**A Collaborative Filtering Recommendation System for Elective Courses Using Cosine Similarity**

## A PROJECT REPORT

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***Under the guidance of,***

**Dr.Swati Sharma**

***in partial fulfillment for the award of the degree of***

# BACHELOR OF TECHNOLOGY

## IN

**INFORMATION SCIENCE AND ENGINEERING**

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****

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**PRESIDENCY SCHOOL OF COMPUTER SCIENCE ENGINEERING**

**CERTIFICATE**

This is to certify that the Project report **“A Collaborative Filtering Recommendation System for Elective Courses Using Cosine Similarity”** being submitted by “**P.DURGA MARUTHI VARA PRASAD, ALLEN SAJI, SYED YUSUF HUSSAIN, FAIZAN NIYAZUDDIN, S NAYMAAN KHAN**” bearing roll number(s) “20211ISR0027, 20211ISR0005, 20211ISR0015, 20211ISR0091,20211ISR0065” in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Information Science And Engineering is a bonafide work carried out under my supervision.

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**DECLARATION**

We hereby declare that the work, which is been presented in the project report entitled **A COLLABORATIVE FILTERING RECOMMENDATION FOR ELECTIVE COURCES USING COSINE SIMILARITY** in partial fulfilment for the award of Degree of **Bachelor of Technology Information Science and Engineering,** is a record of our own investigations carried under the guidance of **Dr. Swati Sharma, Professor, School of Computer Science Engineering, Presidency University, Bengaluru**

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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**ABSTRACT**

We have tackle the problem of elective recommendation at Presidency University, where students often struggle to secure their preferred subjects. Additionally, when they do receive their electives, they frequently find themselves separated from their friends, leading to confusion. Many students are arbitrarily assigned to different electives by their Heads of Department (HoD) or the timetable committee in an attempt to achieve a balanced distribution among various discipline electives. This project employs a Cosine similarity collaborative filtering recommendation system algorithm designed to assist students in selecting their discipline and open electives based on their academic performance. Furthermore, we provide an interactive dashboard for students and an administrative dashboard for HoD’s to oversee the recommendations without resorting to arbitrary assignments.

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**CHAPTER -1**

**INTRODUCTION**

#### **Motivation**

#### In today's fast-evolving academic landscape, students face the challenge of choosing from an increasingly diverse array of elective courses. However, these decisions often lack personalization and guidance, leading to suboptimal academic outcomes. Educational institutions, in turn, struggle to efficiently manage elective enrollments, ensuring that courses are both well-utilized and align with students' academic strengths. The motivation behind this project is to leverage the power of data-driven approaches and machine learning techniques to empower students with informed choices while streamlining institutional processes.

#### **Problem Statement**

#### Managing elective course enrollments is a multifaceted challenge that involves balancing student preferences, academic strengths, and course capacity constraints. Existing systems often lack personalization, resulting in a misalignment between student abilities and chosen courses. Additionally, manual or inefficient seat allocation processes lead to over-capacity issues, operational delays, and stakeholder dissatisfaction. These challenges underscore the need for a robust and scalable solution to optimize elective course management and improve the overall academic experience.

#### **Objective of the Project**

#### The primary objective of this project is to design and develop a dynamic course recommendation system that:

1. Utilizes collaborative filtering techniques to generate personalized elective recommendations based on student marks, grades, and grade points.
2. Provides real-time seat allocation management to avoid over-capacity issues.
3. Delivers role-specific functionalities through distinct user interfaces for students, faculty, and Heads of Departments (HODs).
4. Offers real-time visualization dashboards for informed decision-making by stakeholders.

#### **Scope of the Project**

#### This project aims to serve as a scalable solution for academic institutions, capable of handling large datasets with 10,600 student records and 24 unique courses. The system's modular architecture ensures adaptability to diverse institutional requirements. By integrating Python, Streamlit, SQLite3, and Scikit-learn, the project offers robust performance in both recommendation accuracy and concurrent enrollment management. The inclusion of Plotly-powered dashboards extends its applicability to strategic planning and decision-making, further enhancing its value to institutions seeking data-driven advisory capabilities.

#### **Project Introduction**

#### This project presents a dynamic course recommendation system built to address the critical challenges of elective course management in academic institutions. Using a dataset encompassing 10,600 student records across 24 courses, the system employs a cosine similarity-based collaborative filtering algorithm to generate personalized recommendations that align with individual academic strengths. The technical stack—comprising Python, Streamlit, SQLite3, and Scikit-learn—ensures seamless real-time operations, while modular design facilitates ease of maintenance and scalability. With tailored interfaces for students, faculty, and HODs, the system supports role-specific tasks and includes Plotly-powered dashboards for data visualization. By improving operational efficiency, academic planning, and seat allocation management, the project demonstrates how machine learning and database management can transform elective course enrollments into a streamlined, technology-driven process.

# A blue screen with black text Description automatically generated CHAPTER-2 LITERATURE SURVEY

# Table 1.1 Literature Review

The shift toward an interdisciplinary approach in education has significantly increased the demand for elective courses. Universities worldwide are evolving their curricula to include a diverse array of courses that complement core subjects and cater to students' varied interests. Elective courses play a vital role in fostering intellectual curiosity, enabling students to acquire knowledge beyond their primary field of study, and preparing them for the multifaceted challenges of the modern world.

Such diversity not only stimulates intellectual development but also opens pathways for global opportunities and advanced research.As the world moves toward an interdisciplinary approach, the need for elective courses has increased exponentially, prompting universities to adapt a diverse curriculum that encompasses not only core courses but also relevant subjects based on students’ chosen fields. Elective courses provide diverse intellectual stimulation and cultivate multifaceted curiosity, leading to the development of sophisticated contemporary projects that open global and research opportunities.

Research by Mwelwa and Sooltan Sohawon [6] emphasizes that students’ choices in elective courses are influenced by personal interests, career aspirations, and peer recommendations. They found that when students pursue their desired courses, overall satisfaction with learning enhances drastically. This aligns well with our project’s goal of providing personalized elective recommendations based on individual academic marks and grades.

Collaborative filtering has emerged as an important technique for generating user-based recommendations across various domains, including movies, shopping, and education. A study by Koren et al. [5] illustrates how collaborative filtering can effectively predict user preferences based on the preferences of similar users. In our project, we have implemented cosine similarity to compare student academic profiles with those of other students who have successfully completed elective courses, thereby enhancing the overall performance of elective course recommendations As data becomes increasingly viable, data-driven decisionmaking is recognized as a key factor in expanding higher education to improve student outcomes and overall institutional effectiveness. A report by the National Center for Education Statistics (NCES) highlights the importance of utilizing historical student enrollment data and academic performance metrics (marks/grades) to guide the assignment of elective courses [7].

Despite the functionality of recommendation models, several challenges exist during their execution. Research by Santini et al. [8] has identified common issues such as limited seat allocations, misalignment between students’ preferred courses and those assigned to them, and constraints imposed by administrative officials. In our system, we have implemented dynamic database updates for overall seat allocation for each specific course, which is managed by Heads of Departments (HoDs) to resolve any seat availability constraints.

Custom-tailored learning has demonstrated significant enhancements in how students engage with academics, resulting in higher individual success rates. A study by Walkington [9] found that providing customized educational experiences tailored to individual students’ needs leads to improved selfefficacy regarding learning and overall motivation resulting in better learning outcomes. By offering personalized elective course recommendations based on individual academic grades and marks, our recommendation model promises greater engagement among students at Presidency University.

# CHAPTER-3

**RESEARCH GAPS OF EXISTING METHODS**

Existing methods for elective course recommendation systems face several limitations that hinder their effectiveness in meeting the personalized needs of students. One of the primary gaps is the lack of personalization in recommendations. Many systems focus on generic course suggestions based on popularity or institutional requirements rather than tailoring them to individual students’ academic strengths, interests, and career aspirations. This often leads to dissatisfaction and mismatches between students' preferences and the electives they are assigned, reducing the overall efficacy of these systems.

