An Intelligent Question Bank System for Automated Difficulty Classification Based on Bloom's Taxonomy

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ABSTRACT

Creating and managing assessments is a challenging task for educators, especially when attempting to categorize questions based on varying levels of difficulty. Traditional methods of question categorization are often done manually, which takes a lot of time (time-consuming), and may lead to inconsistencies. These issues become even more difficult when dealing with large question banks and inefficient administrative processes. To address this, our research introduces the design and implementation of an Intelligent Question Bank System that automates the classification of exam questions into difficulty levels : Easy, Medium, and Hard by using Bloom's Taxonomy as the guiding framework. Bloom's Taxonomy provides a hierarchical structure to categorize cognitive skills, ranging from basic recall of facts to higher-order thinking skills like analysis and creation. The system uses a Decision Tree algorithm, a type of Classification in Machine Learning, to classify questions based on their complexity. This approach ensures accurate and consistent categorization by analyzing question patterns, context, and semantics. The system is designed to handle large datasets effectively, making it a suitable solution for educators managing extensive question banks. By combining Bloom's Taxonomy with Machine Learning techniques, the system simplifies the assessment process and improves its quality. It saves educators time, helps them design better exams, and enhances the overall learning experience for students. This system aims to transform the way questions are developed and managed, making education more efficient and effective.

Keywords: Intelligent Question Bank, Bloom Taxonomy, Classification, Machine Learning, Decision Tree

INTRODUCTION

Designing examination questions that accurately assess different levels of student understanding is a persistent challenge for educators. Traditional methods of categorizing questions into easy, medium, and hard levels are done manually, which often leads to inconsistent results and increased workload. These limitations can result in unbalanced assessments and inefficiencies in managing large question banks. To address this, the Intelligent Question Bank System is introduced as an AI-based solution that automates question classification using Bloom's Taxonomy, a trusted framework for organizing cognitive skills.

Bloom's Taxonomy provides a structured approach to evaluating cognitive complexity, but applying it manually across large datasets can be subjective and unreliable. Teacher judgments often vary, resulting in inconsistencies in grading and misalignment with learning outcomes. To overcome these issues, the project integrates Machine Learning—specifically a Decision Tree algorithm—to automatically classify questions into difficulty levels based on semantic and contextual features aligned with Bloom's hierarchy. This improves accuracy, reliability, and fairness in assessment design.

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A key strength of the Intelligent Question Bank System is its ability to process extensive datasets quickly and extensive datasets quickly and efficiently, something manual categorization cannot achieve. Decision Trees offer an interpretable and effective method for automation, able to handle various types of data while providing transparent reasoning for each classification. This reduces errors, saves time, and offers a scalable solution suitable for institutions with large and diverse question repositories.

In addition to classification, the system includes reporting and analytics features that help educators understand question distribution, performance, and effectiveness. These insights support data-driven decision-making, ensuring assessments remain aligned with learning objectives. Overall, the Intelligent Question Bank System advances educational assessment by combining artificial intelligence with established pedagogical frameworks, offering a consistent, scalable, and evidence-based tool that enhances exam quality and supports improved learning outcomes.

Problem Statement

Educators face significant challenges in designing and categorizing exam questions that accurately measure student understanding across different difficulty levels. The manual classification of questions into Easy, Medium, and Hard categories is time-consuming, subjective, and often inconsistent, leading to imbalanced assessments. Managing large question banks across multiple subjects further increases this complexity and administrative workload. Moreover, the lack of analytical tools makes it difficult for educators to evaluate question effectiveness and track performance, hindering the development of data-driven, high-quality assessments that enhance student learning outcomes.

Project Objectives

The objectives of this project are to develop an Intelligent Question Bank System that efficiently manages large datasets and provides educators with a user-friendly interface to add, organize, and manage questions across various subjects. The system aims to automate question classification based on Bloom's Taxonomy, using a Decision Tree Machine Learning algorithm to categorize exam questions into easy, medium, and hard levels according to their complexity, context, and semantics, ensuring consistent and accurate results. Additionally, the project seeks to enhance the assessment process through integrated reporting and analytics tools that offer valuable insights into question usage, distribution, and effectiveness, enabling educators to make data-driven improvements in assessment design and ultimately enhance the quality of education and student learning outcomes.

