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A Hybrid AI-Based Educational Application Recommendation System Using Content Filtering and User Preference Modeling

GUTTULA SUJITHA

PG Scholar. Department of MCA, DNR College, Bhimavaram, Andhra Pradesh

K. Rambabu

(Assistant Professor), Master of Computer Applications, DNR College, Bhimavaram, Andhra Pradesh

ABSTRACT

In the rapidly evolving digital learning ecosystem, users are often overwhelmed by the vast number of educational applications available across multiple domains. Identifying the most relevant and effective learning tools tailored to individual needs remains a significant challenge. This project presents a **Hybrid AI-Based Educational Application Recommendation System** designed to deliver personalized suggestions using a combination of content-based filtering and user preference modeling. The system is developed using the Django web framework and integrates machine learning techniques to enhance user experience. It utilizes **content-based filtering** by analyzing application metadata such as category and description using Term Frequency-Inverse Document Frequency (TF-IDF) and cosine similarity. This enables the system to recommend applications that are similar in content to those previously explored by the user. In addition, the system incorporates **user preference-based personalization**, where user attributes such as interested categories, education level, job role, and location are considered. A scoring mechanism evaluates how well each application aligns with the user's profile, ensuring highly relevant recommendations. To improve diversity and avoid recommendation stagnation, controlled randomness is introduced in the ranking process.

The system also integrates a **crowdsourcing module**, allowing users to provide ratings, reviews, complexity levels, and tags for applications. This user-generated data contributes to improving recommendation accuracy over time. Furthermore, a deep learning model using TensorFlow is proposed as an extension to predict user ratings based on combined user and application features, enabling future scalability and intelligence. The platform supports essential functionalities such as user authentication, search capabilities, detailed application views, and recommendation dashboards. It ensures a seamless and interactive user experience while maintaining modularity and scalability in design. Overall, this system bridges the gap between user needs and available educational resources by leveraging hybrid recommendation strategies. It

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provides an efficient, intelligent, and adaptive solution for personalized learning, making it highly beneficial for students, professionals, and lifelong learners.

KEYWORDS: Educational Recommendation System, Content-Based Filtering, Machine Learning, Deep Learning, Personalization, TF-IDF, Cosine Similarity, Django, User Preferences, Crowd sourcing

I. INTRODUCTION

The digital transformation of education has led to an exponential increase in the number of educational applications available to learners worldwide. From language learning platforms to coding tools and interactive simulations, users now have access to a vast repository of digital learning resources. However, this abundance creates a significant challenge: **how to identify the most relevant applications that suit individual learning needs**.Traditional search methods rely heavily on keyword matching and manual browsing, which are often inefficient and time-consuming. Users may struggle to find applications that align with their interests, skill levels, and goals. This has led to the emergence of **recommendation systems**, which aim to filter and present personalized content based on user behavior and preferences.

This project introduces a **Hybrid Educational Application Recommendation System** that combines multiple recommendation techniques to improve accuracy and relevance. The system is built using Django, a robust Python-based web framework, ensuring scalability and maintainability. It integrates machine learning techniques to analyze application content and user preferences, providing intelligent recommendations.The core of the system lies in two major components: **content-based filtering** and **personalized scoring**. Content-based filtering analyzes textual information such as application descriptions and categories using TF-IDF vectorization and cosine similarity. This helps in identifying applications that are similar to those previously viewed or selected by the user. On the other hand, personalized scoring considers user-specific attributes such as preferred categories, education level, job role, and geographic location. By matching these attributes with application metadata, the system generates recommendations that are more aligned with the user's learning objectives.

To further enhance the system, a **crowd sourcing mechanism** is implemented. Users can contribute ratings, reviews, and tags, which enrich the dataset and improve recommendation quality over time. Additionally, a deep learning model is proposed to predict user preferences based on historical data, paving the way for advanced

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recommendation strategies. The system also includes essential features such as user authentication, search functionality, and a dynamic dashboard, ensuring a user-friendly experience. By combining multiple techniques, the system overcomes the limitations of traditional recommendation methods and provides a more comprehensive solution. In conclusion, this project aims to simplify the process of discovering educational applications by delivering accurate, personalized, and intelligent recommendations. It contributes to enhancing digital learning experiences and supports users in achieving their educational goals effectively.

