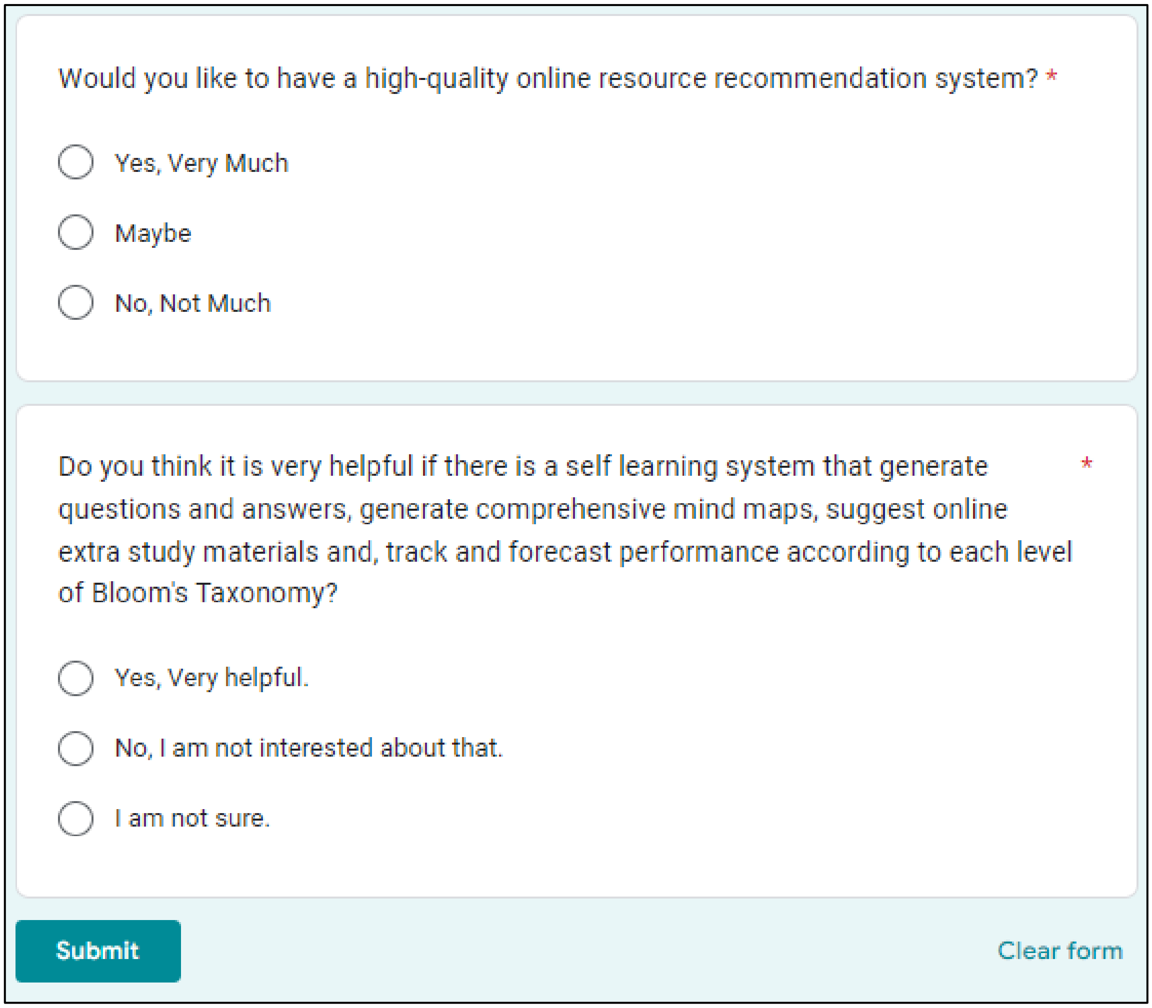
- Very satisfied
- Somewhat satisfied
- Neutral
- Somewhat dissatisfied
- Very dissatisfied

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



Would you like to have a high-quality online resource recommendation system? *

- Yes, Very Much
- Maybe
- No, Not Much

Do you think it is very helpful if there is a self learning system that generate questions and answers, generate comprehensive mind maps, suggest online extra study materials and, track and forecast performance according to each level of Bloom's Taxonomy? *

- Yes, Very helpful.
- No, I am not interested about that.
- I am not sure.

Submit

Clear form

Figure 7: Questions in the questionnaire.

