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Machine-Learning Based Solution for Enhancing the Performance of Undergraduate Research Projects

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Abstract **- Research projects are a critical point of a student's life as they help to generate new knowledge and understanding in a particular field. University students struggle immensely when completing their research projects due to lack of knowledge about the research process. In order to assist students in this process, "LEARNBOOST'' progressive web application provides dashboards with valuable and meaningful insights about the research projects, research areas, research groups, publications and competitions. These dashboards will help the students to get a clear understanding about the past research projects in a more effective manner. In addition, the system provides a research area prediction system that predicts the students research area of interest when they provide the research topic. These predictions are generated using Natural Language Processing (NLP) Transformers so that the students' students research topics will be identified more accurately. Moreover, "LEARNBOOST" student performance enhancement system provides a recommendation system that identifies student research area of interests through text inputs and suggest leading research papers where students can contribute to the further development of new ideas, technologies, and innovations. And through an abstract summarization, students can easily get the abstract summarized into few sentences. We present the results of a pilot study in which the proposed system was used to support a group of students and demonstrate its effectiveness in improving student performance.**

Keywords: Research analysis, research area prediction, information dashboards, research paper recommendation systems, abstract summarization, student performance enhancement, progressive web application, natural language processing, recommendation systems.

I. INTRODUCTION

Education is a critical component of a person's life. From these education levels, undergraduate period plays a significant role. In Sri Lanka, due to the lack of proper methodologies and technologies to track the performance and enhance it, student face difficulties when pursuing their field of education. As an under-developing country, only a minute percentage of students are selected to the universities annually. The students who follow the undergraduate scheme struggle immensely when trying to fulfil their academic goals. Even through the percentage of undergraduates in Sri Lanka is extremely low, it drastically decreases when it comes to the percentage of students who complete the degree program (2000- 2.3%, 2012- 1.2%) [16]. In order to increase thenumber of students completing the degree program, several important milestones should be achieved. The current undergraduate learning structure does not contain a proper system to help the students in their final year research project in a meaningful manner. Beneficial insights are not derived from the past students' research information in Sri Lankan Universities. Only instructions and guidelines are used when leading undergraduate students in their research projects. The majority of undergraduate students struggle when striving for high academic grades for research projects as the help a student gets from the university for the final year research project is inadequate.

These challenges faced by students and lecturers can be addressed through a machine learning-based progressive web application. This paper deals with final-year research project information by offering a dashboard with meaningful insights of past research projects, a machine learning model using NLP Transformers to predict research areas of interest in students, and a recommendation system for research papers that are related to the related research area of interest. Research projects are immensely important as they provide an opportunity to explore a specific topic or issue in-depth. These projects enable students to gather relevant information, analyze data, and draw meaningful conclusions. When 4th year undergraduate students are starting the research project they struggle when searching for the past year research project details because in the university the data is stored in different databases in different formats, making it hard to derive meaningful insights from the data. By implementing a proper dashboard with past data to offer meaningful insights and details like research project topic, research area, research group, H-index and publications about the research projects will help to solve the above problem faced by students. Usually, students do not have a clear idea about the research

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project components at the beginning of the research period. To solve this problem, a feature where the student can input the general idea of the research project is implemented. This text input is processed through Natural Language Processing (NLP) Transformer models. And they identify the relevant research area and the group using the above text input. These models are built using the past research project data of the students who completed their research h projects. From the predicted research area and the group relevant research papers will be suggested through the recommendation system. Through these recommended research papers and their abstract summarization using NLP Transformers. Undergraduate students can identify gaps in existing knowledge and create new theories or ideas that can contribute to the betterment of society.

II. LITERATURE REVIEW

The research project is a vital degree program component, and leveraging insights from past data about research areas and topics can aid students in selecting suitable areas and excelling academically. Many students face challenges in identifying relevant research areas, locating related leading papers, and comprehending paper abstracts, which existing research hasn't tackled.

Use Artificial Intelligence to increase performance of lectures and students at universities [1] research paper suggests developing a structure to increase university student performance and lecturer performance by providing insights about academic performance. This research article encompasses elements such as maintaining attendance records, observing student conduct, evaluating lecturer performance, and summarizing lectures. as main components. And it does not suggest methods to solve issues faced by students when completing their research projects using machine learning. The research paper delves into the topics of artificial intelligence, machine learning, and natural language processing, exploring these technological subjects in-depth. Upon implementation and testing of the suggested approach, it can be deduced that the student activity recognition phase exhibited superior performance compared to the other emotion and gaze aspects, yielding a success rate of 94.5%. The summarized lecture demonstrated a correspondence of 70% with the original lecture content. Student attendance marking accuracy is 83% by using Face Recognition. As a direction for future endeavors, it is recommended that upcoming researchers explore the correlation between student behaviors and lecturer performance, aiming to enrich students' learning experiences. But the performance enhancement through research problem solving components like dashboards with research related insights, research area identification through NLP Transformers, research paper recommendations system and abstract summarization have not been implemented.