II. LITERATURE SURVEY (WITH EXISTING METHODS)

Recommendation systems have been extensively studied in the field of machine learning and data mining. They are broadly categorized into **content-based filtering**, **collaborative filtering**, and **hybrid approaches**. Content-based filtering focuses on analyzing item features to recommend similar items. Research by Salton and Buckley introduced the concept of TF-IDF for text representation, which remains a fundamental technique in information retrieval systems. Later studies demonstrated the effectiveness of cosine similarity in identifying relationships between textual data. In educational domains, content-based systems have been used to recommend courses, learning materials, and applications based on user interests. Collaborative filtering, on the other hand, relies on user behavior and interactions. It identifies patterns among users with similar preferences and recommends items accordingly. Techniques such as user-based and item-based collaborative filtering have shown significant success in platforms like e-commerce and streaming services. However, collaborative filtering suffers from the **cold-start problem**, where new users or items lack sufficient data for accurate recommendations.

To address these limitations, hybrid recommendation systems have been proposed. Burke (2002) highlighted the advantages of combining multiple techniques to improve recommendation accuracy and robustness. Hybrid systems can leverage both item features and user behavior, reducing the impact of data sparsity and cold-start issues. Recent advancements have introduced **deep learning-based recommendation systems**. Neural networks, particularly feed forward and recurrent architectures, have been used to model complex relationships between users and items. Tensor Flow and PyTorch frameworks have enabled scalable implementation of such models. Studies have shown that deep learning models can significantly enhance recommendation accuracy by capturing nonlinear patterns in data. Crowd sourcing has also emerged as a valuable approach for enriching recommendation systems. User-generated content such as ratings, reviews, and tags provides additional insights into item quality and relevance. This data

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can be integrated into machine learning models to improve performance. In the context of educational applications, recommendation systems have been used to suggest learning resources, courses, and tools. However, many existing systems rely on a single technique, limiting their effectiveness. The integration of multiple approaches, along with user preference modeling and crowd sourcing, remains an area of active research. This project builds upon existing literature by combining content-based filtering, personalized scoring, and deep learning. It addresses key challenges such as cold-start and data sparsely while providing a scalable and user-friendly solution.

III. EXISTING SYSTEM

Existing systems for recommending educational applications primarily rely on **basic search mechanisms or single-method recommendation techniques**. Most platforms use keyword-based search, where users manually enter queries to find relevant applications. While this approach is simple, it often fails to provide personalized results, leading to inefficiency and user dissatisfaction. Some systems implement **content-based filtering**, where applications are recommended based on similarities in categories or descriptions. Although effective to some extent, these systems do not consider individual user preferences such as education level, profession, or learning goals. As a result, recommendations may not fully align with user needs. Other platforms use **collaborative filtering**, which depends on user interactions such as ratings and usage patterns. While this method can provide personalized recommendations, it suffers from the cold-start problem, where new users or applications lack sufficient data. This limits the system's ability to generate accurate suggestions.

Additionally, many existing systems lack **user engagement features** such as reviews, tags, and feedback mechanisms. Without crowdsourced data, the system cannot continuously improve or adapt to changing user preferences. Another limitation is the absence of **hybrid approaches** that combine multiple recommendation techniques. Single-method systems often struggle with accuracy, diversity, and scalability. Furthermore, most traditional systems do not incorporate advanced technologies such as deep learning, which can significantly enhance recommendation quality. In summary, existing systems are limited by lack of personalization, inability to handle new users effectively, and minimal integration of user-generated data. These shortcomings highlight

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the need for a more advanced, hybrid recommendation system that can deliver accurate, dynamic, and user-centric suggestions.

IV. PROPOSED METHOD

The proposed system is a **Hybrid Educational Application Recommendation System** that integrates content-based filtering, user preference modeling, and crowdsourced feedback to deliver accurate and personalized recommendations. Unlike traditional systems, this approach combines multiple techniques to overcome limitations such as cold-start problems and lack of personalization.The system operates on three primary components. First, **content-based filtering** analyzes application metadata, including category and description, using TF-IDF vectorization and cosine similarity. This enables the system to identify and recommend applications that are similar in content to those previously viewed or selected by the user.

