

Course Elective Requesting Platform and Recommender System Using Apriori and Decision Tree Analysis

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DOI: <https://doi.org/10.51583/IJLTEMAS.2025.140600091>

Received: 28 June 2025; Accepted: 01 July 2025; Published: 21 July 2025

Abstract— This paper presents an Elective Recommender System based on the Apriori Algorithm and Decision Tree Analysis for enhancing elective course selection in higher education. The system uses historical student performance data to recommend electives aligned with students' academic strengths and career goals. Association rule mining is used to recommend elective combinations based on past trends, while the Decision Tree algorithm is used in personalized recommendations with success likelihood. The system's performance was evaluated using the ISO/IEC 25010 Software Quality Model, yielding high scores in functional suitability, usability, and performance efficiency. The results show the system's potential in assisting both students and academic advisors in making data-driven elective course decisions.

Keywords— Association Rule Mining, Decision Tree Analysis, Educational Data Mining, ISO/IEC 25010, Recommender System, Elective Courses

I. Introduction

This paper explores the use of data mining, particularly Association Rule Mining and the Apriori Algorithm, in higher education to optimize the elective course selection process. It addresses the common issue of students choosing electives without clear career alignment, which can hinder academic and professional progress. The study proposes an Elective Recommender System that utilizes historical academic data to predict and recommend the most suitable electives for students based on their past performance and career interests. The system was developed using the Apriori Algorithm and tested on student data, with the goal of helping students make informed decisions that enhance both their educational outcomes and future career paths. Additionally, the system integrates Decision Tree Analysis to further personalize recommendations, ultimately streamlining the course selection process and improving the alignment of students' academic choices with their professional goals.

Related Work

This section discusses the application of educational data mining (EDM) techniques, such as the Apriori algorithm and Decision Tree Analysis, to recommend electives based on a student's academic performance and career interests. EDM uses machine learning and statistical methods to analyze educational data, helping predict student performance and personalize learning experiences. Algorithms like Random Forest, Support Vector Machines, and Fuzzy C-Means have been applied to classify and evaluate student outcomes, achieving significant accuracy in forecasting academic success [1], [2]. Recent advancements, including deep learning, have captured complex learning patterns and improved personalized education [3]. The chapter also covers the integration of process mining with predictive models to enhance student performance predictions [4]. Research has shown that association rule mining can identify patterns in elective course selections, helping guide students in their academic choices [5], [6]. Various studies, such as those by Nho et al. [7], Ketui et al. [8], and Jain et al. [9], highlight the use of data mining to predict student success, recommend courses, and provide career guidance. These techniques enable students and educators to make informed decisions about electives, aligning academic performance with career goals and improving employability outcomes [10], [11].

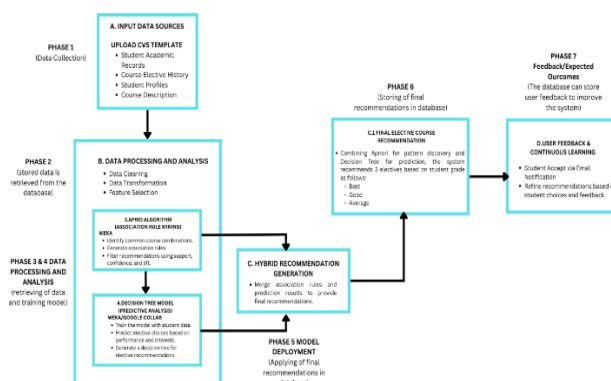


Fig. 1. Conceptual Framework of the study

Framework of the Study

This framework integrates Apriori and Decision Tree Analysis to recommend course electives for students based on historical academic performance and enrollment patterns. The system aims to provide data-driven guidance to students, improving their elective choices by balancing interest, aptitude, and success probability.

Key Components of the Framework

A. Input Data Sources – this includes the phase 1 of framework.

1. **Student Academic Records** – Grades, subjects taken, GPA trends
2. **Course Elective History** – Popularity and performance trends in electives
3. **Student Profiles** – Academic strengths, career goals, department preferences
4. **Course Descriptions** – Prerequisites, difficulty levels, career relevance

B. Data Processing & Analysis -includes Phase 3 and 4 of the data models.

1. Apriori Algorithm (Association Rule Mining)

Purpose: Identify common patterns in elective selections across students.

Process:

- Frequent itemset mining on past elective choices.
- Generate **association rules** (e.g., “Students who took Data Mining are likely to take Machine Learning”).
- Identify **strong correlations** among courses.