Responses,

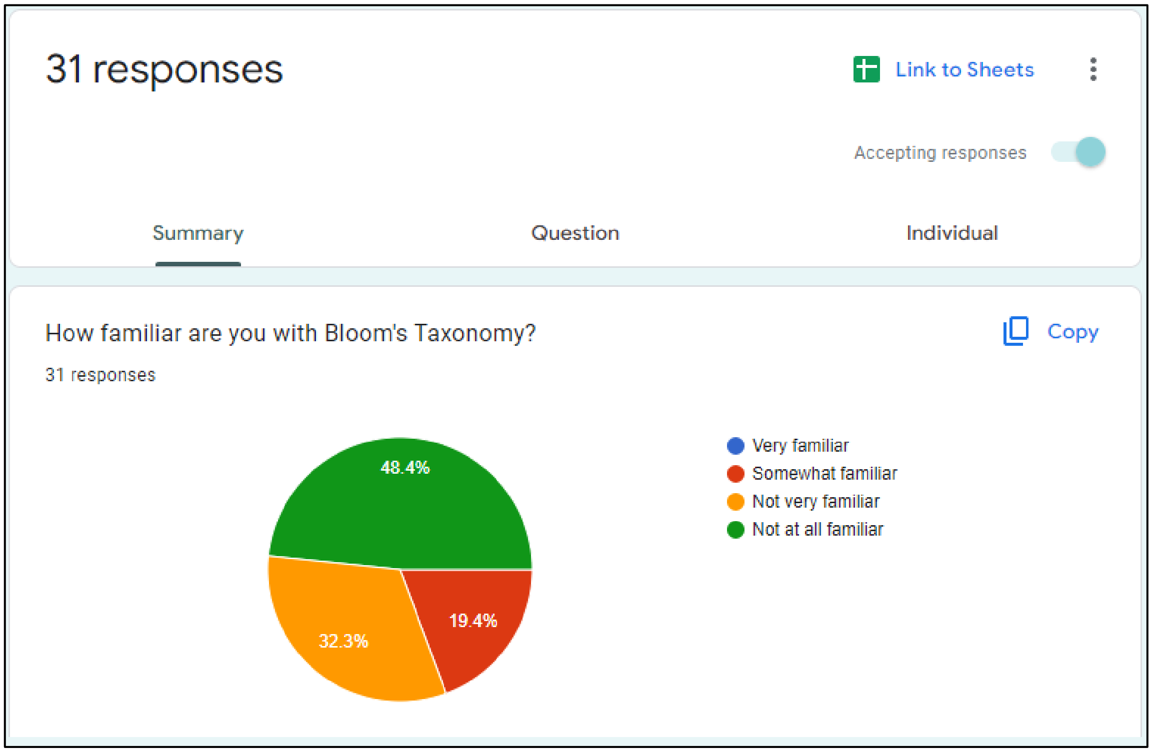
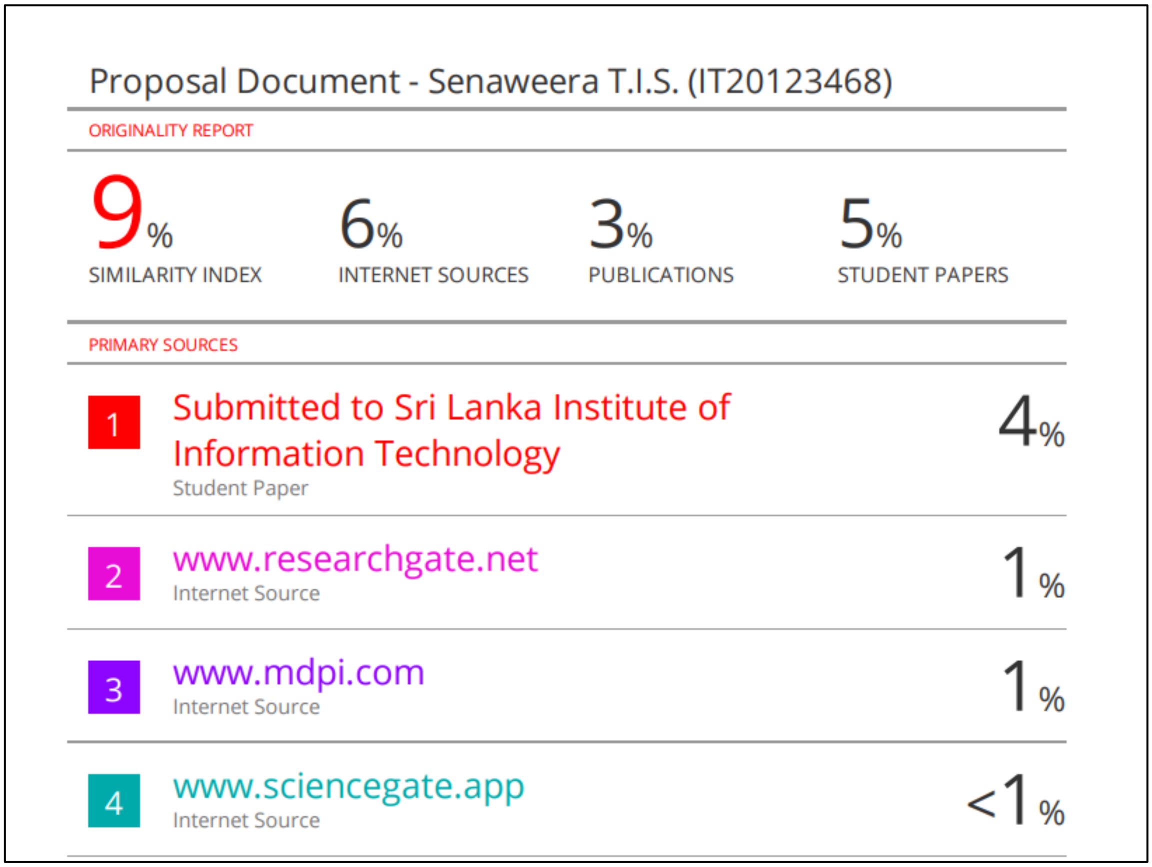


Figure 8: Responses to the questionnaire.

8.2. Plagiarism Report



Proposal Document - Senaweera T.I.S. (IT20123468)

ORIGINALITY REPORT

9%	6%	3%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Sri Lanka Institute of Information Technology Student Paper	4%
2	www.researchgate.net Internet Source	1%
3	www.mdpi.com Internet Source	1%
4	www.sciencegate.app Internet Source	<1%

Figure 9: Plagiarism report.