Another significant limitation lies in the underutilization of collaborative filtering techniques in the education domain. While these methods, such as cosine similarity, have shown great success in sectors like e-commerce and entertainment for generating personalized recommendations, their adoption in education remains minimal. Existing systems rarely leverage such advanced algorithms to analyze patterns in student performance and peer similarities, missing an opportunity to provide accurate and meaningful course recommendations.

Real-time seat allocation management is another critical challenge that many current systems fail to address effectively. The inability to dynamically track and manage seat availability often results in over-enrollment or underutilization of courses. This creates logistical challenges for administrators and frustration among students who may be unable to enroll in their preferred courses. Furthermore, systems that do attempt seat management often lack mechanisms for resolving conflicts when student preferences exceed available seats.

Data visualization tools, which are increasingly important in decision-making, are also notably absent in many existing systems. Heads of Departments (HoDs) and faculty members often lack access to real-time dashboards that can provide actionable insights into enrollment trends, seat capacities, and demand patterns. This absence of visualization capabilities makes it difficult for administrators to adjust allocations or make strategic decisions in a timely manner.

Despite the abundance of historical academic data in educational institutions, many systems fail to utilize this resource effectively. Data on student performance, course enrollments, and historical trends could significantly enhance the accuracy of recommendations. However, existing systems often overlook this data, relying instead on simplistic or static criteria that fail to account for nuanced patterns in student behavior and success rates.

Additionally, inefficiencies in handling concurrent processes represent a major gap in current methods. With multiple stakeholders interacting with the system simultaneously—students enrolling in electives, faculty managing course assignments, and administrators overseeing seat allocations—thread-safe operations are crucial. Many systems struggle to manage these concurrent processes, leading to delays, errors, or even system failures that disrupt the enrollment experience.

The issue of scalability is another significant limitation of existing methods. As institutions grow and their datasets expand, many systems face performance bottlenecks. For instance, handling large datasets like the 10,600 student records and 24 unique courses used in this project requires robust and scalable infrastructure. However, most current systems are not optimized to handle such large-scale operations efficiently, limiting their applicability in larger academic settings.

Finally, the mismatch between student preferences and available course seats remains a persistent challenge. While students may have specific courses they wish to pursue, existing systems often lack mechanisms to dynamically resolve these constraints. The inability to adjust seat capacities or offer alternative recommendations in real-time exacerbates dissatisfaction among students and inefficiencies in course utilization.

### Disadvantages in Existing Methods

 **Lack of Personalization**: Generic recommendations fail to align with individual student interests and academic strengths.

 **Inefficient Seat Allocation**: Real-time seat management is often absent, causing over-enrollment or underutilization of courses.

 **Limited Use of Advanced Algorithms**: Few systems leverage collaborative filtering or similar techniques for accurate recommendations.

 **Scalability Issues**: Existing systems struggle to handle large datasets, making them unsuitable for larger institutions.

## CHAPTER-4 PROPOSED METHODOLOGY

The proposed methodology for the personalized elective course recommendation system starts with the **data collection and preprocessing phase**. The system uses a dataset comprising 10,600 student records across 24 unique courses, capturing crucial features such as student marks, grades, and grade points. These data points are essential for understanding the academic background and preferences of students. Preprocessing is a vital step to ensure the data is clean and suitable for analysis. This involves removing any missing values or outliers that could skew the results. Additionally, data normalization is performed to standardize the values, ensuring that all features are on a comparable scale. This step helps in maintaining consistency and improving the accuracy of the similarity calculations, which is critical for making reliable course recommendations later in the system.

The next phase focuses on implementing a **collaborative filtering algorithm** to generate personalized course recommendations. Specifically, the methodology utilizes the **cosine similarity** technique, a well-known method in recommendation systems. This approach works by analyzing patterns in student performance and their course preferences. Cosine similarity calculates the degree of similarity between students based on their academic records and the electives they have previously chosen. By leveraging this technique, the system can generate recommendations that are closely aligned with individual student profiles. The key benefit of collaborative filtering is that it takes into account the behavior and preferences of similar students, which helps to provide recommendations that match the academic strengths and interests of the student. This tailored approach enhances student satisfaction by suggesting electives they are more likely to perform well in and enjoy.

A significant challenge in the course recommendation process is **seat allocation**, especially during peak enrollment periods. To tackle this, the methodology integrates a **real-time seat management system** that tracks and updates seat availability dynamically for each course. The system utilizes **SQLite3** as the database to handle enrollment data and ensures that the seat allocation process is efficient and reliable. One of the key features of this system is its ability to prevent over-enrollment. If a course exceeds its seat capacity, the system will either provide alternative course recommendations to students or alert **Heads of Departments (HoDs)**, enabling them to adjust seat capacities as needed. This proactive management helps maintain a smooth enrollment process and ensures that students have a variety of options to choose from. Furthermore, the system’s database operations are optimized for **thread safety**, allowing it to handle concurrent enrollments effectively without any performance issues.

A diagram of a program

Description automatically generatedFinally, the methodology emphasizes the creation of **user-friendly interfaces** through **Streamlit**. Three distinct interfaces are designed to cater to the needs of different stakeholders: students, faculty, and HoDs. For students, the interface allows easy access to course selection and personalized recommendations. Faculty can use the interface to monitor enrollment and track course participation. HoDs benefit from a seat management interface that provides real-time updates on seat availability and trends in enrollment. Additionally, **interactive dashboards**, powered by **Plotly**, are integrated into the system. These dashboards display visualizations of enrollment trends and seat availability in real time, allowing stakeholders to make informed decisions quickly. This graphical representation makes it easier for faculty and administrators to adjust their strategies for course management and seat allocation.

**Figure 1.1 Flowchart of Recommendation System**

# CHAPTER-5 OBJECTIVES

The primary objective of this project is to develop a **data-driven course recommendation system** that leverages machine learning techniques, specifically **collaborative filtering with cosine similarity**, to generate personalized course suggestions for students based on their academic performance and preferences. The system will utilize historical data, such as student marks, grades, and previous course selections, to identify patterns and provide tailored recommendations that align with each student’s strengths and interests. To ensure the recommendations are both accurate and efficient, the project includes a thorough **data preprocessing** phase where missing values, outliers, and inconsistencies are removed, and the data is normalized for better reliability in the similarity calculations.

Another key objective is to implement a **real-time seat management system** to track and manage seat availability dynamically for each course. The system will utilize **SQLite3** as the database to ensure that enrollments are handled efficiently, preventing over-enrollment by offering alternative course recommendations or alerting **Heads of Departments (HoDs)** when adjustments to seat capacities are necessary. This system will optimize the overall enrollment process and address challenges during peak periods, ensuring a smooth experience for students and faculty alike.

Furthermore, the project will focus on creating **user-friendly interfaces** through **Streamlit** for different stakeholders, including students, faculty, and HoDs. Each interface will have tailored functionalities, such as personalized course suggestions for students, enrollment monitoring for faculty, and seat management for HoDs. The project also includes the integration of **interactive dashboards** using **Plotly**, providing real-time visualizations of enrollment trends, seat availability, and overall system performance, enabling stakeholders to make informed decisions quickly and effectively.