Project Scope

The Intelligent Question Bank System focuses on creating an efficient and user-friendly platform that supports multiple subjects and enables educators to easily create, organize, and manage questions. The system allows the inclusion of additional materials such as images and supporting content to enhance question quality. Using AI-powered algorithms based on Bloom's Taxonomy, it will automatically classify questions into three difficulty levels—Easy, Medium, and Hard—by analyzing their complexity and semantic patterns. Distinct user roles will be defined for educators to manage and organize the question bank effectively. Additionally, integrated reporting and analytics tools will provide insights into question usage and performance, helping educators improve the quality and fairness of assessments..

LITERATURE REVIEW

An Intelligent Question Bank System (IQBS) based on comparing keywords is a software that allows users to user (lecturer) to make a question based on Bloom Taxonomy. In addition to determine for the search accuracy, these applications may also imply Natural Language Processing (NLP) which is a subfield of artificial intelligence (AI) and filtering features that filter the relevant result searching.

The research paper by Chang (2021) proposes an automated system for selecting exam questions using a binomial distribution model. The system aims to improve the efficiency and accuracy of creating test papers by ensuring a balanced distribution of question difficulty and types. It ensures that each question has an equal chance

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of being selected, with criteria for difficulty level, question type, and knowledge points. The paper also discusses the use of Expert-Based algorithms and Genetic algorithms for better question selection and large-scale test paper creation. It highlights the importance of standardized test question banks to reduce teacher workload and improve exam quality.

A research paper by Rachman, Alfian, and Yuhana (2023) focuses on using Deep Learning to classify questions in the Indonesian National Assessment. It addresses the challenge of small datasets by applying data augmentation and using Convolutional Neural Networks (CNN) to classify illustrated images into two categories: information and literature. The study found that ResNet-50 gave the best performance, and transfer learning helped solve the dataset issue. This work shows how Deep Learning can improve automated classification in educational assessments, supporting Intelligent Question Bank Systems.

Yu, B. (2023) presents an intelligent system for creating exam papers using a Random Extraction algorithm. This algorithm is selected for its speed and simplicity in meeting constraints like question type, quantity, difficulty, and knowledge coverage. The study highlights the shift from traditional exams to AI-aided methods, improving efficiency and fairness in assessments. It also compares the random extraction approach with other algorithms and explores its application in teaching Chinese as a foreign language to enhance test quality.

The article by Zhang, J., and Li, Z. (2023) describes a question bank system using Machine Learning to support intelligent paper grouping, online mock exams, and automated grading. Built with JSP, Java, and MySQL, it includes roles for administrators, teachers, and students, ensuring fair and accurate marking by integrating natural language processing and text similarity detection libraries. The system minimizes grading errors, enhances personalized learning, and streamlines exams, reducing educators' workload while improving assessment accuracy.

The research paper by Liu, X., and Yang, C. (2022) introduces an intelligent system for creating English test papers using the Radial Basis Function (RBF) algorithm. The RBF neural network, known for its simple structure and fast learning, helps select and organize questions based on knowledge points, difficulty levels, and total scores. This system aims to reduce teachers' workload and improve fairness in exams by ensuring a standardized and efficient test composition process. It also addresses challenges in China's paper-making systems, such as inefficient grouping and the need for a large question bank, using advanced clustering and optimization techniques. This innovative approach enhances the quality and accuracy of assessments in education.

Banujan et al. (2023) present an automated system for classifying over 16,000 exam questions from Sri Lankan universities into the six levels of revised Bloom's Taxonomy (remember, understand, apply, analyze, evaluate, create) using Deep Learning models like LSTM combined with BERT and GloVe embeddings, alongside ANN with TF-IDF, achieving superior accuracy through semantic pattern recognition and NLP preprocessing such as tokenization and stop-word removal. This approach addresses manual classification's subjectivity and scalability issues in large question banks, outperforming traditional ML like SVM or DT by capturing contextual relationships in text that directly complementing this project, which similarly analyzes keywords, complexity, and cognitive demands for Easy/Medium/Hard categorization aligned with Bloom's framework, thus enhancing consistency and efficiency in assessment design for educators managing extensive repositories.