The research article titled "Knowledge Based Recommender System for Academia Using Machine Learning: A Case Study on Higher Education Landscape of Pakistan [2]" proposes the development of a web application capable of allocating courses and research students according to their specialization and areas of interest. Through the utilization of collaborative filtering and content-based recommender systems, they are advocating methods to enhance the quality of higher education and enrich the student experience. This paper offers the following methods to achieve the goals in academics. They are generating recommendations using probabilistic topic models, course allocation and supervisor assignment based on specialization and area of interest, identifying past research themes and course teaching, research supervision, and industry using generate recommendations. This research paper does not implement methods to recommend research papers under identified research themes. And does not implement research information dashboards or abstract summarization methods. As a direction for future research, they have recommended the utilization of additional feature types such as bigrams and term frequency-inverse document frequency (TF-IDF) to represent words as tokens. This exploration aims to assess their influence on tasks related to supervisor recommendations and course allocation.

The paper titled "Research-paper recommender systems: a literature survey [3]" examines the mentioned articles pertaining to recommendation systems. It provides an overview of recommendation system technologies, descriptive statistics, and a discourse on their pros and cons. The study highlights that over 50% of the utilized recommendation methods involved content-based filtering (55%). Collaborative filtering was applied by only 18% of the reviewed approaches, and graph-based recommendations by 16%. Stereotyping, item- centric recommendations, and hybrid recommendations are some other types of recommendation systems discussed in this research paper. But this paper does not suggest a system to resolve issues faced by students during their research projects. The shortcomings of the recommendation system research were included in the future update section. It has become a problem when it comes to the evaluation of recommendation systems, which are often non-reproducible and incomparable.

A comprehensive analysis of the scholarly literature titled "A Systematic Literature Review of Student' Performance Prediction Using Machine Learning Techniques [5]" explores the utilization of educational data to improve students' academic performance. Educational Data Mining plays a

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crucial role in enhancing the learning environment through its contribution of cutting-edge methodologies, techniques, and applications. Analyzing performance, providing high-quality education, strategies for evaluating the students' performance, and future actions are among the existing challenges universities face. In order to solve these problems proper plans with proper technologies must be implemented in the universities. To tackle the problem, a range of Machine Learning (ML) methods are applied to comprehend the issues and formulate remedies. Ultimately, the utilization of Machine Learning technologies aids in forecasting students who may be at risk of dropout or facing challenges, subsequently leading to enhancements in student performance. Solving Research project issues using Machine Learning is not executed through the research paper.

The paper titled "Transformer-based Approaches to Natural Language Comprehension and Production" [6] explores the fundamental aspects of Natural Language Processing (NLP), focusing on Natural Language Understanding (NLU) and Natural Language Generation (NLG). These components play pivotal roles in the realm of language processing and communication. NLU comprehends the fundamental meaning of a provided sentence, whereas NLG aims to create the corresponding sentence by utilizing the given meaning. Natural language is translated into formal representations using NLU. Using these technologies research area prediction using research topic and abstract summarization are implemented through LEARNBOOST system. The research paper proposed a model known as Transformer-based Natural Language Understanding and Generation (T-NLU&G). The model demonstrated enhanced performance on both the E2E dataset and the Weather dataset, validating the practicality and efficacy of performance enhancements for the mentioned tasks through the proposed approach. This model proves to be a strong contender among the existing cutting-edge techniques. Eventually we can conclude that Transformer-based NLP is more beneficial and more effective.

The 'LEARNBOOST' system addresses student research project challenges by offering a progressive web app solution. It features research info dashboards, NLP-transformer-based research area prediction, hybrid paper recommendations, and abstract summarization for more reliable and effective outcomes.

III. METHODOLOGY

"Learnboost" progressive web application is implemented to resolve issues faced by university students in their research project period. It offers insightful dashboards about research projects, groups, publications, and competitions, aiding students in understanding past research effectively. The system also employs NLP Transformers to predict students' research area of interest based on their research topics accurately. Furthermore, it includes a recommendation system for leading research papers, enabling students to contribute to new ideas, technologies, and innovations, along with abstract summarization for quick understanding.