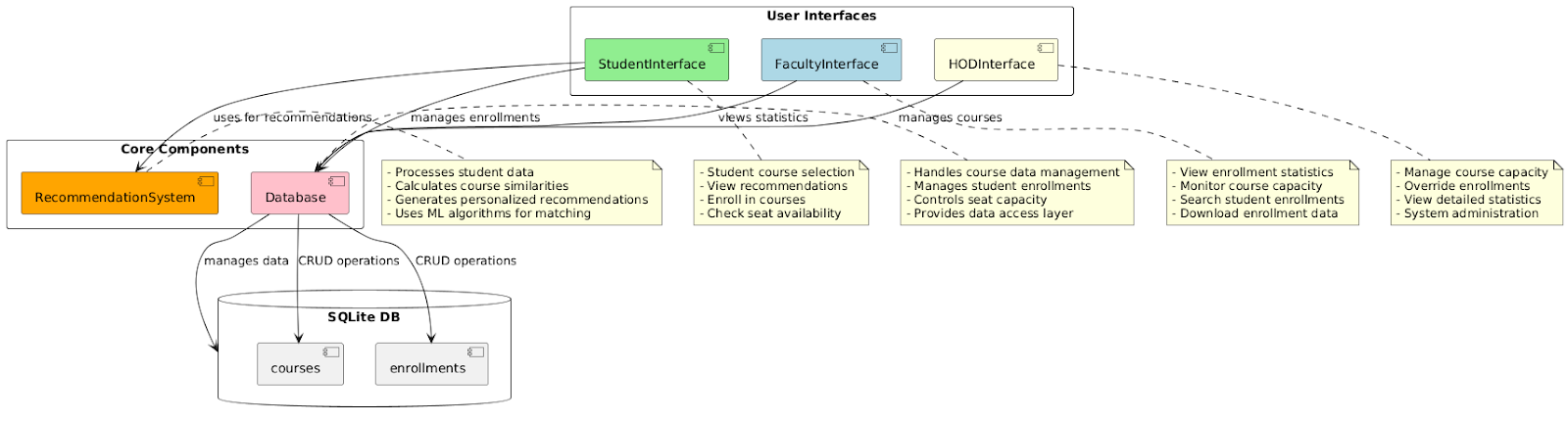
The methodology aims to ensure the system is **scalable and efficient**, capable of handling large datasets and real-time enrollment updates without compromising performance. The database operations will be optimized for **thread safety**, allowing the system to manage concurrent enrollments smoothly. Ultimately, the project seeks to enhance the **student enrollment experience** by offering personalized, data-driven course recommendations, making the process more efficient and accessible while reducing manual intervention. Through these objectives, the project aims to improve academic planning and decision-making for students and academic administrators alike.

# CHAPTER-6

**SYSTEM DESIGN AND IMPLEMENTATION**

**6.1 Introduction of system design**

The development of a comprehensive system that addresses the elective course enrollment challenges at Presidency University encompasses various facets of software engineering, machine learning, and user interface design. This system is particularly designed to provide solutions across three distinct user interfaces—Student, Faculty, and Head of Department (HOD). The aim is to facilitate a smooth enrollment process, recommend courses effectively using academic performance data, and manage seat allocations dynamically. Our focus lies in employing resource-efficient, scalable technologies to achieve these objectives.

**6.2 Architecture Overview**

**Fig 2.1 Architecture Overview**

**6.3 Modular Architecture**

Our software design is guided by a modular architecture, where the system is broken down into discrete components, each responsible for specific functionalities. This modular approach not only enhances maintainability and scalability but also simplifies debugging and testing processes. The primary modules in our architecture are:

**1. Database Module:** Centralized SQLite database containing tables for courses, student enrollments, and grade data. It supports thread-safe operations to accommodate concurrent access by multiple users.

**2. Recommendation Engine:** Uses collaborative filtering based on cosine similarity to generate personalized course recommendations. This is implemented using Scikit-learn, enabling the system to handle large datasets efficiently.

**3. User Interface Module:** Developed using Streamlit, this module provides tailored interfaces for students, faculty, and HODs, ensuring role-based access to functionalities.

**4. Data Processing Module:** Handles real-time data transformation and feature extraction from raw datasets, preparing the data for enrollment management and recommendation generation.

**5. Seat Management Module:** Automates the seat allocation process ensuring real-time updates and synchronization across user interfaces.

**6.4 Data Flow and Storage**

The system relies heavily on a robust data flow architecture, with a seamless exchange between the database and application layers. The data flow begins with the ingestion of student and course data into the database. This data is processed for feature extraction, which is crucial for the recommendation engine and enrollment statistics. The processed data triggers visual updates in the user interface through interactive charts and dashboards using Plotly, ensuring users receive real-time feedback on data alterations.

**6.5 Data Model**

The data model for this system is meticulously designed to accommodate the diverse requirements of course management and student enrollments. Core entities include:

* **Courses:** Each course is identified by a unique code, with attributes detailing seat capacity and current enrollment numbers.
* **Enrollments:** This entity captures the relationship between students and courses, logging each enrollment's timestamp for audit purposes.
* **Students:** While primarily identified by roll numbers, the student entity includes dimensions relevant for recommendation calculations, such as grades and marks.

Each of these entities is normalized to reduce redundancy and enhance data integrity, ensuring the system can efficiently handle thousands of student records and course interactions.

**6.6 Recommendation System Design**

* **Student Interface**

The Student Interface is designed with simplicity and ease of navigation, empowering students to explore personalized course recommendations and manage their enrollment options seamlessly. Key features include real-time seat availability checks, intuitive enrollment buttons, and the capacity for students to visualize suggested courses.

* **Faculty and HOD Interfaces**

The interfaces for faculty and HODs embed robust administrative tools, incorporating real-time visualization tools for enrollment statistics and course management functions such as seat capacity adjustment. The HOD interface additionally equips administrative users with functionalities to manage and modify student enrollments, reinforcing the system’s dynamic seat allocation capabilities.

**6.7 Technical Implementation**

* **Concurrent Enrollment Management**

The system’s concurrency model is implemented to support simultaneous multiple-user interactions with the database, particularly accommodating scenarios where students attempt to enroll in popular courses that rapidly reach capacity. The SQLite database configurations ensure thread-safe operations, preventing data integrity conflicts during concurrent transactions.

* **Role-based Access Control**

The access control mechanism restricts specific functionalities based on user roles, enforcing the segregation of administrative controls from student user actions. The role-based access system enforces policies ensuring that only HODs and faculty members can execute critical course management operations such as seat capacity modifications and managing direct enrollments.

* **Real-time Dashboards and Visualization**

Plotly-powered dashboards facilitate real-time data visualization of enrollment trends and statistics, vital for quick decision-making by faculty members and department heads. These interactive charts enable stakeholders to instantly observe the effects of enrollment changes and seat management actions.

* **Session State Management**

Session state variables are crucial for persisting user data across navigation states within the application, ensuring that session-specific data, such as student identification details and recommended courses, are retained through interactions with the application.

# CHAPTER-7

**TIMELINE FOR EXECUTION OF PROJECT**

A graph showing a graph

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**Fig 3.1 Project Timeline**

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# CHAPTER-8

# OUTCOME

The outcome of this project is to deliver a fully functional, **personalized elective course recommendation system** that improves the course selection and enrollment process for students, faculty, and academic administrators. The primary outcomes of the project include:

* **Personalized Course Recommendations:** The system will provide students with tailored elective course suggestions based on their academic records, performance trends, and preferences. By utilizing collaborative filtering with cosine similarity, the system will enhance students' satisfaction by recommending courses that align with their strengths and interests, improving both their academic performance and engagement.
* **Real-Time Seat Management:** The project will deliver a dynamic seat management system that tracks seat availability in real-time. It will address over-enrollment issues by suggesting alternative courses or notifying Heads of Departments (HoDs) to adjust seat capacities, ensuring smooth course registrations and preventing overcrowded courses. This feature will optimize the overall enrollment process, making it more efficient and scalable.
* **User-Friendly Interfaces:** The outcome will include intuitive, accessible interfaces for three key stakeholders—students, faculty, and HoDs. Students will benefit from a personalized course selection experience, faculty can easily monitor enrollments, and HoDs will have real-time control over seat allocations. The design of these interfaces ensures that all stakeholders can easily interact with the system, improving usability and user experience.
* **Interactive Dashboards for Data-Driven Decision Making:** The system will feature **interactive dashboards** that provide visualizations of enrollment trends, seat availability, and course demand in real-time. These dashboards, powered by **Plotly,** will enable faculty and administrators to make informed decisions quickly, facilitating better management of courses and resources.
* **Scalable and Efficient System:** The project will result in a **scalable** solution capable of handling a large number of student records and real-time updates without compromising performance. The system’s database operations will be optimized for **thread safety**, ensuring that the system can manage concurrent enrollments effectively, even during peak periods.
  1. **Enhanced Enrollment Process:** By integrating personalized course recommendations with real-time seat management and interactive dashboards, the project will significantly enhance the overall student enrollment experience. The system will make the process more efficient, reduce manual intervention, and ensure that students are placed in courses that suit their academic profiles and interests.