While, Romadhony et al. (2022) present a Machine Learning framework for classifying primary and high school exam questions into Bloom's Taxonomy's six cognitive levels (remembering, understanding, applying, analyzing, evaluating, creating), using feature extraction techniques like TF-IDF variants and word embeddings to detect semantic complexity and reduce teacher workload in manual categorization. This also directly complements this project, which automates difficulty classification (Easy, Medium, Hard) aligned with Bloom's hierarchy for large-scale question banks, by demonstrating ML's efficacy in handling diverse educational datasets and ensuring consistent, scalable assessments across subjects addressing similar challenges of inefficiency and subjectivity in traditional methods.

METHODOLOGY

The Intelligent Question Bank System (IQBS) uses a well-structured database to manage questions, categorized by subject, topic, and difficulty. The system supports roles for Teacher (create, edit/manage, and categorize

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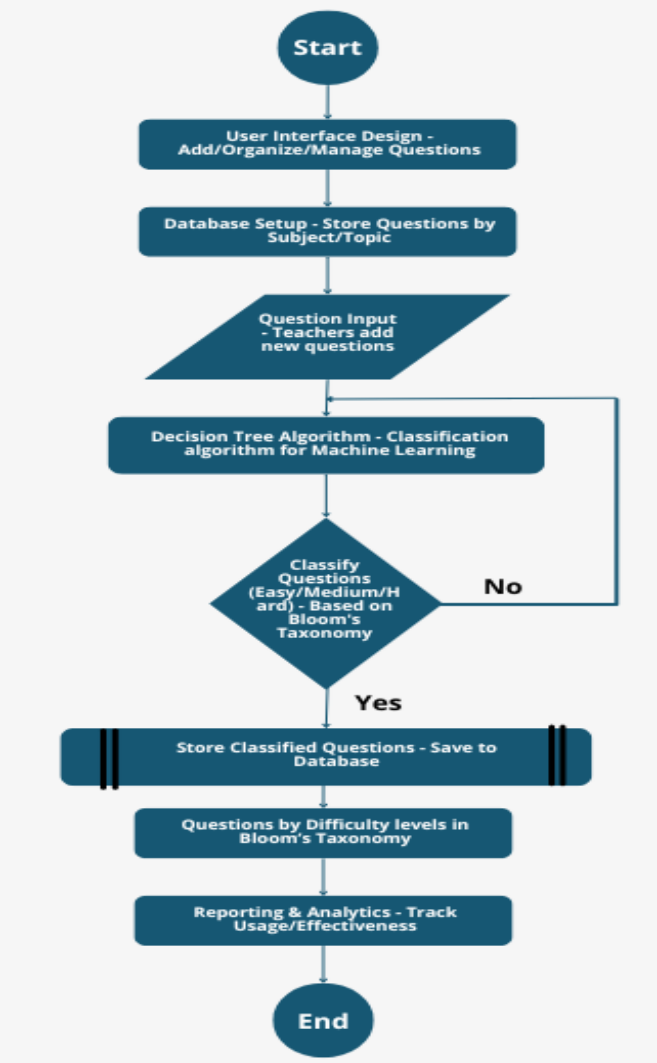
questions) and Admin (who manage the system). The system leverages AI, specifically a Decision Tree algorithm, to classify questions by difficulty (Easy, Medium, Hard) using Bloom's Taxonomy, analyzing factors like wording, knowledge domain, and required cognitive skills. Teachers can build questions, track student performance, and access analytics for better learning outcomes. It ensures security and supports future expansion for additional subjects.

Flow Chart

According to the Figure 1.0, The Intelligent Question Bank System (IQBS) begins with a user-friendly interface where teachers can add, organize, and manage questions. These questions are stored in a database, categorized by subject and topic. Teachers input new questions, and the system uses a Decision Tree algorithm to classify them into difficulty levels (Easy, Medium, Hard) based on Bloom's Taxonomy. The algorithm analyzes the question's wording or keywords, cognitive skills required, and complexity to assign accurate difficulty levels. Once classified, the questions are saved back to the database for use in generating balanced questions tailored to student needs.

The Decision Tree algorithm mimics human decision-making by breaking down questions into attributes, such as keywords or the knowledge domain, and comparing them against predefined criteria from Bloom's Taxonomy. For instance, a question that requires simple recall is classified as "Easy," while one involving critical analysis is "Hard." This automated classification ensures consistency and accuracy, far surpassing traditional methods. The system also integrates reporting and analytics tools, enabling teachers to track question effectiveness, analyze student performance trends, and refine their questions. This data-driven approach supports educators in enhancing teaching strategies and improving learning outcomes.