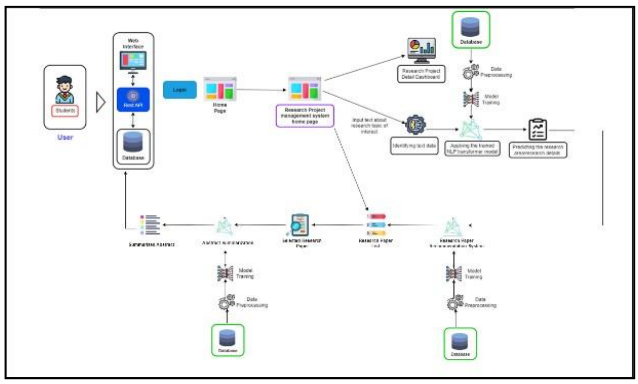

Figure 1: System overview

3.1 Implementing research information dashboard

In order to give a proper understanding about past research papers and to derive valuable insights from past research information, students are given a dashboard that can convey information easily. This dashboard contains research project name, research area, research groups, publications, and competitions. Since students are not provided past research information by current day student performance enhancement systems, students struggle when finding past research information from a reliable source. "Learnboost" system provides the past research information dashboard and it helps students to search research papers by research name, research area and research group. That improves the findability of past research papers.

3.2 Research area prediction using Natural Language Processing Transformers

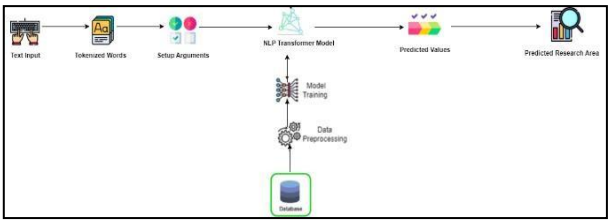

Figure 2: Research Area Prediction System using NLP

When starting a research project students lack knowledge about the research areas that the particular research topic belongs to. Students manually search for research topics and search for their relevant research area. This method is

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inconvenient and inefficient. And current student performance enhancement systems do not provide any solution to this problem (which is defined in Figure 2).

In order to solve this problem, "Learnboost" system implements a machine learning model using Natural Language Processing Transformers to predict the research area when the student input the research project of interest as a text input. Through this function students can describe their research project topic of interest. This is entered as a text input through the keyboard. NLP Transformer algorithms identifies this text input and classifies the text into a relevant research area.

The machine learning model was developed using 2023 Main Student Research Database of Sri Lanka Institute of Information Technology which contained information about the research projects of 2023. The original dataset had 400 records and 26 research areas. Under the model architecture TFDistilBertForSequenceClassification, a pre-trained transformer-based model for sequence classification tasks using TensorFlow, was used. This uses distilbert-base-uncased model. When using all 26 research areas, the evaluation loss was calculated as 2.54567. In order to increase the accuracy of the model, the 15 largest research areas were used. It contained 92.25% from the original dataset. Under the same TFDistilBertForSequenceClassification algorithm, the evaluation loss is calculated as 2.34278.

3.3 Suggesting relevant research papers using recommendation systems using NLP

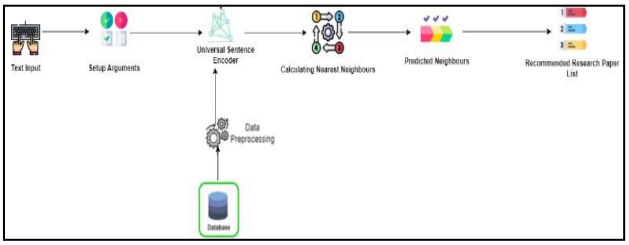

Figure 3: Research Paper Recommendation System

After selecting a research topic, students can get the research area prediction using the NLP transformer model. Students can get past leading research papers related to the predicted research area using the recommendation system. This recommendation system is implemented using machine learning models that predict the research papers that are most related to the research topic under the relevant research topic (which is defined in Figure 3).

The machine learning model was developed using 2023 Main Student Research Database of Sri Lanka Institute of Information Technology which contained information about the research projects of 2023. The original dataset had 400 records and 26 research areas. The model "Universal Sentence Encoder" from TensorFlow Hub is used for this implementation. It is a pre- trained model developed by Google that is designed to convert sentences or short text snippets into embeddings. When the research topic or area is inserted, the model will provide the 10 nearest research papers that is related to the input text.