Second, **user preference modeling** plays a crucial role in personalization. The system collects user-specific information such as interested categories, education level, job role, and location. These attributes are matched with application features to generate a relevance score. Applications that closely align with user preferences are prioritized, ensuring meaningful recommendations.

Third, the system incorporates a **crowdsourcing mechanism**, where users can provide ratings, reviews, complexity levels, and tags. This user-generated data enriches the dataset and enhances recommendation accuracy over time. It also allows the system to dynamically adapt to evolving user preferences.Additionally, the proposed system introduces a **deep learning component** using a neural network model to predict user ratings based on historical interaction data. Hybrid models combining deep learning with traditional techniques have been shown to significantly improve recommendation accuracy and scalability .The system is implemented using Django, ensuring scalability, modularity, and efficient data handling. It also includes features such as search functionality, user authentication, and an interactive dashboard.

Overall, the proposed system provides a robust, adaptive, and intelligent solution for personalized educational app recommendations.

V. IMPLEMENTATION

The implementation of the proposed system is carried out using the **Django web framework**, combined with machine learning and deep learning libraries such as Scikit-learn and TensorFlow. The system is designed in a modular architecture to ensure scalability and maintainability.The backend is developed using Django, which handles

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user authentication, database operations, and request-response cycles. Models such as EducationalApp, UserPreference, and CrowdsourcedData are defined using Django ORM, enabling efficient data storage and retrieval. The system supports user registration, login, logout, and personalized dashboards.The recommendation engine is implemented as a separate module (RecommendationEngine). For content-based filtering, application data is extracted from the database and converted into a Pandas DataFrame. Textual features such as category and description are combined and processed using **TF-IDF vectorization**. The similarity between applications is computed using cosine similarity, allowing the system to recommend similar applications efficiently.For personalized recommendations, the system retrieves user preferences and calculates a relevance score for each application. This score is based on multiple factors, including category matching, education level, job role, and location. A weighted scoring mechanism is used to prioritize applications that align closely with user preferences. Random noise is introduced to ensure diversity in recommendations.

The system also includes a **crowdsourcing module**, where users can submit ratings, reviews, and tags for applications. This data is stored in the database and can be used for future improvements in recommendation accuracy.A basic deep learning model is implemented using TensorFlow. The model consists of multiple dense layers and is designed to predict user ratings based on combined user and application features. Although currently a prototype, this component provides a foundation for future enhancements.The frontend is developed using HTML, CSS, and Django templates. It includes pages for user authentication, dashboard display, application details, and search functionality. The interface is designed to be user-friendly and responsive.Overall, the implementation integrates web development and machine learning techniques to create a functional and scalable recommendation system.

VI. ALGORITHMS

The proposed system uses a combination of machine learning algorithms to generate accurate recommendations.

1. Content-Based Filtering

This algorithm recommends applications based on similarity in features such as category and description. The process involves:

- Converting text data into numerical vectors using TF-IDF.
- Calculating similarity between applications using cosine similarity.

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- Ranking applications based on similarity scores.

This approach ensures that users receive recommendations similar to their interests.

2. Personalized Scoring Algorithm

A custom scoring algorithm is used to rank applications based on user preferences. The steps include:

- Extracting user attributes (categories, education, job role, location).
- Assigning weights to each attribute.
- Calculating a cumulative score for each application.

The scoring formula combines base ratings with preference matching and randomness to ensure diversity.

3. Cosine Similarity

Cosine similarity measures the angle between two vectors to determine similarity. It is widely used in text-based recommendation systems due to its efficiency and accuracy.

4. Deep Learning Model

A feedforward neural network is used to predict user ratings. It consists of:

- Input layer (user and app features)
- Hidden layers with ReLU activation
- Output layer for rating prediction

Deep learning models can capture complex relationships and improve recommendation accuracy .

5. Hybrid Recommendation Approach

The system combines content-based filtering and personalized scoring. Hybrid approaches are known to improve performance by leveraging the strengths of multiple techniques .

VII. SYSTEM DESIGN

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The system follows a **three-tier architecture**, consisting of presentation, application, and data layers.

1. Presentation Layer

This layer represents the user interface of the system. It includes web pages such as signup, login, dashboard, and application detail pages. The frontend is built using HTML, CSS, and Django templates. It interacts with the backend through HTTP requests.