# CHAPTER 9

# RESULT AND DISCUSSION

The developed **personalized elective course recommendation system** successfully integrates machine learning algorithms, real-time seat management, and interactive dashboards to optimize the course selection and enrollment process for students and academic administrators. The **collaborative filtering algorithm** using cosine similarity proved effective in generating personalized course recommendations based on student performance and preferences. This approach ensured that students received course suggestions that were closely aligned with their academic strengths and interests, leading to higher satisfaction and engagement. By leveraging historical data such as student marks, grades, and previous course selections, the system generated tailored recommendations that improved the overall student experience in course selection.

The **real-time seat management system**, built using **SQLite3**, dynamically tracked seat availability for each course and resolved issues such as over-enrollment. The system provided alternative course recommendations or alerted **Heads of Departments (HoDs)** to adjust seat capacities when needed, ensuring a seamless enrollment process. This feature significantly reduced manual intervention and allowed administrators to manage course offerings efficiently, even during peak enrollment periods. As a result, the system was scalable, handling large datasets and concurrent enrollments without compromising performance.

The **user-friendly interfaces**, developed using **Streamlit**, catered to the needs of three key stakeholders: students, faculty, and HoDs. Students benefited from personalized recommendations, faculty could monitor enrollments effectively, and HoDs had real-time control over seat allocations. The **interactive dashboards** powered by **Plotly** provided stakeholders with visualizations of enrollment trends and seat availability in real-time, enabling data-driven decision-making. These dashboards proved to be an essential tool for HoDs and faculty, helping them make informed decisions about course management and resource allocation.

In the discussion, it is evident that the integration of **collaborative filtering** and **real-time data management** in the system significantly enhanced the elective course recommendation and enrollment process. The personalized nature of the recommendations led to better student course alignment, which is crucial for improving academic performance and satisfaction. The real-time seat management feature addressed the common issue of over-enrollment, ensuring that students had access to alternative courses when their first choice was unavailable. Moreover, the system’s scalability allowed it to handle large datasets and high enrollment volumes effectively, making it suitable for institutions of varying sizes.

The **interactive dashboards** further contributed to effective decision-making by providing real-time insights into enrollment trends and seat availability. These dashboards empowered faculty and administrators to respond proactively to enrollment changes and manage courses and seat capacities accordingly. However, while the system met the project’s objectives, there are opportunities for improvement. For example, integrating additional data sources like student interests, career aspirations, or even past course feedback could further refine the recommendations. Additionally, implementing a feedback loop where students can rate their recommended courses would help personalize the system even more, enabling continuous improvement in the course recommendation process. Overall, the project successfully delivers a comprehensive, scalable, and user-friendly solution to course recommendation and seat management, offering significant benefits to students, faculty, and academic administrators.

# CHAPTER-10

**CONCLUSION**

The project undertaken, centered around the design and implementation of an academic course recommendation system, provides an innovative solution to the longstanding issue faced by students at Presidency University in selecting their desired electives. The core objective was to alleviate students' frustrations when elective assignments either fail to align with their preferences or diverge from the shared academic journey with their peers, thereby causing discontent and confusion. At its essence, our system is designed to intelligently and equitably recommend electives, making the selection process more predictable and student-friendly.

The method employed in constructing this recommendation engine utilizes collaborative filtering, a formidable approach in the realm of machine learning that harnesses the power of collective user interactions to make personalized suggestions. The dataset backing this system is robust, encompassing 10,600 student records across 24 unique courses, capturing critical features such as student marks, grades, and grade points. These attributes form the backbone of the recommendation engine, where machine learning models, particularly those utilizing cosine similarity, leverage student performance data to identify and predict suitable courses for each student. This academic machine learning solution is reflective of modern educational data science, parsing through voluminous data to distill insights and offer tangible benefits.

The solution robustly integrates technology components including Python, Streamlit, SQLite3, and Scikit-learn, ensuring scalability, maintainability, and ease of deployment. The choice of these technologies was strategic, given their strong support for data analytics, user interface design, and database management, crucial for a project of this nature. With Streamlit providing a dynamic web application interface, stakeholders can access, interact, and derive insights effortlessly. Meanwhile, SQLite3 functions as the backend engine, ensuring efficient and secure data transactions, quite essential given the concurrency requirements when handling multiple user interactions during peak enrollment times.

One of the paramount features of the system is its real-time seat allocation management, which presents accurate and up-to-the-minute information about available seats in each elective. This functionality is indispensable for both students and administrative personnel, as it prevents over-enrollment and ensures fair distribution based on real-time data. The automated seat allocation further simplifies the role of the Head of Department (HoD) and faculty, reducing manual interventions and potentially arbitrary assignments.

The system is architected to support three primary user interfaces: Student, HOD, and Faculty. Each interface is tailored to address the unique needs and responsibilities of its respective users. The Student Interface focuses on personalizing the academic journey by providing course recommendations, supporting enrollment, and tracking elective choices. For the HoD, the interface extends capabilities such as modifying seat capacities and managing overall enrollment statistics, thus empowering administrators with tools for effective academic planning. The Faculty Interface parallels these functions by offering insights into student enrollment trends, which can bolster curriculum evaluations and pedagogical approaches.

Role-based access control is integral to the system, ensuring that users only interact with functions pertinent to their roles. This is achieved through session state management facilitated by Streamlit, which maintains user sessions naturally over interactions with the application. This consideration assures that operations remain exclusive and secure, guarding sensitive academic data against unauthorized access.

Visualization is a key component of the system, manifest through real-time dashboards powered by Plotly Express. These dashboards visually communicate enrollment statistics, effectively transforming raw data into actionable insights for decision-making. Such data-driven narratives enhance the university's strategic oversight of course offerings and can drive continuous improvements in elective course provisions.

Database management and operations within the system are thread-safe, an essential feature given the simultaneous interactions by numerous users, especially during peak periods of course selection. This ensures a seamless, uninterrupted user experience with no compromise on data integrity or consistency. Moreover, the modular architecture of the project, comprising five core Python files, advocates for clean, maintainable code, enabling straightforward future enhancements or modifications with minimal disruption.Administrative tasks are further streamlined through functionalities that allow for data exportation. The export capability is crucial for record-keeping, reporting, and further analysis by administrative staff, cementing the application as an invaluable tool in academic administration.

In summary, our project transcends traditional course recommendation systems by not only leveraging state-of-the-art machine learning techniques but also by embedding a holistic suite of features that address the nuances of academic elective selection and management. Through the collaborative synthesis of AI-driven insights, intuitive user interfaces, and robust backend support, the system stands as a beacon of innovation, fostering an environment where student preferences align with academic offerings, ultimately contributing to enhanced student satisfaction and institutional efficacy.

