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A Collaborative Filtering Approach to Enhance Academic Performance of Students in Computer Science Department at KSUST, Aliero

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ABSTRACT: This research paper focuses on the critical issue of study mate selection for undergraduate students. The selection of an appropriate study mate can greatly affect a student's academic and career future, and a poor selection can lead to negative consequences such as poor academic performance and wastage of resources. To address this problem, this paper proposes a preliminary study of a recommender system (RS) that recommends suitable study mates based on students' grades. The RS guides students in the selection process based on their abilities. The collaborative filtering technique is used to build the RS, and K-fold cross-validation is used to evaluate its performance. The experimental results indicate that the RS successfully predicts suitable study mates for each student with good accuracy. These promising initial results provide a feasible solution to further investigate this issue in future studies. The proposed RS has the potential to guide students towards more successful academic outcomes and better resource utilization.

KEYWORDS: Collaborative filtering, personalized recommendations, student success, personalized learning approaches, Machine learning.

I. INTRODUCTION

According to [1], recommender systems have become ubiquitous, and many online vendors, such as Amazon and Barnes & Noble, rely on machine learning techniques to recommend products, services, and other items to people. Commercial recommender systems suggest products based on predicted or estimated taste, whereas educational recommender systems focus on recommending resources that are beneficial for learning purposes [2]. Despite differences in their goals, collaborative filtering algorithms are often used in both commercial and educational recommender systems. [3] proposed collaborative filtering-based recommendations of resources, users, and communities from a digital library. [1] compared different collaborative filtering algorithms to recommend learning resources based on teacher evaluations. Additionally, more automated approaches for learning have been proposed, which use user feedback to recommend learning resources [4].

Collaborative filtering can also be used for recommending students to each other, a task known as reciprocal recommender systems. The recommender system must aim to satisfy the mutual benefits of the students, such as maximizing argumentation levels, final performance, motivation and engagement, and shared and individual learning outcomes, among others. The system can make recommendations based on cognitive features, problem-solving strategies used in students' previous work, general and social information such as gender, personality, personal preferences, and geographic location, and the weights given to these features can guide the way groups are formed. As an example, a recommender system could propose the creation of groups with diverse cognitive abilities by matching students based on their distinct problem-solving approaches, learning strategies, or knowledge and skills. It can also foster cross-gender and cross-cultural collaborations by promoting the recommendations of students with different gender and geographical locations.

Group learning has many pedagogical and social benefits, but simply assigning students to groups is not sufficient for these benefits to occur. Effective group formation for collaborative learning is challenging, and teachers need



to make non-trivial decisions when forming their student groups. Collaborative filtering has been successfully used for matching students with one another [5], and in this research, we describe our approach to enhance student learning through collaborative filtering. We intend to apply our approach to the Computer Science department at Kebbi State University of Science and Technology Aliero, where small group formation within a class is an important issue.

AIM OF THE STUDY

The aim of this research is to develop and evaluate a recommender system (RS) that can suggest appropriate study mates to undergraduate students based on their grades and abilities. The study aims to address the problem of poor study mate selection, which can have negative consequences on academic performance and resource utilization.

OBJECTIVES OF THE STUDY

- a) To conduct a preliminary study to develop a recommender system (RS) that recommends suitable study mates based on students' grades.
- b) To evaluate the performance of the RS using the collaborative filtering technique and K-fold cross-validation.
- c) To assess the accuracy of the RS in predicting suitable study mates for each student.
- d) To provide a feasible solution to further investigate the issue of study mate selection in future studies.

To demonstrate the potential of the proposed RS in guiding students towards more successful academic outcomes and better resource utilization.

II. LITERATURE REVIEW

According to [6], recommendation systems are software or tools that provide users with recommendations of items they might be interested in. These systems are used in various sectors to assist users in making better choices online, such as recommending products, movies, or online courses. [7]proposed a recommendation system to promote employability by matching users' skills gap with the appropriate course. [8]introduced a hybrid model for an intelligent recommender system for e-learning platforms using data mining. [9]suggested a model for an intelligent classroom that can recommend adaptive learning resources tailored to individual student characteristics.