2. Application Layer

The application layer contains the core logic of the system. It includes Django views, forms, and the recommendation engine. The views handle user requests, process input data, and return appropriate responses.

The recommendation engine is the central component of this layer. It processes application data and user preferences to generate recommendations. It includes:

- Content-based filtering module
- Personalized scoring module
- Deep learning module

3. Data Layer

The data layer consists of the database, managed using Django ORM. It includes tables for:

- Educational applications
- User preferences
- Crowdsourced data

This layer ensures efficient storage and retrieval of data.

System Workflow

1. User registers and logs into the system.
2. User preferences are stored in the database.
3. The system retrieves application data.
4. The recommendation engine processes data using filtering and scoring techniques.
5. Personalized recommendations are displayed on the dashboard.

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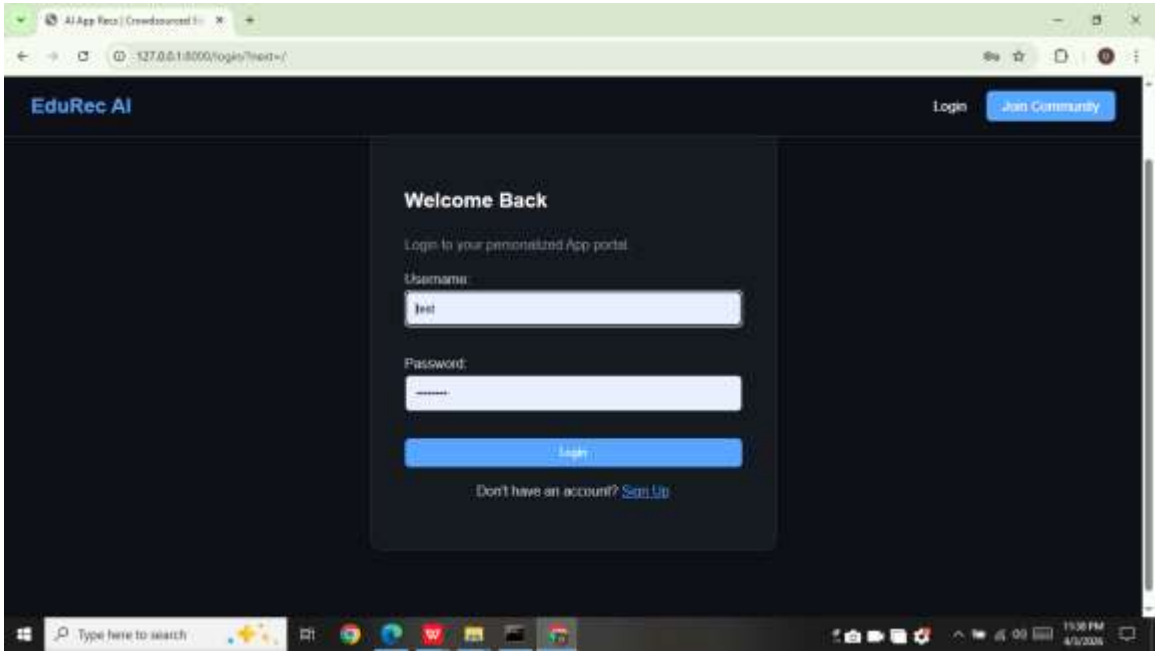
Design Features

- **Scalability:** Modular architecture allows easy integration of new features.
- **Flexibility:** Supports multiple recommendation techniques.
- **User-centric design:** Focuses on personalization.
- **Extensibility:** Deep learning module can be enhanced in future.

Modern hybrid recommendation systems combine multiple techniques to improve accuracy and handle scalability challenges effectively .

