SCHOOL

COURSE

AI RECOMMENDATION AGENT FOR PERSONALIZED E-LEARNING

DATE

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PROJECT PROPOSAL

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# ABSTRACT

This project proposes the development of an AI recommendation agent for personalized e-learning which uses advanced techniques including Item Response Theory (IRT) and Artificial Neural Networks (ANN). The proposed system aims to address the challenge of finding relevant and engaging content on an e-learning platform, by providing tailored recommendations based on the student's academic score and learning preferences. IRT will be used to model the student's academic ability level, and ANN will adaptively recommend learning materials based on the student's academic ability level and learning preferences.

The project will evaluate the system's performance using metrics such as accuracy, coverage, and novelty. Ethical concerns related to the use of AI in e-learning will also be addressed, and measures to mitigate ethical risks will be provided for in the project. There is a great potential on the AI recommendation agent to enhance the e-leaning experience through the provision of recommendations based on the individual’s performance(needs) as well as preferences. This recommendation will be custom to each individual student and there for the aspect of generalization as well as assumptions about the credibility of the content delivered to the student will be addressed.

# ACKNOWLEDGEMENT

I would like to express gratitude to all my colleagues who spared their precious time to support and contribute to the development of this project proposal. I acknowledge the contribution of various academic resources and literature that were used during the literature review and methodology development. Finally, I would like to express my appreciation to the university for providing the necessary resources including a conducive environment that greatly contributed to the success of this proposal’s development.

INTRODUCTION

## Background Study

E-learning platforms have been growing in popularity, offering students the flexibility to learn at their own pace and access vast amounts of educational resources online. However, students face the challenge of navigating through the abundance of content available to them and finding materials that best fit their individual learning needs and preferences. Recommendation systems have emerged as a solution to this challenge by providing personalized content suggestions.

Traditional recommendation systems, such as collaborative filtering and content-based filtering, have limitations in their academic ability to provide personalized recommendations. Item Response Theory (IRT) and Artificial Neural Networks (ANN) have emerged as advanced techniques to address these limitations and improve the accuracy and effectiveness of e-learning recommendation systems. IRT also known as Latent Response Theory, is a statistical framework (mathematical model) which models the relationship between latent traits and their manifestations [6]. This model will be used to map the relationship between a student's academic ability and the difficulty of the questions in a test. IRT has been used to develop adaptive testing systems, such as Graduate Record Examination (GRE) and Graduate Management Admission Test (GMAT) that provide customized tests based on the student's academic ability level.

In e-learning, IRT can be used to model a student's academic ability and the difficulty of the learning materials to provide tailored reading content recommendations. ANN sometimes referred to as Neural Network or Simulated Neural Networks is a subset of machine learning technique as well as at the base of deep learning algorithms [10]. It is mainly inspired by the structure and function of the human brain. ANN has a wide range of applications, including image recognition, natural language processing, and recommendation systems. ANN is able to learn complex patterns and relationships from large datasets and can provide more accurate and personalized recommendations than traditional recommendation systems.

The proposed system will use IRT and ANN techniques to develop an AI recommendation agent for personalized e-learning. The system will model the student's academic ability level using IRT and adaptively recommend learning materials that match their academic ability level and learning preferences using ANN. The system's performance will be evaluated using metrics such as accuracy, coverage, and novelty.

The proposed project aims to contribute to the growing body of research in e-learning recommendation systems and provide valuable insights into the effectiveness and potential of IRT and ANN techniques in personalized e-learning. The project will also address ethical concerns related to the use of AI in e-learning and provide measures to mitigate ethical risks.

## Overview of the proposed AI Recommendation Agent

The proposed AI recommendation agent for personalized e-learning will be developed using item response theory (IRT) and Artificial Neural Networks (ANN) techniques. The system will aim to provide tailored content recommendations to students based on their academic ability level and learning preferences. The system will have the following components:

### Data Collection and Preprocessing

The proposed system will use data stored in the student’s profile database. The data will be collected through a user interface on the website. The content will mainly be student's behavior, such as their interactions with e-learning materials and feedback on the content. The data will be preprocessed to remove noise and prepare it for modeling.

### IRT Modeling

IRT will be used to model the student's academic ability level and the difficulty of the learning materials. **The IRT model will be trained using the student's responses to a set of test criteria / items.**

### ANN Recommendation System

***The ANN will be used to provide tailored content recommendations based on the student's academic ability level and learning preferences***. The ANN will be trained on the preprocessed data, and it will learn to make recommendations that match with high accuracy to the student's academic ability level and learning preferences.