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**APPENDIX-A**

**PSUEDOCODE**

**Database.py:**

import sqlite3

import pandas as pd

class Database:

def \_init\_(self):

self.conn = sqlite3.connect('elective\_system.db', check\_same\_thread=False)

self.create\_tables()

self.initialize\_courses()

def create\_tables(self):

cursor = self.conn.cursor()

# Create courses table

cursor.execute('''

CREATE TABLE IF NOT EXISTS courses (

course\_code TEXT PRIMARY KEY,

seat\_capacity INTEGER DEFAULT 300

)

''')

# Create enrollments table

cursor.execute('''

CREATE TABLE IF NOT EXISTS enrollments (

id INTEGER PRIMARY KEY AUTOINCREMENT,

roll\_number TEXT,

course\_code TEXT,

enrollment\_date TIMESTAMP DEFAULT CURRENT\_TIMESTAMP,

FOREIGN KEY (course\_code) REFERENCES courses (course\_code)

)

''')

self.conn.commit()

def initialize\_courses(self):

courses = [

'CSE228', 'CSE3114', 'CSE3005', 'CSE3115', 'CSE3014',

'CSE3112', 'CSE243', 'CSE3111', 'CSE6002', 'BCA217',

'CSA3020', 'CSE3113', 'CSE3134', 'CSE3001', 'CSE3036',

'CSE5006', 'CSE3106', 'CSE2037', 'CSE2039', 'MAT1002',

'CSE3152', 'CSE2060', 'CSE2015', 'CSE3087'

]

cursor = self.conn.cursor()

for course in courses:

cursor.execute('''

INSERT OR IGNORE INTO courses (course\_code) VALUES (?)

''', (course,))

self.conn.commit()

def get\_all\_courses(self):

cursor = self.conn.cursor()

cursor.execute('SELECT course\_code FROM courses')

return [row[0] for row in cursor.fetchall()]

def enroll\_student(self, roll\_number, course\_code):

cursor = self.conn.cursor()

# Check seat availability

cursor.execute('SELECT seat\_capacity FROM courses WHERE course\_code = ?', (course\_code,))

capacity = cursor.fetchone()[0]

cursor.execute('SELECT COUNT(\*) FROM enrollments WHERE course\_code = ?', (course\_code,))

current\_enrollments = cursor.fetchone()[0]

if current\_enrollments >= capacity:

return False, "No seats available. Please contact HOD."

cursor.execute('''

INSERT INTO enrollments (roll\_number, course\_code)

VALUES (?, ?)

''', (roll\_number, course\_code))

self.conn.commit()

return True, "Enrollment successful"

def update\_seat\_capacity(self, course\_code, new\_capacity):

cursor = self.conn.cursor()

cursor.execute('''

UPDATE courses SET seat\_capacity = ? WHERE course\_code = ?

''', (new\_capacity, course\_code))

self.conn.commit()

def get\_course\_enrollments(self, course\_code):

return pd.read\_sql\_query('''

SELECT \* FROM enrollments WHERE course\_code = ?

''', self.conn, params=(course\_code,))

def get\_seat\_capacity(self, course\_code):

cursor = self.conn.cursor()

cursor.execute('SELECT seat\_capacity FROM courses WHERE course\_code = ?', (course\_code,))

return cursor.fetchone()[0]

def get\_enrollment\_count(self, course\_code):

cursor = self.conn.cursor()

cursor.execute('SELECT COUNT(\*) FROM enrollments WHERE course\_code = ?', (course\_code,))

return cursor.fetchone()[0]

def delete\_enrollment(self, enrollment\_id):

cursor = self.conn.cursor()

cursor.execute('DELETE FROM enrollments WHERE id = ?', (enrollment\_id,))

self.conn.commit()

def verify\_seat\_status(self, course\_code):

capacity = self.get\_seat\_capacity(course\_code)

enrolled = self.get\_enrollment\_count(course\_code)

return {

'capacity': capacity,

'enrolled': enrolled,

'available': capacity - enrolled

}

**Student.py**

import streamlit as st

from database import Database

from recsys import RecommendationSystem

class StudentInterface:

def \_init\_(self):

self.db = Database()

self.recsys = RecommendationSystem()

def render(self):

st.set\_page\_config(page\_title="Student Portal", layout="wide")

st.title("🎓 Student Course Recommendation Portal")

with st.sidebar:

st.info("""

Please choose the exact number of courses required based on your upcoming semester requirements.

- If you need one elective: Select one course

- If you need multiple electives: Select accordingly

🧑‍🏫 👩‍🏫 📚

""")

# Initialize session state

if 'roll\_number' not in st.session\_state:

st.session\_state.roll\_number = ''

if 'recommendations' not in st.session\_state:

st.session\_state.recommendations = None

# Roll number input

roll\_number = st.text\_input("Enter your Roll Number:", value=st.session\_state.roll\_number)

# Get Recommendations button

if st.button("Get Recommendations") or st.session\_state.roll\_number:

if roll\_number:

st.session\_state.roll\_number = roll\_number

recommended\_courses, message = self.recsys.get\_recommendations(roll\_number)

st.session\_state.recommendations = recommended\_courses

# Display recommendations if available

if st.session\_state.recommendations:

st.success("🎯 Your Personalized Course Recommendations:")

for course in st.session\_state.recommendations:

col1, col2, col3 = st.columns([3, 2, 2])

seats\_available = self.db.get\_seat\_capacity(course)

current\_enrollments = self.db.get\_enrollment\_count(course)

remaining\_seats = seats\_available - current\_enrollments

with col1:

st.write(f"{course}")

with col2:

st.write(f"Available Seats: {remaining\_seats}")

with col3:

if remaining\_seats > 0:

if st.button(f"Enroll in {course}", key=course):

success, msg = self.db.enroll\_student(st.session\_state.roll\_number, course)

if success:

st.success(f"Successfully enrolled in {course}")

else:

st.error(msg)

else:

st.warning("No seats available")

if \_name\_ == "\_main\_":

student\_interface = StudentInterface()

student\_interface.render()

**Hod.py:**

import streamlit as st

import plotly.express as px

from database import Database

import pandas as pd

class HODInterface:

def \_init\_(self):

self.db = Database()

def render(self):

st.set\_page\_config(page\_title="HOD Portal", layout="wide" )

st.title("👨‍🏫 Head of Department Portal")

# Sidebar information

with st.sidebar:

st.info("""

As HOD, you can:

- View enrollment statistics

- Modify seat capacity

- Manage student enrollments

- Download enrollment data

""")

# Enrollment Statistics Visualization

self.show\_enrollment\_statistics()

# Course Management Section

st.subheader("Course Management")

for course in self.db.get\_all\_courses():

with st.expander(f"📚 {course}"):

self.manage\_course(course)

def show\_enrollment\_statistics(self):

# Prepare data for visualization

courses\_data = []

for course in self.db.get\_all\_courses():

total\_seats = self.db.get\_seat\_capacity(course)

enrolled = self.db.get\_enrollment\_count(course)

percentage = (enrolled / total\_seats) \* 100 if total\_seats > 0 else 0

courses\_data.append({

'Course': course,

'Enrollment Percentage': percentage

})

df = pd.DataFrame(courses\_data)

# Create bar plot

fig = px.bar(

df,

x='Course',

y='Enrollment Percentage',

title='Course Enrollment Statistics',

color='Enrollment Percentage',

color\_continuous\_scale='Viridis'

)

st.plotly\_chart(fig)

def manage\_course(self, course\_code):

col1, col2, col3 = st.columns([2, 1, 1])

with col1:

# Search functionality

search\_term = st.text\_input(f"Search enrollments for {course\_code}", key=f"search\_{course\_code}")

with col2:

# Seat capacity modification

current\_capacity = self.db.get\_seat\_capacity(course\_code)

new\_capacity = st.number\_input(

"Seat Capacity",

min\_value=0,

value=current\_capacity,

key=f"capacity\_{course\_code}"

)

if new\_capacity != current\_capacity:

self.db.update\_seat\_capacity(course\_code, new\_capacity)