SYSTEM DESIGN IMAGES



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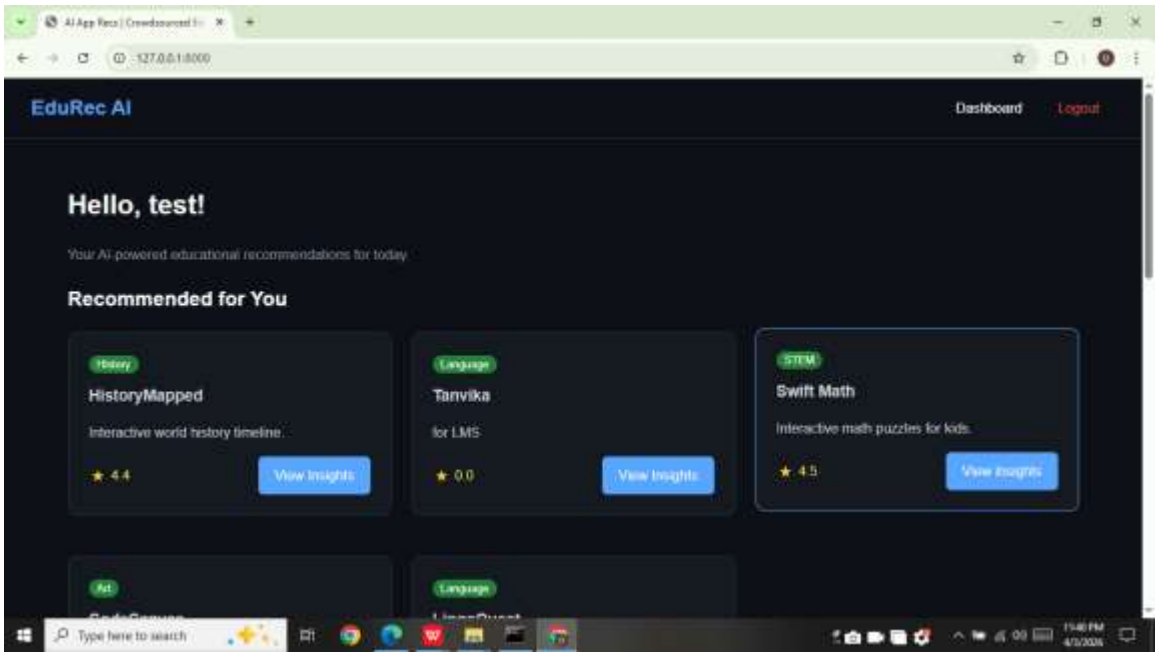