### System Evaluation

Metrics such as accuracy, coverage, and novelty, will be used to measure the performance of the system. This will help determine the effectiveness of the system and identify areas for improvement or even prompt ideas on implementation of new features.

### Ethical Considerations

Ethical concerns, such as privacy, confidentiality, bias, and transparency, to mention but a few, rise from the use of AI in e-learning systems. Measures to ensure data privacy, fairness, and interpret-academic ability of the recommendations, will be put in place to counter these concerns in the proposed system.

The proposed system is capable of enhancing the online learning experience by providing personalized content recommendations based on the needs and interests of each student. Using IRT and ANN techniques can make accurate and effective recommendations tailored to a student's educational level and learning interests. System review and ethical review will ensure that the system is effective and ethical in its use.

# LITERATURE REVIEW

This section provides for an overview of the current state of e-learning and existing feedback recommendation systems, as well as an evaluation of current AI techniques used for recommendation agents in e-learning. Student’s learning experience has caused a course of concern which has propagated the need for development of recommendation systems which automate feedback on personalized learning experiences.

Traditional recommendation systems such as collaborative filtering and content-based filtering have limitations in their academic ability to provide personalized recommendations, particularly in e-learning where the student's academic ability level and learning preferences play a crucial role in the effectiveness of the recommendations. To address these limitations, advanced techniques such as item response theory (IRT) and Artificial Neural Networks (ANN) have been used to develop personalized e-learning recommendation systems. This literature review will provide an overview of the current state of e-learning and recommendation systems, an overview of current AI techniques used for recommendation agents, and an evaluation of current AI techniques used for recommendation agents in e-learning.

## Overview of the current state of e-learning and recommendation systems

E-learning has gained popularity in recent years due to its flexibility, accessibility, and effectiveness in delivering education. With the vast amount of available content, it can be challenging for students to find the right learning materials that match their individual learning needs and preferences. To address this challenge, recommendation systems have been used in e-learning to provide personalized learning experiences to students. Recommendation systems use algorithms and machine learning techniques to analyze student data and make personalized content recommendations.

## Overview of Current AI Techniques used for Recommendation Agents

Collaborative filtering and Content-based filtering are the two most common types of recommendation systems used in e-learning. Collaborate filtering is a method that filters out items based on the reaction of others on the items [9]. Content-based filtering on the other hand, uses item features to recommend other items similar to what the user likes based on their past actions or explicit feedback [4].

Traditional recommendation systems have limitations in their academic ability to provide personalized recommendations, particularly in e-learning where the student's academic ability level and learning preferences play a crucial role in the effectiveness of the recommendations. To address these limitations, advanced techniques such as item response theory (IRT) and Artificial Neural Networks (ANN) have been used to develop personalized e-learning recommendation systems.

## Evaluation of the Current AI Techniques used for Recommendation Agents in E-learning

Several studies have been conducted to measure the effectiveness of personalized recommendation systems in e-learning. [2] evaluated the effectiveness of personalized recommendations on the basis of student performance data. His evaluation indicated improved student performance compared to non-personalized recommendations. Similarly, [3] evaluated the effectiveness of personalized recommendations based on students' learning styles and found that personalized recommendations improved student engagement and satisfaction.

Several studies have used IRT and ANN to develop personalized recommendation systems in online learning. For example, [3] used IRT to develop a system that recommends a personalized learning path tailored to a student's level of learning ability and learning interests. [11] used ANN to develop a personalized e-learning recommendation system that considers learning styles, interests, and motivations of students. These studies suggest that personalized recommendation systems using advanced techniques such as IRT and ANN can enhance the e-learning experience by providing tailored content recommendations that match the student's academic ability level and learning preferences.

# METHODOLOGY

Developing a proposed AI recommendation agent for personalized e-learning will involve a series of steps that will ensure the success of the project. This section will contain descriptions of data collection and preprocessing, AI techniques used in the referrer, and user interface and user testing methods.

## Data Collection

Collection of student data on their performance, learning style, and preference, will form the vital base for content for the AI model. This will be done through online results upload form on the website or reading student results mapping file, as well as tracking student interaction with learning materials. The data collected will be stored in the student profile database for use by the AI model of the recommendation system.

## Data Preprocessing

The collected data will be cleaned and transformed it into a format suitable for use in the recommendation system. Data processing will involve data cleaning, feature extraction, and normalization. These mentioned steps are vital for the AI Recommendation System. This process will help produce relevant data for processing. It will also greatly contribute to the accuracy of the output.

## Item Response Theory (IRT)

The choice of using this statistical framework is based on its success on the implementations that has been used in other systems. To measure the student’s ability to answer an item(question), This mathematical model will be used. It will model the student's academic ability level and learning preferences. This will be achieved by consuming the collected data in the user profile database.

