IT4010 – Research Project - 2023

Topic Assessment Form

Project ID : TMP-23-035

1. Topic (12 words max)

BloomQuest - Personalized Learning System Based on Knowledge Graphs and Bloom's Taxonomy.

2. Research group the project belongs to

Knowledge Inspired Computing (KIC)

3. Research area the project belongs to

Natural Language Processing (NLP)

4. If a continuation of a previous project:

Project ID	-
Year	-

5. Team member details

Student Name	Student ID	Specialization
Leader: Wijayasena W.D.N.D.T	IT20133368	DS
Member 2: Senaweera T.I.S	IT20123468	SE
Member 3: Weerasekara N.N	IT20133504	DS
Member 4: Colambage K.G	IT20126438	DS

6. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

It is crucial to create balanced and high-quality exams to undergraduates that caters to various cognitive levels. As a result, lecturers rely on **Bloom's Taxonomy** cognitive domain, a popular framework developed to assess students' intellectual abilities and skills [1]. 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. To address this issue, **a personalized self-learning system** that helps students understand and apply Bloom's Taxonomy in their own learning process can be implemented.

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 [2].

Many undergraduate students find it difficult to advance above the lower levels of the taxonomy (such Remembering and Understanding) and into the higher levels (such as Analyzing, Evaluating, and Creating). This means that instead of exhibiting a deeper comprehension of the subject and its ramifications, how they approach exams may be limited to mere memory and description.

Therefore, this presents a research problem as it raises questions about how the 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 the higher levels. By addressing this research problem, we can create educational environments that better support student learning and development, leading to more effective and efficient learning outcomes.

Main References:

[1] R. P. Vadhera, “Impact of Training of Teachers in Bloom’s Taxonomy on Question-Paper Setting,” International Journal of Science and Research, vol. 10, no. 9, Sep. 2021, doi: 0.21275/SR21919043527.

[2] V. Pant, S. Bhasin and S. Jain, "Self-learning system for personalized e-learning," 2017 International Conference on Emerging Trends in Computing and Communication Technologies (ICETCCT), Dehradun, India, 2017, pp. 1-6, doi: 10.1109/ICETCCT.2017.8280344.

[3] H. Ali, Y. Chali, and S. A. Hasan, “Automatic Question Generation from Sentences,” 2011.

[4] A. Saha, V. Pahuja, M. M. Khapra, K. Sankaranarayanan, and S. Chandar, “Complex Sequential Question Answering: Towards Learning to Converse Over Linked Question nswer Pairs with a Knowledge Graph,” 2018. [Online]. Available: www.aaai.org.

[5] M. Peer, I. K. Brunec, N. S. Newcombe, and R. A. Epstein, “Structuring Knowledge with Cognitive Maps and Cognitive Graphs,” 2020.

[6] V. Bradáč, P. Smolka, M. Kotyrba, and T. Průdek, “Design of an Intelligent Tutoring System to Create a Personalized Study Plan Using Expert Systems,” Applied Sciences (Switzerland), vol. 12, no. 12, Jun. 2022, doi: 10.3390/app12126236.

[7] G. Sedrakyan, J. Malmberg, K. Verbert, S. Järvelä, and P. A. Kirschner, “Linking learning behavior analytics and learning science concepts: Designing a learning analytics dashboard for feedback to support learning regulation,” Comput Human Behav, vol. 107, Jun. 2020, doi: 10.1016/j.chb.2018.05.004.

[8] M. Mohammedid and N. Omar, “Question classification based on Bloom’s taxonomy cognitive domain using modified TF-IDF and word2vec,” PLoS One, vol. 15, no. 3, 2020, doi: 10.1371/journal.pone.0230442.

[9] S. Ullrich and M. Geierhos, “Using Bloom’s Taxonomy to Classify Question Complexity,” 2021.

7. Brief description of the nature of the solution including a conceptual diagram (250 words max)

For students to understand their current level in terms of Bloom's Taxonomy and work toward fulfilling the benchmark expectations, a personalized self-learning system can be quite beneficial. A system like this would offer a customized educational experience that takes into consideration each student's learning preferences, shortcomings, and abilities.