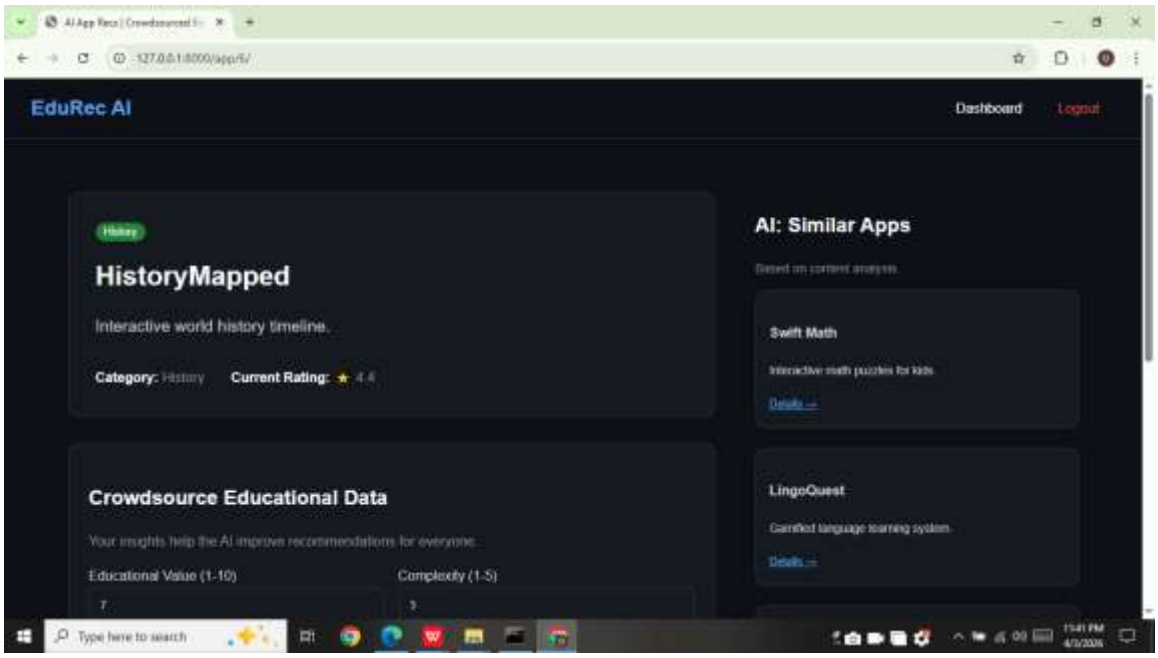

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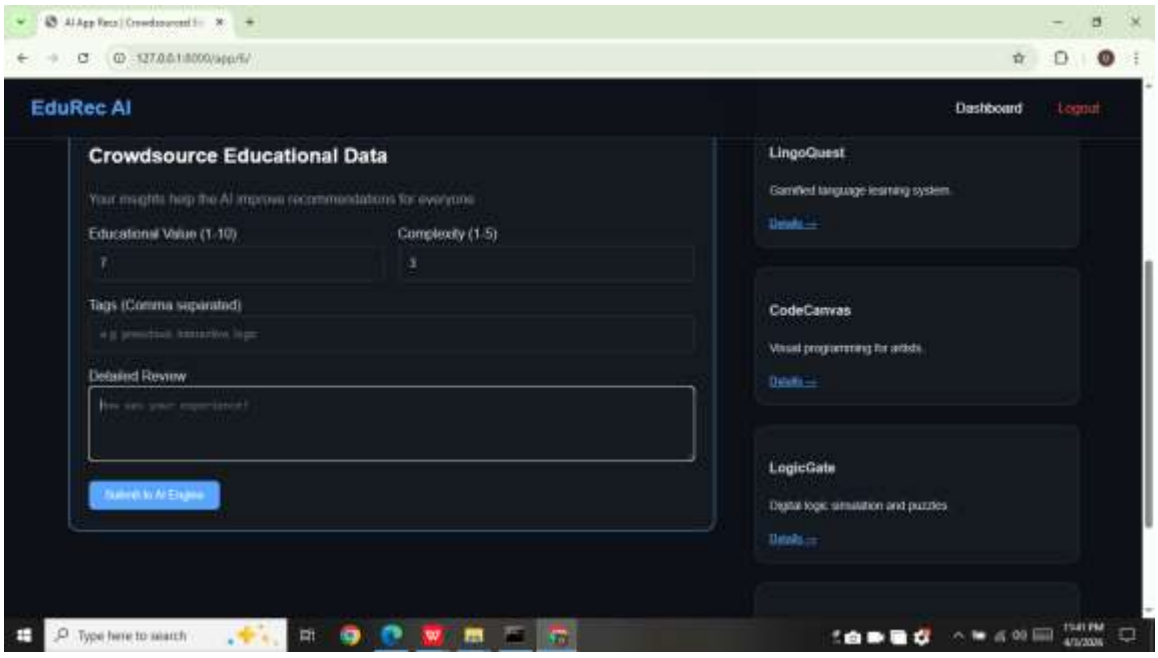

VIII. CONCLUSION

IX. The proposed Hybrid Educational Application Recommendation System successfully addresses the challenges of discovering relevant learning applications in a vast digital ecosystem. By integrating content-based filtering, user preference modeling, and crowdsourced data, the system provides highly personalized and accurate recommendations.

X. One of the key strengths of the system is its hybrid approach, which combines multiple techniques to overcome limitations such as cold-start problems and lack of personalization. The use of TF-IDF and cosine similarity ensures effective content analysis, while the personalized scoring mechanism enhances relevance based on user attributes.

XI. The inclusion of a crowdsourcing module further improves the system by incorporating user-generated data such as ratings and reviews. This allows the system to continuously evolve and adapt to changing user preferences. Additionally, the integration of a deep learning model provides a foundation for future enhancements, enabling the system to capture complex relationships between users and applications.

XII. The system is implemented using Django, ensuring scalability, modularity, and efficient performance. Its user-friendly interface and robust backend make it suitable for real-world deployment.

XIII. In conclusion, this project demonstrates the effectiveness of hybrid recommendation systems in delivering personalized educational content. It provides a scalable and intelligent solution that enhances user experience and supports efficient

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learning. Future work may include integrating advanced deep learning models, real-time recommendation updates, and collaborative filtering techniques to further improve performance.

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