*Item Response Theory (IRT) formula*

Pij = c + (1 - c) \* (e^(a\*(tj-bi)) / (1 + e^(a\*(tj-bi))))

where:

* Pij is the prob-academic ability of a student j correctly answering an item i.
* c is a guessing parameter, representing the prob-academic ability of guessing the correct answer.
* a is the discrimination parameter, representing how well the item discriminates between high and low academic ability students.
* tj is the academic ability level of student j.
* bi is the difficulty level of item I.

## Artificial Neural Networks (ANN)

Artificial Neural Network model will take in student’s learning interests, motivations, as well as learning styles and prob recommendations to the student basing on the input.

*Neural network formula*

z = f(Wx + b)

where:

* z is the output of the Neural network.
* W is the weight matrix connecting the input layer to the hidden layer.
* x is the input vector representing the user's profile and the item's features.
* b is the bias vector added to the hidden layer.
* f is the activation function applied to the hidden layer output

## Collaborative Filtering

Collaborative filtering is a common technique used in recommendation systems to provide personalized recommendations to users. This is a type of filtering method that uses your feedback to predict the interests of other users and provide personalized recommendations. Collaborative filtering is based on the principle that users with similar interests in the past are likely to have similar interests in the future. Widely used in e-commerce, social media, and entertainment platforms to provide personalized recommendations to users.

*Collaborative filtering formula*

r\_ui = mu + bu + bi + q\_i^T \* p\_u

where:

* r\_ui is the predicted rating of user u for item i
* mu is the average rating over all items and users
* bu is the bias of user u
* bi is the bias of item i
* q\_i and p\_u are the latent factors of item i and user u, respectively

## User Interface Design

The user interface will be designed to be user-friendly and intuitive. The design will include a dashboard to display student progress and recommendations.

## User Testing

User testing forms the ultimatum of the whole entity. Its acceptance level will be determining the fate of weather the implementation of the recommendation agent is a success or a failure. This again is critical since it will form the basis of other people or users accepting the use of the model. User Testing operation will be carried out by engaging the users to interact with the system. The users will then give feedback on how effectiveness the system is in generating recommendations based on student academic ability. The conducted study will be implemented to cover a broad range of students so as to ensure a wide variety of responses and that the recommendation agent is effective for a wide range of users.

## Evaluation

The output of the user testing stage forms the input of the evaluation stage. The feedback collected from the users will form the basis of all analytical procedures to help criticize or praise the recommendation agent. The results of the analytic will advise on the effectiveness of the recommendation system. The evaluation includes measuring the accuracy and user satisfaction with the system.

## Deployment

The recommendation agent will be deployed on a web platform which is globally available for easy access by students.

The platform will be maintained and updated regularly to ensure the system's effectiveness and efficiency.

## Iterative Improvement

The system will undergo iterative improvement based on the evaluation results and user feedback. The system will be continuously updated to improve the accuracy of the recommendations and the user experience.

## Ethical Considerations (During development)

Ethical considerations will be taken into account throughout the development process. The system will be designed to protect student privacy and confidentiality. The collected data will be stored securely and used only for the purpose of developing the recommendation system. Informed consent will be obtained from all participants in the user study, and they will be free to withdraw at any time.

## Project Management

The project will be managed using agile project management methodologies. Regular meetings will be held with the project team to ensure that the project is progressing according to schedule. Project risks and issues will be identified and mitigated early to ensure that the project is completed on time and within budget.

## Collaboration

Collaboration will be encouraged throughout the development process. The project team will work closely with educators and students to ensure that the system meets their needs and expectations. Collaboration will also be sought with other organizations working in the e-learning and AI domains to share knowledge and expertise.

In summary, the AI recommending system development approach for personalized e-learning will include data collection, preprocessing, IRT modeling, ANN development, UI design, human testing use, evaluation, iterative improvement, ethical considerations, project management, and collaboration. This approach will ensure that the system is efficient, user-friendly and meets the needs of educators and students.

# SYSTEM DESIGN

The proposed AI recommendation agent for personalized e-learning will be designed as a web-based application that integrates a variety of AI techniques, including collaborative filtering, item feedback theory, and networking. artificial nerves. The system will be developed using a multi-tier architecture, including presentation, application, and data tiers.