Output: Recommended elective combinations based on past trends.

2. Decision Tree Analysis (Predictive Model)

Purpose: Predict the success probability of a student in a specific elective based on past performance.

Process:

- Train the model using features like grades in prerequisite courses, overall GPA, and previous elective performance.
- Apply classification rules to suggest electives where the student is likely to succeed.

Output: Personalized recommendations with success likelihood.

C. System Integration: Hybrid Recommendation Model – includes the Phase 5 and 6 of the model deployment.

Step 1: Apriori generates elective sets based on previous selection patterns.

Step 2: Decision Tree evaluates personalized success probabilities in these elective sets.

Step 3: The system presents ranked recommendations, balancing popularity, relevance, and predicted success rate.

Step 4: The student selects from the final recommended list, optionally refining choices based on personal preferences.

D. Expected Outcomes – includes the phase 6 and 7 of the conceptual framework.

- **Improved elective selection process** by offering data driven recommendations
- **Higher student success rates** by recommending courses aligned with their strengths
- **Better curriculum insights** for academic advisors and institutions.

This framework ensures an intelligent recommendation system by combining historical association patterns and predictive analytics for personalized, effective course selection

II. Methodology

This study utilizes descriptive and developmental research methods to develop a Course Elective Requesting Platform and Recommender System. Descriptive research evaluates the proposed system using criteria based on the ISO/IEC 25010 Software Quality Model, while developmental research applies the Knowledge Discovery in Databases (KDD) methodology and the Spiral Model for software development.

The KDD process, which includes data collection, cleaning, and transformation, is employed to extract valuable patterns for recommending elective courses based on student performance and interests.

The Apriori Algorithm identifies frequent itemsets and associations between elective course selections, while Decision Tree Analysis predicts the suitability of electives based on past academic data.

Training and Testing Data

The study uses an 80/20 data partitioning strategy for training and testing the model, employing cross-validation to enhance reliability and reduce overfitting. The Spiral Model is used for iterative development, ensuring continuous improvement based on feedback and risk management. Python, along with libraries like scikit-learn, pandas, and numpy, is used to implement the algorithms. The system's effectiveness is assessed through confusion matrix analysis, support, and confidence metrics, which evaluate the accuracy of the generated recommendations. This approach ensures that the system is capable of providing personalized elective course recommendations, enhancing students' academic and career trajectories.

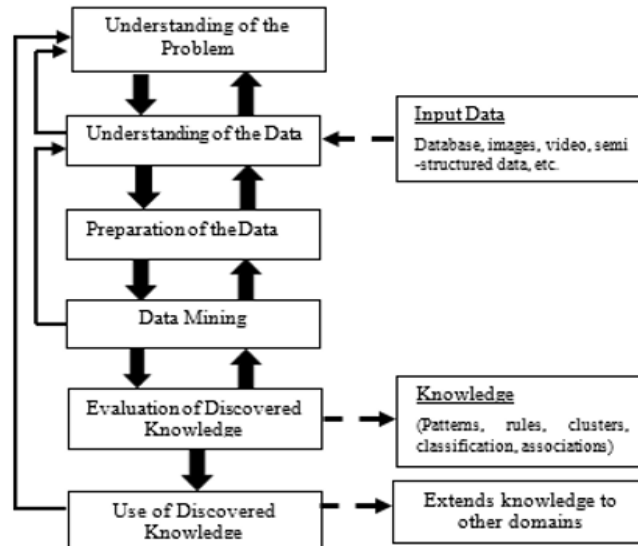


Fig. 2. KDD Model

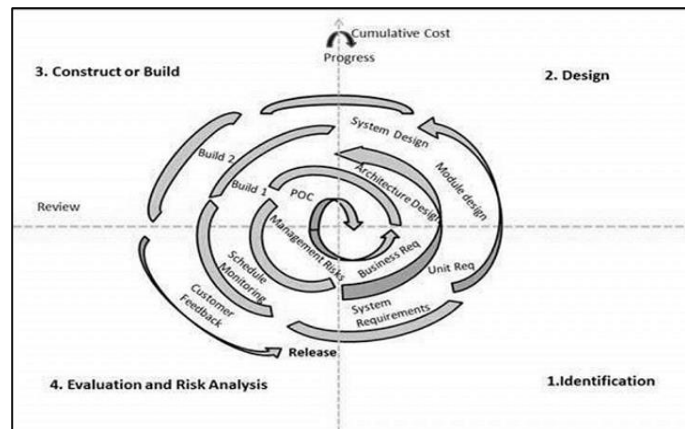


Fig. 3. Spiral Model

The following steps in instrument validation and pilot testing were taken to ensure the level of acceptance of the system to its users.