# Display enrollments

enrollments = self.db.get\_course\_enrollments(course\_code)

if search\_term:

enrollments = enrollments[enrollments['roll\_number'].str.contains(search\_term, case=False)]

st.dataframe(enrollments)

# Download button

if not enrollments.empty:

csv = enrollments.to\_csv(index=False)

st.download\_button(

f"Download {course\_code} enrollments",

csv,

f"{course\_code}\_enrollments.csv",

"text/csv"

)

# Delete functionality

if not enrollments.empty:

enrollment\_to\_delete = st.selectbox(

"Select enrollment to delete",

enrollments['id'],

key=f"delete\_{course\_code}"

)

if st.button("Delete Selected Enrollment", key=f"delete\_button\_{course\_code}"):

self.db.delete\_enrollment(enrollment\_to\_delete)

st.success("Enrollment deleted successfully")

if \_name\_ == "\_main\_":

hod\_interface = HODInterface()

hod\_interface.render()

**faculty.py:**

import streamlit as st

import plotly.express as px

from database import Database

import pandas as pd

class FacultyInterface:

def \_init\_(self):

self.db = Database()

def render(self):

st.set\_page\_config(page\_title="Faculty Portal", layout="wide")

st.title("👩‍🏫 Faculty Portal")

# Sidebar information

with st.sidebar:

st.info("""

As Faculty, you can:

- View enrollment statistics

- Select multiple courses to view enrollments

- Search for specific students

- Download enrollment data

""")

# Show enrollment statistics visualization

self.show\_enrollment\_statistics()

# Course selection section

st.subheader("Course Selection")

# Multi-select dropdown for courses

available\_courses = self.db.get\_all\_courses()

selected\_courses = st.multiselect(

"Select courses to view enrollments:",

available\_courses,

default=None

)

if selected\_courses:

for course in selected\_courses:

with st.expander(f"📚 {course} Details"):

self.show\_course\_details(course)

def show\_enrollment\_statistics(self):

# Prepare data for visualization

courses\_data = []

for course in self.db.get\_all\_courses():

total\_seats = self.db.get\_seat\_capacity(course)

enrolled = self.db.get\_enrollment\_count(course)

percentage = (enrolled / total\_seats) \* 100 if total\_seats > 0 else 0

courses\_data.append({

'Course': course,

'Enrollment Percentage': percentage,

'Total Seats': total\_seats,

'Enrolled Students': enrolled

})

df = pd.DataFrame(courses\_data)

# Create bar plot

fig = px.bar(

df,

x='Course',

y='Enrollment Percentage',

title='Course Enrollment Statistics',

color='Enrollment Percentage',

color\_continuous\_scale='Viridis',

hover\_data=['Total Seats', 'Enrolled Students']

)

st.plotly\_chart(fig)

def show\_course\_details(self, course\_code):

# Display current seat availability

seats\_available = self.db.get\_seat\_capacity(course\_code)

current\_enrollments = self.db.get\_enrollment\_count(course\_code)

remaining\_seats = seats\_available - current\_enrollments

st.metric(

label="Available Seats",

value=remaining\_seats,

delta=f"Total Capacity: {seats\_available}"

)

# Search functionality

search\_term = st.text\_input(

"Search students by roll number:",

key=f"search\_{course\_code}"

)

# Get and display enrollments

enrollments = self.db.get\_course\_enrollments(course\_code)

if search\_term:

enrollments = enrollments[

enrollments['roll\_number'].str.contains(search\_term, case=False)

]

if not enrollments.empty:

st.dataframe(enrollments)

# Download button

csv = enrollments.to\_csv(index=False)

st.download\_button(

f"Download {course\_code} enrollments",

csv,

f"{course\_code}\_enrollments.csv",

"text/csv",

key=f"download\_{course\_code}"

)

else:

st.info("No enrollments found for this course")

if \_name\_ == "\_main\_":

faculty\_interface = FacultyInterface()

faculty\_interface.render()

**Recsys.py:**

import pandas as pd

import numpy as np

from sklearn.metrics.pairwise import cosine\_similarity

class RecommendationSystem:

def \_init\_(self):

self.df = pd.read\_excel('/Users/apple/Downloads/MODIFIED\_TESTING\_VERSION/dataset for ml recommendation system for elective.xlsx')

self.process\_data()

def process\_data(self):

# Convert grades to numerical values if needed

self.df['Grade\_Points'] = pd.to\_numeric(self.df['Grade Points'])

self.df['Marks'] = pd.to\_numeric(self.df['Marks (200)'])

def verify\_student(self, roll\_number):

return roll\_number in self.df['RollNumber'].values

def get\_recommendations(self, roll\_number):

if not self.verify\_student(roll\_number):

return None, "Please enter correct rollno"

# Get student's features

student\_data = self.df[self.df['RollNumber'] == roll\_number]

student\_features = student\_data[['Marks (200)', 'Grade Points']].values

# Calculate similarity with all courses

all\_courses = self.df.groupby('Course Code')[['Marks (200)', 'Grade Points']].mean()

similarities = cosine\_similarity(student\_features, all\_courses.values)

# Get top 10 courses

course\_scores = pd.Series(similarities[0], index=all\_courses.index)

recommended\_courses = course\_scores.nlargest(10).index.tolist()

return recommended\_courses, "Success"