Decision tree, content-based filtering, and collaborative filtering are powerful techniques used in recommendation systems [6]. Some studies in this field rely solely on decision tree approaches, while others combine them with other approaches to achieve greater accuracy, such as the association rule approach [6]. [10]utilized decision tree and association rule approaches to build an institutional recommendation system, achieving an accuracy level of 69.03%. [11]built a recommendation system to predict specialization and study track for students based on grades using a combination of the decision tree and neural network approaches. [12]conducted a case study using a neural network with the decision tree technique to predict enrolment decisions, future grades, and satisfaction level, achieving an accuracy level of 99.95%. [13]proposed a different approach, the R-Tree algorithm, for the efficient management of huge training datasets.

Content-based filtering is frequently used in education, as seen in [14] proposed recommendation system for predicting students' course selection based on marks and job interest using clustering techniques. [15]proposed a course recommendation system to improve students' future careers, utilizing content-based filtering techniques and an ensemble learning algorithm with k-means clustering and TF-IDF keyword extraction. [16]proposed a recommendation system that predicted elective subjects for new students by analysing personal records and past behaviour. [17]recommended elective courses based on affinity between courses taken by similar students. [18]used the correlation threshold and nearest neighbour approach, while [19] utilized the Pearson Correlation Coefficient and ALS algorithm to recommend optional courses. [20] applied the collaborative technique to recommend schools in Spain.

Based on the literature review, collaborative filtering has proved accurate in some studies [19]. Therefore, this paper adopts collaborative filtering techniques to develop an accurate recommendation system for computer science students at KSUSTAliero. As there is no previous recommendation system for KSUSTAliero computer science students, there is a need for a system to help improve their performance.

III. METHODOLOGY

Predictive model development was carried out using Python. Python is a language that is commonly used in machine learning applications. The methodology selected for this study features built-in libraries. The proper output for building the algorithm is produced with the assistance of these built-in libraries. The Python



applications were ran in Jupyter Notebook. The acquired information was saved using the features listed in a Microsoft Excel Comma Separated Values File (.csv) format. The dataset was cleaned to get rid of duplicates, missing data, and extraneous symbols (such colons, commas, and spaces).

To ensure satisfactory outcomes of the system, it is essential to have appropriate and consistent data prior to implementation. In this study, a questionnaire was used to gather data from 38 students of the 200 level computer science department at KSUSTA, which included their admission numbers and CGPAs. In addition, interviews were conducted to examine whether group study had a positive impact on the students' academic performance. The research was aimed at pairing high-performing students with low-performing students in the computer science department at the 200 level. Information regarding the studying ability of each student was also collected for the study.

ALGORITHM APPLIED

This study focused on analysing the cosine similarity algorithm for making recommendations. The purpose of selecting this particular algorithm was to gain insights into its optimal applications and use cases.

A RECOMMENDER SYSTEM BASED ON COSINE SIMILARITIES

The method utilizes cosine similarity to estimate similarity, which involves calculating the cosine of the angle formed by two vectors. When the angle between two vectors, denoted as e_1 and e_2 is equal to 0° , the cosine value is 1 since both vectors have the same direction. Conversely, when the angle is 180° , the cosine value is -1 since the vectors have opposite directions. Mathematically, it is expressed as:

$$\text{Cos}(e_1, e_2) = \frac{e_1 \cdot e_2}{\|e_1\| \cdot \|e_2\|}$$

where:

$e_1 \cdot e_2$ is the dot product of the vectors e_1 and e_2

$\|e_1\|$ and $\|e_2\|$ are the Euclidean norms (lengths) of the vectors e_1 and e_2 , respectively.

A cosine similarity-based recommender is a type of recommendation system that uses cosine similarity as a measure of similarity between items or users. It works by comparing the similarity between the items or users based on their features, such as their ratings, preferences, or behaviours.

The cosine similarity measure calculates the cosine of the angle between two vectors of features, where the angle represents the similarity between the vectors. The closer the angle is to 0 degrees, the more similar the items or users are considered to be. This measure is commonly used in text-based recommendation systems, where the features are the words or terms that describe the items.

Cosine similarity-based recommenders have been shown to be effective in many applications, such as e-commerce, social networks, and content recommendation. They are easy to implement, scalable, and can handle sparse and high-dimensional data. However, they also have limitations, such as the cold start problem, where new items or users have no or little data, and the lack of personalization, where the recommendations are not tailored to the individual preferences of the users.

IV. RESULTS AND DISCUSSION

The data used for this research was 200 level computer science students' data from faculty of physical science of Kebbi State University of Science and Technology, Aliero, Nigeria. The size of the data is 38 comprising of 34 males and 4 females. The data consist of a set of undergraduate students. The data was collected through a Google form questionnaire between April 2023 and May 2023. The questionnaire was shared on the student's WhatsApp group. The distribution of gender of the students sampled is contained in Figure 1.