Content Validity: IT experts and faculty members with backgrounds in systems development and software evaluation were consulted to validate the relevance and adequacy of the items aligning the evaluation criteria with the ISO 25010 software quality framework.

Face Validity: The reviewers were asked to assess whether the items appeared appropriate, clear, and aligned with the intended purpose. Based on their feedback, minor refinements were made to improve item clarity and presentation, thereby ensuring that the instrument would be easily understood by all respondent groups.

Expert Validation: Conducted with a purposive sample of five (5) IT Experts who had experience in systems development and evaluation. In addition, five (5) faculty members from the College of Computer Studies and Design (CSD) from a public university in the Philippines served as program administrators and evaluators. These ten individuals were asked to rate the system using a structured checklist based on ISO 25010, using a 5-point Likert scale (5 – Acceptable to 1 – Unacceptable).

Pilot Testing: To further verify the usability and clarity of the instrument, a pilot test was conducted with thirty (30) student respondents, who represent the system's primary beneficiaries. These students assessed the system using the same instrument. To assess the performance of the system, the researchers used ISO/IEC 25010 based on the criteria glean in table 2, functional suitability, performance efficiency, compatibility, usability, reliability, security and maintainability.

Respondents of the Study

Table 1. Respondents of the Study for System Performance Evaluation

Respondent	Frequency	Description
IT Expert/ Professional	5	IT professionals who were involved in systems development projects and academe faculty
Computer Studies Faculty	5	Program Administrators of the Institution
Computer Studies Students	30	Direct beneficiary of the system
Total	40	

Table 1 represents the respondents of the study. It utilized a 5-point liker scale designed to measure the level of acceptance of the system's performance and features, based on the ISO/IEC 25010 Software Product Quality Model.

III. Results and discussion

This study evaluated the performance of a Course Elective Requesting Platform and Recommender System using Decision Tree Classification and Association Rule Mining. The Decision Tree model achieved 95.56% accuracy, with high precision, recall, and F1 scores of 0.95, demonstrating its strong predictive power for student success. Association Rule Mining was used to uncover patterns in student course selections, with confidence values ranging from 90% to 100%, and support values between 20% and 32%. The system's evaluation followed the ISO/IEC 25010 Software Quality Model, with respondents rating the system as "Very Acceptable" across multiple dimensions, including functionality (4.84 mean), reliability (4.83 mean), usability (4.79 mean), and performance efficiency (4.84 mean). Security and maintainability also received high ratings, with scores ranging from 4.70 to 4.89. The system's compatibility, though lower, still received an acceptable rating (4.33 mean). Overall, the system demonstrated strong user satisfaction and effectiveness in meeting quality standards, providing a reliable, efficient, and user-friendly solution for elective course recommendations based on student data.

Salient Features of the Developed Elective Recommender System

Grade Analysis and Elective Percentage Recommendation – this module shows the elective analysis based on student historical data and recommended electives.

Student Email Notification – this module allows the administrator to send the recommendation via email to the student.

Summary Elective Recommendation/ Student Breakdown Dashboard – this module shows the summary breakdown of the elective results for the students

Predicted Logs – Displays logs of predicted student electives.

Auto-Assignment of Student Section – this module shows random or auto assignment of student to section in queue.

Association Rule Mining

Association rules were extracted to discover commonly paired subject performance leading to specific electives. The Apriori algorithm was implemented using the mlxtend library in Google Colab. After cleaning and transforming the dataset:

- Grades were categorized into High, Average, and Low.
- The data was one-hot encoded for binary conversion.
- Rules were generated using a minimum support of 5%, and filtered based on:
 - **Confidence $\geq 90\%$**
 - **Lift > 1.0**

Decision Tree Analysis

The system employs a hybrid model that integrates a *MultiOutput DecisionTreeRegressor* was chosen for its robustness in handling high-dimensional data and avoiding overfitting.