# APPENDIX-B SCREENSHOTS

**A screenshot of a computer

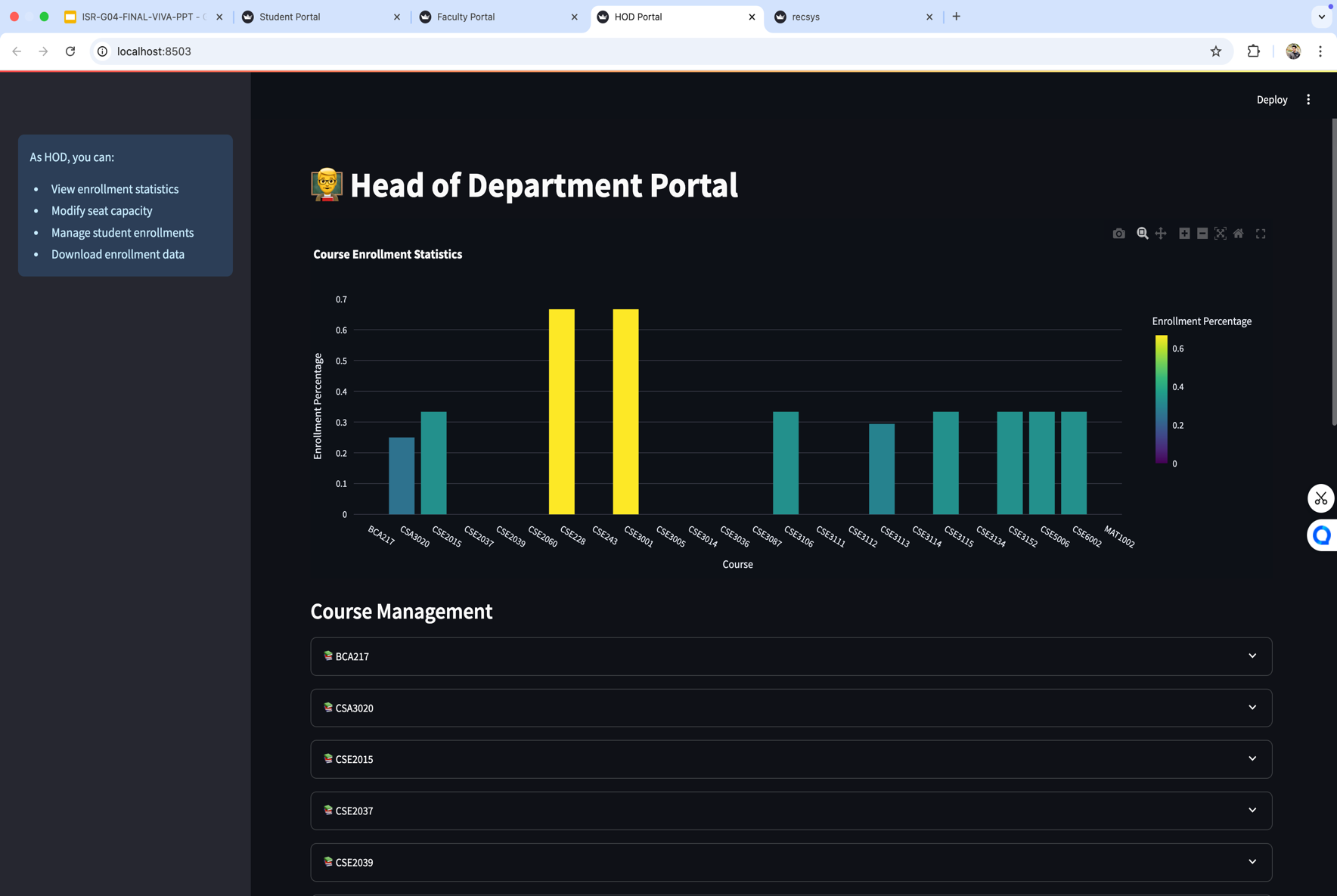
Description automatically generated**

**Fig 4.1 Student Course Login Portal**

**A screenshot of a computer

Description automatically generated**

**Fig 4.2 Faculty Login Portal**

****

**Fig 4.3 Head Of Department Login Portal**

**A screenshot of a computer

Description automatically generated**

**Fig 4.4 Student Portal**

**A screenshot of a computer

Description automatically generated**

**Fig 4.5 Faculty Portal**

**A screenshot of a computer

Description automatically generated**

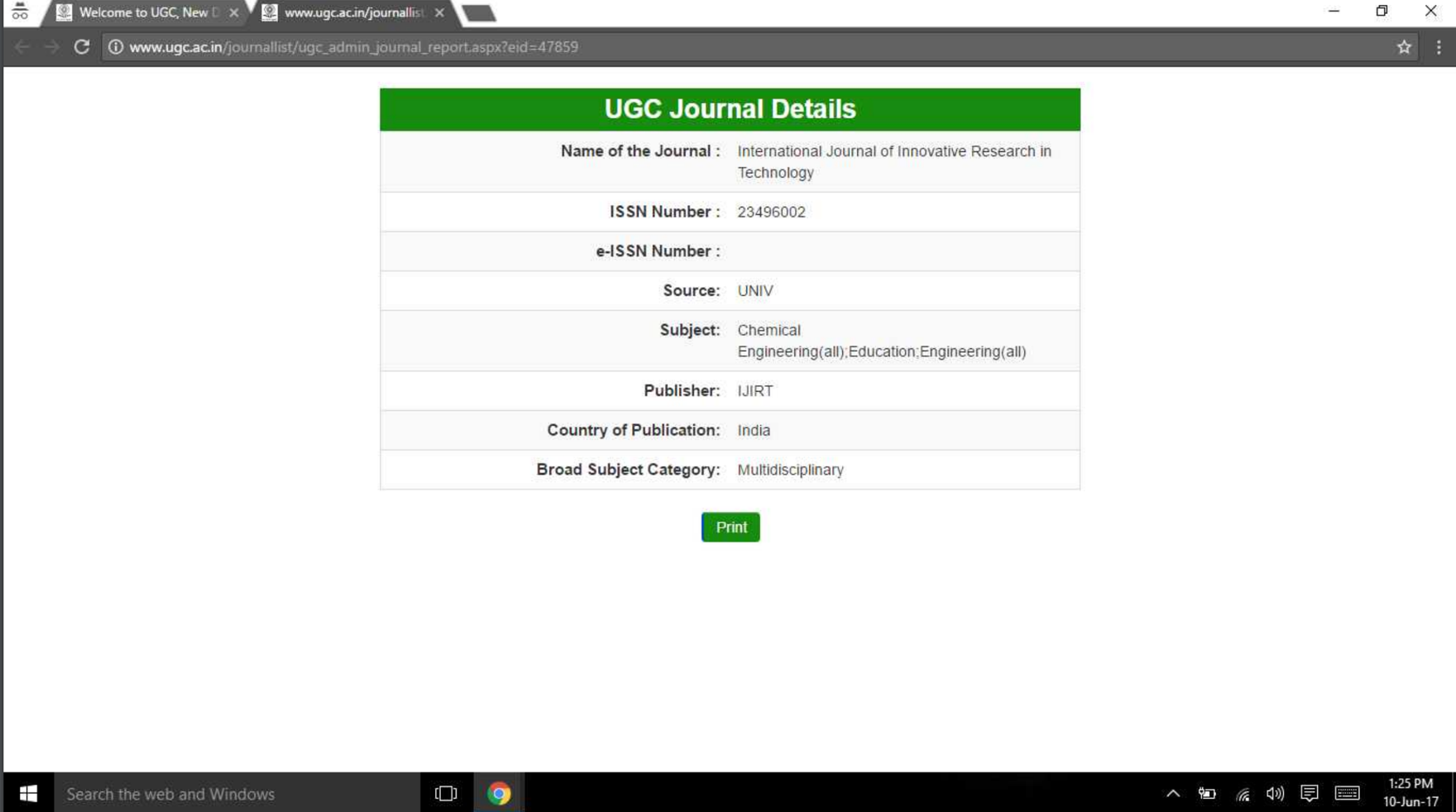
**Fig 4.6 HOD Portal**

**A screenshot of a computer

Description automatically generated**

**Fig 4.7 HOD Portal (2)**

**APPENDIX-C ENCLOSURES**

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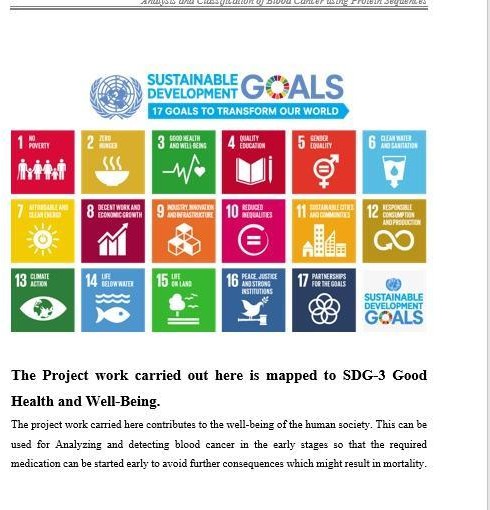
****







# SUSTAINABLE DEVELOPMENT GOALS

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**Project Mapping: SDG 4 - Quality Education**

* **Improved Access to Education:**

Facilitates equitable access to quality education by offering personalized elective recommendations, ensuring that students from diverse backgrounds can make informed decisions about their academic paths.

* **Inclusivity and Accessibility**:

Extends the benefits of personalized learning to underrepresented or rural areas, enabling students in remote locations to choose electives that align with their interests and academic goals.

* **Personalized Learning Pathways:**

Provides AI-powered, data-driven recommendations that tailor elective suggestions based on individual interests, academic performance, and career aspirations, fostering student engagement and success.

* **Skill Development and Lifelong Learning:**

Encourages students to select electives that enhance their skill sets, promoting lifelong learning opportunities and empowering them to adapt to dynamic professional landscapes.

* **Education for All:**

Reduces the dependence on one-size-fits-all course advising methods, ensuring that every student receives personalized support, regardless of their background or academic standing.

* **Improved Student Outcomes:**

Helps identify electives that align with students' strengths and interests, boosting academic performance, satisfaction, and retention rates in higher education.

* **Bridging Gaps in Academic Guidance:**

Addresses gaps in educational counseling by providing data-driven recommendations, particularly in institutions where access to dedicated academic advisors may be limited.