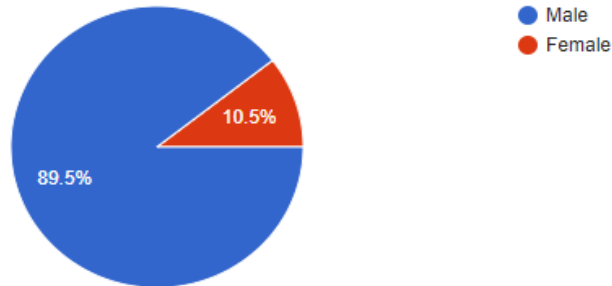


Figure 1: The percentage distribution of gender of the students

The CGPA of the students was used as input parameters to pair academic at risk students with bright students. The preparation of the dataset for model building is the first step taken. At this point, conventional pre-processing techniques such as data cleaning, variable modification, and data segmentation were used.

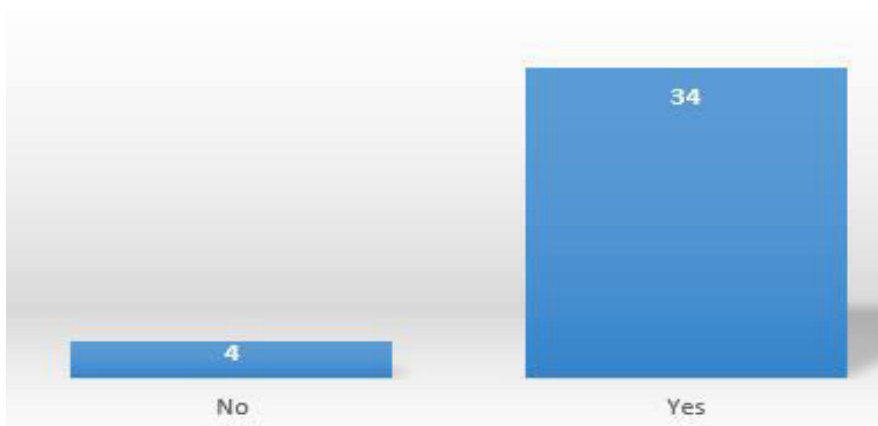


Figure 2:The distribution of whether academically at risk students collaborate with bright students when they are faced with academic challenge.

The figure above shows that collaborative studies or group reading can positively impact academic performance of 200 level students of computer science department of Kebbi State University of Science and Technology, Aliero.

COMPLEMENTARY FREINDS/RECOMMENDAION LIST FO R 2010203022	
Students_id	Similarity with target
2220203056	0.0
2120203035	0.0
2120203026	0.0
2010203062	0.0
2120203027	1.0
2120203023	1.0
2120203015	1.0
2010203079	1.0
2010203073	1.0
2010203058	1.0

Table 1: Recommendation table for student with admission number 2010203022



METRIC EVALUATION

Performance metric such as precision, recall and f-measure were used to evaluate the performance of the algorithm. Table 2 presents a summary of the outcome obtained in the experiment.

Metric Evaluation	Cosine Similarity
Precision	0.50
Recall	0.50
F1-score	0.50

Table 2: Metric performance of algorithm

V. CONCLUSION

After reviewing previous studies on recommendation systems, this paper presents the development of the KSUSTARS system, which has not been applied to Kebbi State University of Science and Technology Aliero before. The system was created by considering the experiences of solutions in recommendation systems that could be adapted for the educational field, and comparing them to similar studies in the literature. The results of the system are consistent with those of previous studies. Initial testing of the system was successful and demonstrated the need for it at Kebbi State University of Science and Technology Aliero, Kebbi, Nigeria.

However, due to the preliminary nature of the study, the dataset was limited to only cover 200-level students in the computer science department. In order to draw more general conclusions, larger datasets will be used in future studies.

The selection of suitable study partners is a critical decision for all students in Kebbi state universities, and thus this paper proposes the KSUSTARS system to guide students in selecting the most appropriate study partner based on their CGPA. The recommendation system developed for 200-level computer science students at KSUSTA uses a collaborative filtering technique based on real student data. The experimental results indicate that the recommendation accuracy ratio is good enough to predict the specialization.

The future work of this paper will aim to integrate the KSUSTARS system into the official KSUSTAlieroweb site to guide students in choosing their study partners, in order to improve their academic performance.

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