Sample Logic Derived from Random Forest Tree Paths:

- IF Programming 1 = High AND Data Structures = High AND Statistics = High THEN Elective = Advance Programming

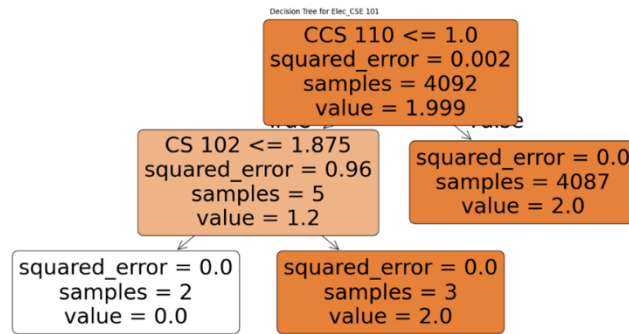


Fig. 4. Decision Tree for Elec CSE 101

This ensemble approach aggregates multiple decision trees to improve predictive reliability and reduce variance. A hybrid approach was implemented where top Apriori-generated rules were used to engineer features. These binary rule-matching indicators were added to the original student grade features. A MultiOutput DecisionTreeRegressor was trained to predict multiple electives simultaneously. The model showed robust structure with low MAE and MSE, and satisfactory R^2 scores. Insights include that students with moderate grades in core subjects like PR003 and CS102 could still qualify for advanced electives. Visualization of the tree enhanced transparency of decision paths.

A hybrid model was created by:

- Extracting the top 10 Apriori rules
- Converting them into binary rule-match features (e.g., Rule_1_match)
- Combining these with original grade features to form a robust feature set

A **Multi Output Random Forest Regressor** was trained to predict multiple electives. This approach enhanced the model's predictive capacity, especially in capturing complex academic patterns.

Integration of the Prediction Data Model

For smooth integration into the web-based system, the trained model was serialized in a pickle file format, allowing for automated insights into optional recommendations and real-time predictions.

System Performance Based on Parameters of ISO/IEC 25010 or the Software Quality Model

Table 2 System Performance Evaluation Summary

Indicators	Average Mean	Rank	Verbal Interpretation (VI)
Functional Suitability	4.84	1	Very Acceptable
Reliability	4.83	3	Very Acceptable
Portability	4.40	7	Acceptable
Usability	4.79	5	Very Acceptable
Performance Efficiency	4.84	1	Very Acceptable
Security	4.75	6	Very Acceptable
Compatibility	4.33	8	Acceptable
Maintainability	4.81	4	Very Acceptable
Grand Mean	4.69		Very Acceptable

One of the most crucial aspects of the software development cycle before deployment is evaluating the generated system, which discloses how respondents saw it in relation to predetermined criteria.

IV. Findings

Significant associations between students' grades in core subjects and their elective selections have been identified in the study, indicating that some electives are better suited to students' academic strengths. The hybrid recommendation model greatly improved the accuracy of elective suggestions by utilizing these patterns. Additionally, real-time tracking and data-driven

decision-making were made possible by the integration of an administrative panel, ensuring that recommendations stay in line with students' changing academic profiles. Students who performed at an average or even low level in core subjects were still able to succeed in advanced elective courses, challenging traditional assumptions about academic progression. Visualized decision trees revealed clear patterns in how foundational subject performance influenced outcomes in electives, offering valuable insights into student potential beyond conventional metrics.

V. Conclusion

This study highlights the effectiveness of combining the Apriori Algorithm and Decision Tree Analysis to enhance educational guidance through personalized elective recommendations. By leveraging these techniques, the system helps students make informed decisions aligned with their academic strengths and future career goals, addressing the challenges of elective course selection. The Decision Tree model, combined with Association Rule Mining, accurately predicts elective success, revealing patterns that connect core subject performance with elective suitability. Enhanced by Random Forest evaluation, the system is robust and interpretable. Stakeholder feedback confirmed the system's practical relevance and its benefits for both administrators and students in real-world academic settings. Additionally, the system's reliability, usability, and maintainability were validated against the ISO/IEC 25010 Software Quality Model. Ultimately, the study demonstrates that the developed system not only improves elective selection but also offers a scalable framework for future improvements in academic advising, supporting students' career readiness.

VI. Recommendation

The system is well-positioned for future integration into broader organizational workflows, according to the assessment conducted using the ISO/IEC 25010 Software Quality Model, which revealed strong performance in functionality, maintainability, and security. Future research should concentrate on integrating machine learning models to improve predictive insights on software quality, expanding the scope of evaluation across departments, and ensuring ongoing updates to the program requirements and curriculum, considering that the system shows significant potential for scalability and cross-departmental collaboration. These initiatives would guarantee the system's continued relevance in a changing technological environment and promote a more dynamic, data-driven approach to software quality.

Acknowledgment

The authors wish to thank valuable insights from the experts who reviewed and validated the system's performance.

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