3.4 Research paper abstract summarization system using Transformers

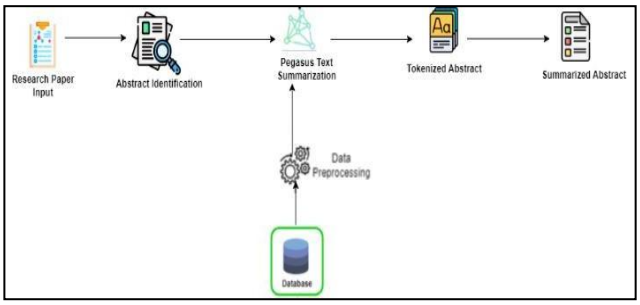

Figure 4: Abstract Summarization System

When students are searching for a research project, they tend to refer to past research papers. In order to give a clear idea about a past research project students has to read the complete research paper, without having a prior knowledge of particular technologies. Through this function in "Learnboost" system, students can summarize the abstract of a selected research paper (which is defined in Figure 4).

The abstract text summarization model called Pegasus, which is built by Google Research is used here. This model is based on DistilBERT. After the research abstract is input to the model, it is summarized into few sentences so that students can understand the research paper more effectively.

IV.RESULTS AND DISCUSSIONS

A research project's significance lies in its role as a catalyst for generating new knowledge and expertise in a particular field during a student's academic journey. Our "Learnboost" progressive web app addresses challenges students face during research. It includes an insightful dashboard offering valuable insights on final-year research projects. Fueled by NLP transformers, our solution utilizes a machine learning algorithm to forecast research domains using topics, assisting in accurate project delineation. Additionally, a recommendation system suggests relevant research papers, enabling students to explore pertinent works aligned with their interests. Moreover, we've integrated abstract summarization, streamlining the understanding of past research and enhancing students' ability to position their work within the academic landscape.

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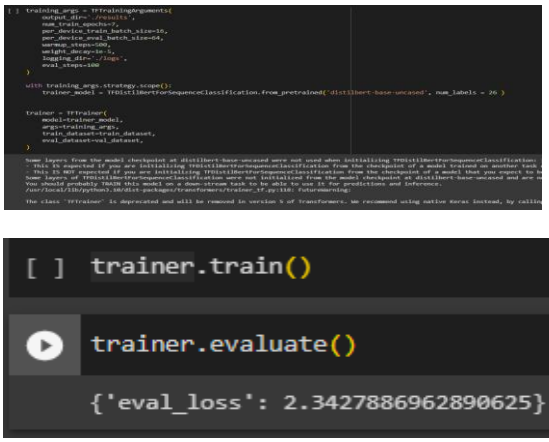
4.1 Implementing research information dashboard

Figure 5: Past Research Information Dashboard

Through a user-friendly dashboard, the "Learnboost" system improves students' access to prior research publications. The research project titles, areas, groups, publications, and competitions are among the crucial information provided by this dashboard. The "Learnboost" system provides students with a trustworthy source for historical research material, in contrast to present student performance systems that are devoid of such data. The technology considerably improves the accessibility and findability of relevant prior research articles by providing searches based on research name, area, and group.

4.2 Research area prediction using Natural Language Processing Transformers



```
[ ]  trainer.train()

     trainer.evaluate()

     {'eval_loss': 2.3427886962890625}
```

Figure 6: Research Area Prediction using TFDistilBertForSequenceClassification and calculating evaluation loss as 2.34278

The "Learnboost" system seeks to address the problem of students finding it difficult to pinpoint relevant research areas for their project topics. Students can enter their research topic into a machine learning model using NLP Transformers, which then uses those topics to predict appropriate research areas.

The model uses TFDistilBertForSequenceClassification architecture and was created using a dataset of 400 records and 26 study areas from the Sri Lanka Institute of Information Technology's 2023 Student Database. The model improved its evaluation loss to 2.34278 by concentrating on the 15 most significant research areas, increasing accuracy (which is defined in Figure 6).