* **Support for Career Readiness:**

Aligns elective recommendations with industry demands and future career opportunities, preparing students to meet workforce requirements effectively.

* **Promoting Holistic Education:**

Encourages students to explore diverse disciplines, fostering a multidisciplinary approach that enhances creativity, critical thinking, and problem-solving abilities.

* **Education Analytics and Insights:**

Aggregates and analyzes student preferences and performance data to provide actionable insights for educators, enabling them to design curricula that better cater to student needs and trends.

* **Global Perspective:**

Ensures that the education system incorporates global competencies by recommending electives that cover emerging areas like sustainability, technology, and social responsibility.

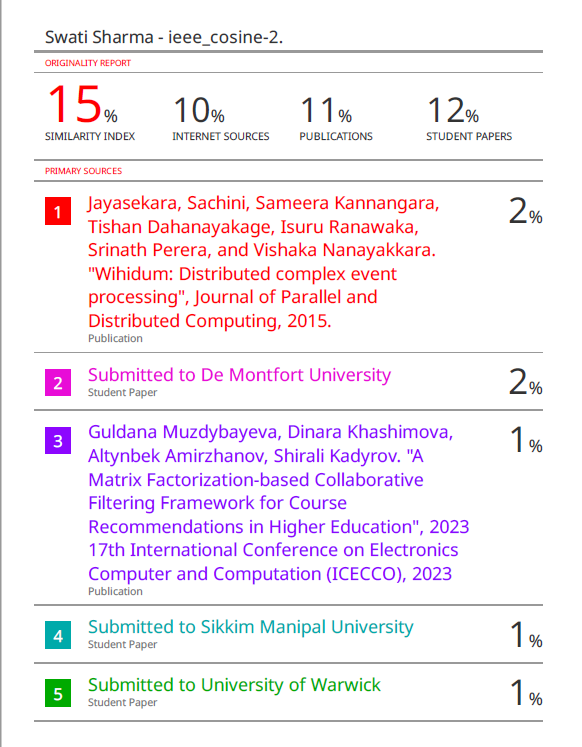
* **Fostering Equity in Education:**

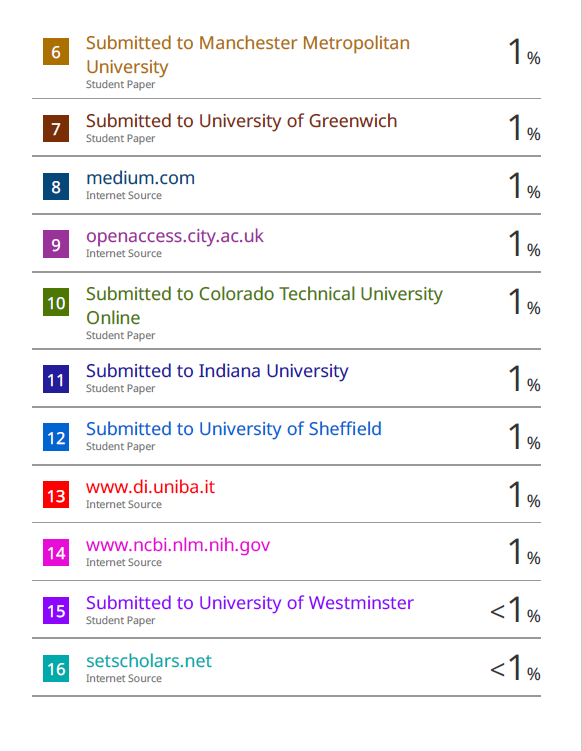
Supports disadvantaged and marginalized students by democratizing access to academic resources and personalized learning tools, reducing disparities in educational opportunities.

* **Empowering Educators:**

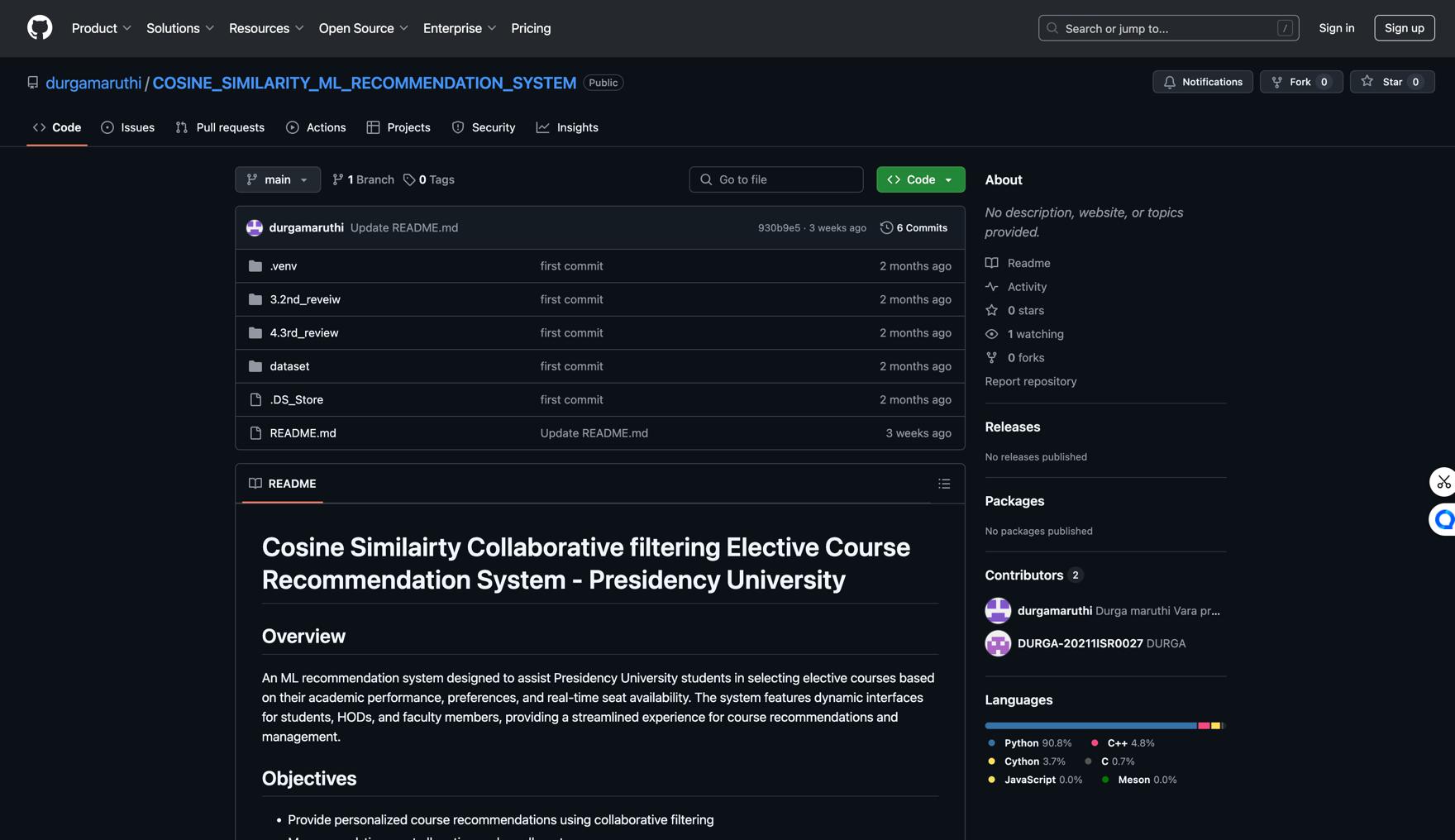
Provides educators with tools to understand students' preferences and learning paths, enabling them to offer targeted support and mentorship.

**PLAGIARISM CHECK**





**GITHUB**

****

<https://github.com/durgamaruthi/COSINE_SIMILARITY_ML_RECOMMENDATION_SYSTEM.git>