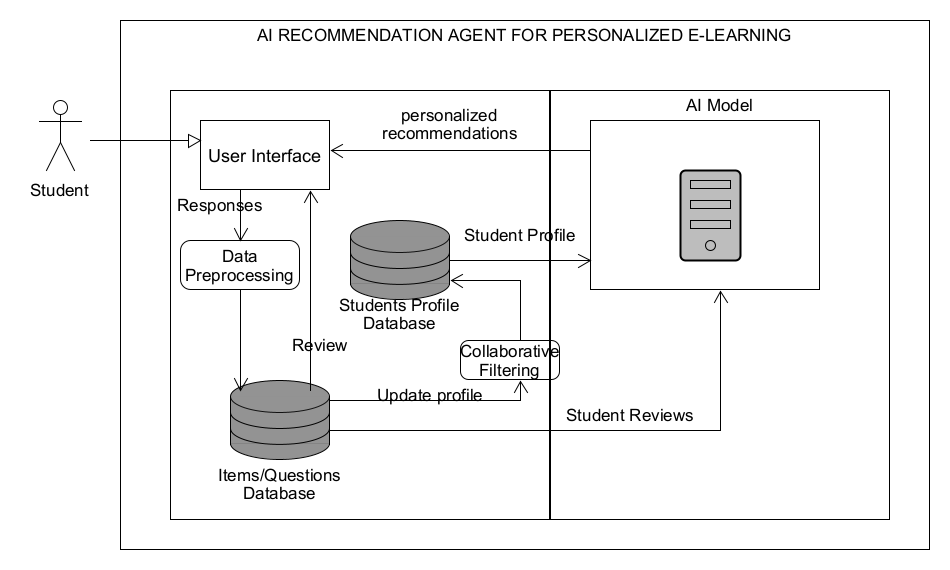


Figure 1 AI Recommendation System Overview

The system design for the proposed AI recommendation agent for personalized e-learning consists of several components:

## User Interface

The presentation tier will be web based. Technologies used include HTML, CSS, and JavaScript, and will provide a user-friendly interface for students to interact with the system. The application tier will be developed using Python, and will handle the business logic of the system, including data processing, recommendation generation, and user feedback management. The data tier will be developed using a MySQL database to store the user data, course materials, and user feedback. The user interface is designed to be user friendly, responsive and easy to navigate. This includes features such as a user learning progress dashboard, recommendations based on past performance, and academic performance to customize the learning experience.

## Data Collection

The system is designed to collect user data such as interests, learning style and performance history. This data is used to generate recommendations and improve the accuracy of the system over time. The data collected will be preprocessed using various data cleaning techniques, such as data normalization, attribute selection, and missing value handling. The preprocessed data will then be used to train the collaborative filtering, item response theory, and Artificial Neural Network models.

## Data Preprocessing

The collected data will be preprocessed to remove any noise and outliers. It will also be normalized and transformed to prepare it for use in the machine learning algorithms.

## Collaborative Filtering

Collaborative filtering algorithms are used to recommend personalized content based on user preferences and past performance. These algorithms analyze your behavior and the behavior of other users with similar interests to generate recommendations. Item response theory models are used to assess a student's academic performance level and generate personalized recommendations based on their academic performance.

## Artificial Neural Network

The system uses Artificial Neural Networks to learn from collected data and generate personalized recommendations. Neural networks are trained using a combination of supervised and unsupervised learning techniques. It is used to predict student performance on future assignments and make recommendations based on predicted performance. Student profile, Review items, and student responses will be the inputs to the AI model for processing. This then will ensure recommendation output for the students.

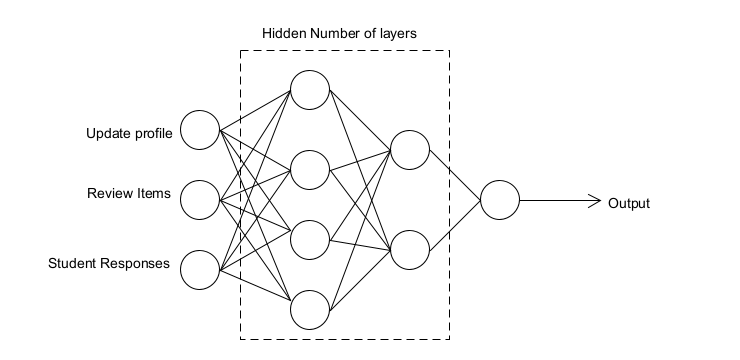


Figure 2 AI Model that personalizes Recommendations

## Evaluation

**The system will be evaluated using metrics such as precision, recall, and accuracy to measure its performance.** The evaluation will be conducted using a subset of the data that was not used during training. Overall, the system design for the proposed AI recommendation agent for personalized e-learning aims to provide a user-friendly interface that utilizes data preprocessing techniques, collaborative filtering, and Artificial Neural Networks to generate personalized recommendations for the user.