4.3 Suggesting relevant research papers using recommendation systems with NLP

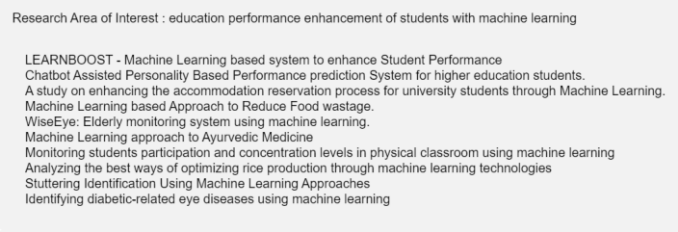


Figure 7: Research Paper Recommendation System

```
def embed(texts):
    return use_recomsys_model(texts)


df1 = pd.read_csv('C:\\Users\\User\\Downloads\\LRNBST -ML-MODEL-DEPLOYMENT-USING-FLASK-main\\ML-MODEL-DEPLOYMENT-USING-FLASK-main\
df1 = df1[["project_topic", "research_group"]]
proj_topics = list(df1['project_topic'])
embeddings = embed(proj_topics)

nn = NearestNeighbors(n_neighbors=10)
nn.fit(embeddings)

def recommend_rs_pprs(text):
    emb = embed([text])
    neighbors = nn.kneighbors(emb, return_distance=False)[0]
    return df1['project_topic'].iloc[neighbors].tolist()



recom_rs_pprs = recommend_rs_pprs(string_features_rsarea)
```

Figure 8: Research paper recommendation functionality

The provided code defines a Python function called "recommend()" intended for a Flask web application. When a user submits a form with a field named 'Research_area,' this function is executed. It first extracts the value of 'Research_area' from the form, converts it to a string, and prints it. Next, it loads a dataset from a CSV file containing columns 'project_topic' and 'research_group.' It then utilizes a pre-trained model called 'use_recomsys_model' (which is defined in the code Figure 8) to embed the 'project_topic' values from the dataset into numerical vectors. After setting up a nearest neighbors model (k-NN) with a k-value of 10 on these embeddings, the function defines a recommendation function 'recommend_rs_pprs' that takes a text input and returns a list of 10 project topics from the dataset that are most similar to the input. Finally, it calls 'recommend_rs_pprs' with the 'Research_area' value, and the results are passed to a Flask HTML template for rendering, including the recommended project topics and the original 'Research_area' value. Note that there are some commented-out lines and unresolved references, like 'use_recomsys_model,' which may need further implementation to make this code functional.

4.4 Research paper abstract summarization system using Transformers

The provided code defines a Python function called "abssummarize()" intended for a Flask web application. When a user submits a form, this function is executed. It first extracts the form values, converts them into strings, and prints them.

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Then, it uses a text summarization model (referred to as 'abs_sum_model') to generate a concise summary of the input text (which is defined in the code Figure 9).

```
#ABSTRACT SUMMARIZATION
@flask_app.route("/abssummarize", methods = ["POST"])
def abssummarize():
    str_features_abstract = [str(x) for x in request.form.values()]
    print(str_features_abstract)
    features = [np.array(str_features_abstract)]


    def abstract_summarize(absinput):
        tokens = tokenizer(absinput, truncation=True, padding="longest", return_tensors="pt")
        summary = abs_sum_model.generate(**tokens, max_length=64)
        summary_sentence = tokenizer.decode(summary[0])

        # Remove special tokens
        summary_sentence = summary_sentence.replace("<pad>", "").replace("</s>", "")

        # Remove extra spaces
        summary_sentence = " ".join(summary_sentence.split())
        return summary_sentence


    summarized_abs = abstract_summarize(str_features_abstract)
    print(summarized_abs)
```

Figure 9: Abstract summarization functionality

The input text is tokenized, and the summarization model generates a summary with a maximum length of 64 tokens. After generating the summary, it cleans it by removing special tokens and extra spaces. The resulting summarized text is printed and passed to a Flask HTML template for rendering, along with the original input text. It's worth noting that some components, such as the 'tokenizer' and 'abs_sum_model,' are referenced but not defined within this code snippet and would need to be imported or defined elsewhere to make the code functional.

V. CONCLUSION

In order to help university students successfully complete the crucial research project phase, "LEARNBOOST," a progressive web app, was created. By providing dashboards that shed light on research projects, topics, groups, publications, and competitions, it tackles their problems and improves comprehension. Based on research topic inputs, the app's research area prediction algorithm uses NLP Transformers to precisely identify students' research areas. Additionally, its recommendation system offers leading research publications, encouraging creativity. Understanding is made simpler through abstract summarization. The system's ability to improve student performance by promoting informed decision-making and advancing research is supported by a pilot study. "LEARNBOOST" turns into a priceless resource in students' research endeavors.

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