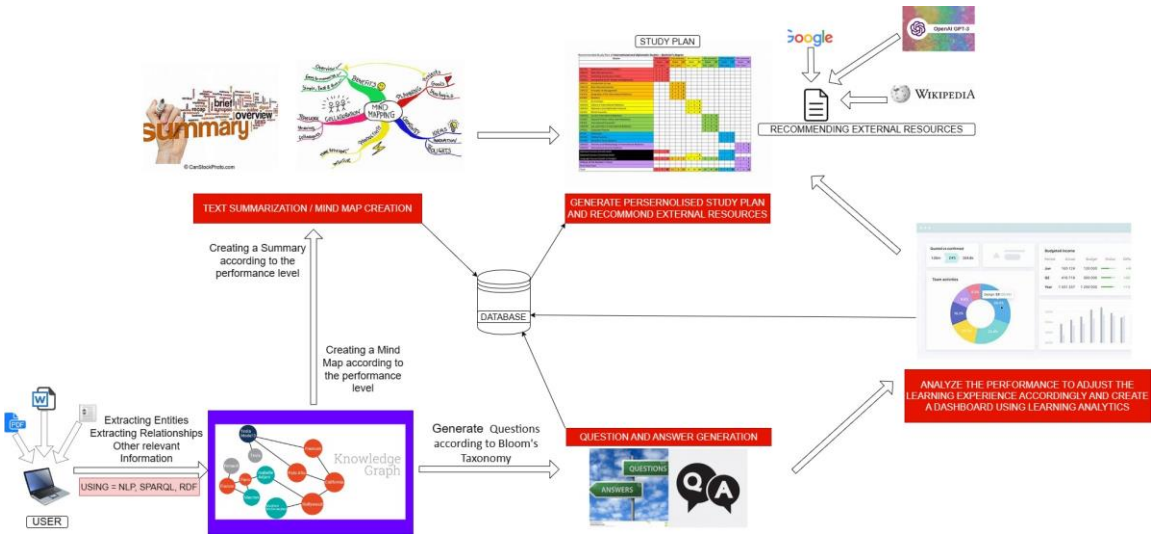
The system may take a student's study material then constructs a knowledge graph by extracting named entities and relations between the entities from material. Knowledge graphs is an extension of semantic nets, which represent knowledge in the form of interconnected nodes and arcs, where nodes represent 'objects' or 'concepts' and the arcs or edges represent the interaction or relations between them.

Then the system will utilize this knowledge to,

1. Generate a set of questions and answers using the knowledge graph and categorize them according to bloom's taxonomy [3], [4],
2. Create a comprehensive mind map which changes dynamically according to the performance level [5],
3. Generate personalized dynamic study plan and recommend external resources according to the performance level [6],
4. Analyze the performance level to adjust the learning experience accordingly and create a dashboard using learning analytics [7].

Because of this, students can become more self-directed and motivated learners, and they can produce high-quality work that meets and exceeds university expectations.

As explained, it is expected to consolidate all the above-mentioned functionalities under a single platform and to present an effective solution that is equipped to fulfill the mentioned research gap.



8. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

Domain Expertise in Education and Cognitive Psychology: To build a system that accurately categorizes student performance, it is important to have a deep understanding of the educational and psychological theories and concepts that underlie Bloom's Taxonomy.

Knowledge of Machine Learning and Artificial Intelligence: To build a personalized self-learning system, expertise in machine learning and artificial intelligence is necessary. This includes knowledge of algorithms for natural language processing, information retrieval, and data analysis.

Data on Performance Analytics: To build a system that accurately categorizes student performance, data on students' past performance is necessary. This data can come from questions categorized according to Bloom's Taxonomy.

Expertise in Data Management and Analysis: To build a system that can categorize student performance based on large amounts of data, expertise in data management and analysis is necessary. This includes knowledge of database management, data visualization, and statistical analysis techniques.

Knowledge of User Experience Design: To build a system that is user-friendly and effective, it is important to have expertise in user experience design. This includes knowledge of interface design, usability testing, and user research methods. Data Requirements:

Date requirements: To train the model, publicly available datasets will be used.

9. Objectives and Novelty

Main Objective

Develop a personalized self-learning system to help undergraduate students understand their current level in terms of Bloom's Taxonomy to work efficiently and effectively by utilizing student materials and building a knowledge graph that integrates information on the students' learning progress and performance.