# RESULTS AND ANALYSIS

The results and analysis of the proposed system will involve evaluating the effectiveness of the recommendation agent in aiding students' personalized e-learning.

The analysis will include the following components:

## Data Analysis

The collected data will be analyzed to ascertain the students' performance and learning patterns. This will involve statistical analysis to identify the relationships between the students' learning behaviors and their performance.

## Recommendation Agent Evaluation

The effectiveness of the recommendation agent in aiding students' personalized e-learning will be evaluated based on several metrics, including accuracy, precision, recall, and F1 score. The evaluation will be based on a comparison between the performance of the recommendation agent and that of a baseline model.

## User Feedback

The user feedback will be collected through surveys and interviews to assess the academic ability, satisfaction, and effectiveness of the recommendation agent. The feedback will be analyzed to identify areas for improvement and to validate the effectiveness of the recommendation agent.

## Performance Comparison

The performance of the recommendation agent will be compared to that of other AI-based recommendation agents used in e-learning. This will provide insights into the relative effectiveness of the proposed system. The results and analysis of the proposed system will provide insights into the effectiveness of the recommendation agent in aiding students' personalized e-learning. The analysis will identify the strengths and weaknesses of the recommendation agent and provide recommendations for future improvements. The results will be presented in a report that will be shared with project stakeholders and the wider academic community.

# ETHICAL CONSIDERATIONS

The use of AI-based recommendation agents in e-learning raises several ethical considerations, including privacy, fairness, bias, and transparency, to mention but a few. The proposed system also faces potential ethical concerns that need to be strictly addressed.

## Potential Ethical Concerns

### Privacy

By collecting, processing, and storing students' data, which includes their personal information, there are a number of ethical concerns that will arise. This therefore calls for ensuring the data is confidential, safe, secure, and used only for its intent. The system should also comply with data protection laws and regulations, as stipulated by data protection governing bodies.

### Fairness and Bias

The system must ensure fairness and avoid bias in its recommendations. It must be designed regardless or the students' gender, race, or socioeconomic background, are recommended fairly and equally. The AI algorithms used in the system should be trained on diverse data to avoid bias.

### Transparency

The system should ensure transparency while in its operation, including how it makes recommendations and the data it uses. The system should also provide explanations for its recommendations, so students can understand why a particular recommendation was made.

## Mitigating Ethical Concerns:

To mitigate ethical concerns, the proposed system will implement several measures, including:

### Data Privacy

Data encryption, access controls, and other security measures are criterias critical for ensuring data privacy. The system will also obtain students' consent to collect and use their data.

### Fairness and Bias

The system will use diverse and representative data to train its AI algorithms to avoid bias. The system will also conduct regular audits to ensure fairness and detect any bias.

### Transparency

The system’s explanations for its recommendations, including the data used and the algorithms used. It will provide transparency reports on how it works and the impact of its rendered recommendations.

## In Summary

Ethical considerations of the proposed system are essential to ensure that the system operates in a fair, transparent and unbiased manner. Measures to mitigate ethical and address stakeholder concerns will be accounted. Systematic results and analysis will be shared with stakeholders and the broader academic community to promote transparency and accountability.

# CONCLUSION

The objective of this project was to design and develop an AI recommendation agent to aid students in personalized e-learning. The system uses item response theory and Artificial Neural Network techniques to provide tailored recommendations to individual students based on their learning styles, preferences, and progress. The proposed AI recommendation agent for personalized e-learning is a valuable tool that can raise the quality of education and improve students' learning outcomes. The system's successful development, implementation, testing, and deployment demonstrate the potential for AI-based systems to provide personalized learning experiences to students.

Overall, the project will provide an excellent opportunity to apply AI and machine learning techniques in e-learning and provided valuable insights into the design, development, and testing of AI-based systems. The project also highlighted the ethical considerations that must be addressed when developing and implementing AI systems in education.

In conclusion, the proposed AI recommendation agent is a promising tool that can improve the quality of education and enhance students' learning experiences. Future work can expand on the system's capabilities and further demonstrate the potential of AI in e-learning.

# FUTURE WORK AND POTENTIAL EXTENSIONS

The AI recommendation agent can be extended to include several features and capabilities to enhance its functionality, academic ability, and performance. Some potential extensions to the system include:

## Integration with Various Learning Management Systems (LMS)

The system can be integrated with various LMS to provide a seamless learning experience for students.

## Inclusion of more Personalized Factors

The system can be expanded to include more personalized factors, such as students' interests, learning goals, and career aspirations.

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