Member Name	Sub Objective	Tasks	Novelty
Weerasekara N.N	Create a comprehensive mind map which changes dynamically according to the performance analytics.	Generate a knowledge graph from the study material provided by the student: • The knowledge graph would represent the concepts, ideas, and relationships between them in the study material. • This could be done using Natural Language Processing (NLP) techniques like Named Entity Recognition (NER), Dependency Parsing, and Coreference Resolution to extract relevant entities and their relationships from the text. Identify the key knowledge that needs to be summarized and represented in the mind map: • This could be done by analyzing the graph to identify the most important concepts and relationships between them. • The key knowledge could also be determined based on the learning objectives or the performance goals for the student.	Effective and efficient self-learning using mind-mapping as a learning tool to automatically create mind map to summarize the study material as a cognitive visualization of knowledge stored in the knowledge graph. No current self-learner system provides a mind-map which summarizes the study material as a cognitive visualization.

		Build a model that can transfer the text summary of the key knowledge to a visualization-based summarization (mind map): • This model could use techniques like Graph Neural Networks (GNNs) to analyze the knowledge graph and generate a summary in the form of a mind map. • The mind map could be dynamic, updating in real-time based on the student's performance analytics.	
Colambage K.G	Generate a set of questions and answers using knowledge graph and categorize them according to bloom's taxonomy.	Use SPARQL queries to retrieve relevant information from the knowledge graph: • This can be done by formulating queries that extract information related to specific topics or concepts within the study material. • The retrieved information can then be used to generate questions and answers. • Build a natural language processing (NLP) model which trained on the retrieved information. The NLP model will be able to generate grammatically correct and meaningful questions and answers based on the information provided to it. Categorize the questions according to Bloom's taxonomy:	In this research, questions that categorize for the bloom's taxonomy are not pre-build questions. The system will generate questions utilizing student own materials and categories them according to bloom's taxonomy and then provide to the student. Here the questions generated are categorized according to bloom's taxonomy level. This kind of categorization of

		• Once questions and answers are generated, the next step is to categorize them according to Bloom's taxonomy. • This can be achieved by building a classification model that can identify the level of cognitive complexity required to answer a given question. • The model will be able to categorize questions into one of the six levels of Bloom's taxonomy. Integrate both NLP and classification models to generate questions and answers that are categorized according to Bloom's taxonomy: • The NLP model can be used to generate questions and answers, and the classification model can be used to categorize them according to their cognitive complexity level.	questions are not included in any self-study systems that are currently available.
Senaweera T.I.S	Analyze the performance level to adjust the learning experience accordingly and create a dashboard using learning analytics.	Define the learning analytics metrics that will be used to track student performance: • This could include metrics such as time spent on a particular topic, number of attempts taken to answer a question correctly, or the average score on assessments. Retrieve the data from the system according to the learning analytics metrics. Pre-process the data and identify the features required to build a model to identify student's performance.	The current self-learner systems do not include models to detect the performance level of students. Those systems just give some usage information where in our system, performance level is analyzed, and also comprehensive dashboard is provided to track the progress.

		Build a model to predict the student's current performance level. Design dashboard according to the user performance: • Based on the results of the analysis, a user-friendly and customizable dashboard will be developed that presents relevant data and insights to students. • The dashboard allows students to drill down into specific metrics and data points. The dashboard should be updated regularly to monitor student progress and evaluate the effectiveness of the learning experience. Based on this evaluation, further adjustments can be made to the learning experience to ensure that students are meeting the desired learning outcomes.	
Wijayasena W.D.N.D.T	Generate personalized dynamic study plan and recommend external resources according to the performance level.	Collect data on student performance, which can be done by tracking their progress in the learning platform. (Created Dashboard data) Generate a dynamic study plan that changes to match the student's standards of Bloom's taxonomy: • Based on the student's strengths and weaknesses, a personalized study plan can be generated. • The study plan should be designed to focus on the areas where the student needs improvement while still building on their strengths.	Extra resources that are suggested to students are personalized based on performance analytics, and this approach ensures that the student receives the support they need to improve their performance and reach the expected standard

		• The plan should be dynamic and adjusted according to the student's progress and performance level. • This can be done by incorporating adaptive learning techniques that adjust the difficulty of the learning materials based on the student's performance. • The output of this task is a personalized study plan that is tailored to the student's needs and adjusts dynamically based on their progress. Develop a model to find personalized extra resources, such as videos, podcasts, and articles, from online platforms that can aid the user in achieving their academic objectives: • The knowledge graph developed earlier will be used to find relevant resources for the student based on their learning objectives and performance level. • The model uses natural language processing techniques to analyze the student's learning objectives and identify the most relevant resources. • The resources will be sourced from online platforms such as chatGPT, Google, Wikipedia, and other educational websites.	according to Bloom's taxonomy. No current self-learner system gives their users dynamic study plans and recommendations for extra study materials based on the student's performance level.