Figure 1.0 : The design for the work flow of IQBS.



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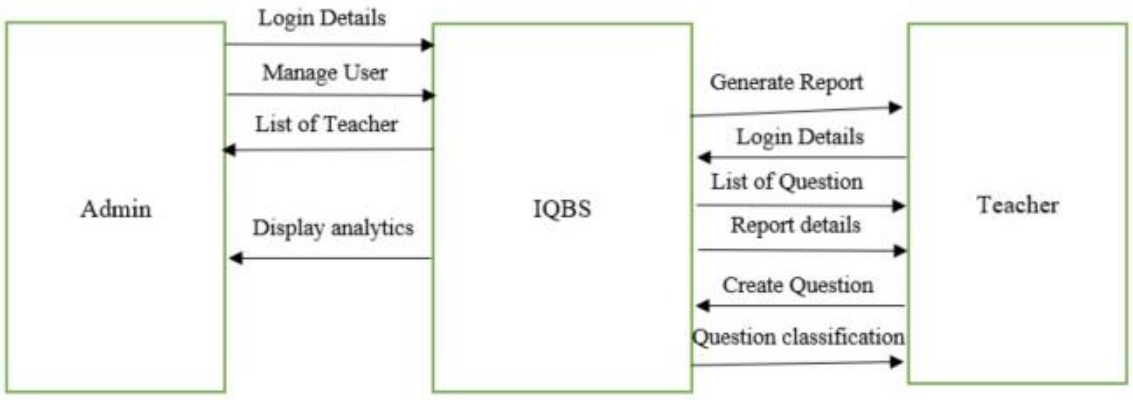
Context Diagram

The context diagram in Figure 2.0 shows how Admins and Teachers interact with the system to create/manage questions, and generate reports. The system uses a Decision Tree algorithm to classify questions based on difficulty levels (Easy, Medium, Hard) by analyzing keywords, complexity, and cognitive skills required. When a teacher creates a question, the algorithm processes the question by identifying keywords such as "define," "analyze," or "evaluate," which correspond to different cognitive levels in Bloom's Taxonomy.

The Decision Tree uses these keywords and other attributes to categorize the question, helping organize the question bank for creating balanced questions. Admins manage the system, user accounts, and question bank, while Teachers focus on creating, editing, and categorizing questions, and using analytics to improve questions.

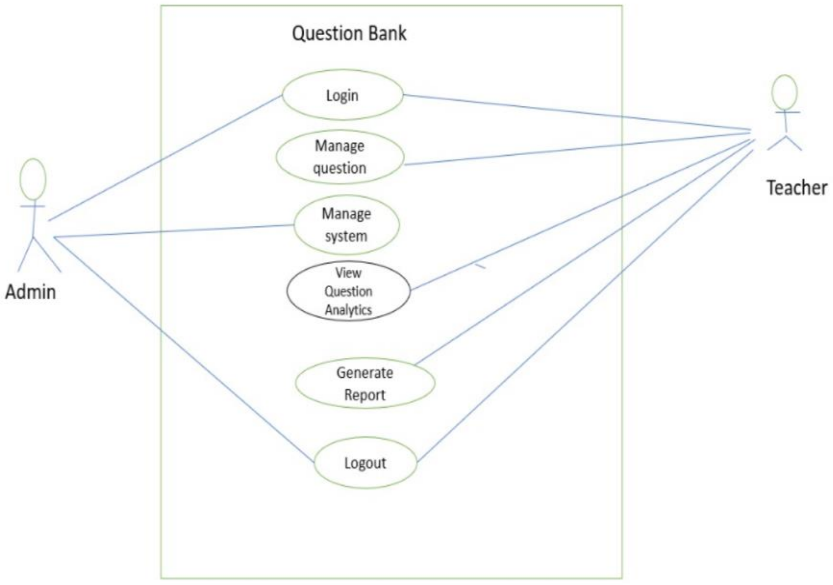
Figure 2.0 : The Context Diagram of IQBS for the interaction between Admin and Teacher within the system.



Use Case Diagram

As depicted in Figure 3.0, the use case diagram for the Intelligent Question Bank System (IQBS) delineates the interactions between the system and its users: Admin and Teacher. Each user engages with the system through various functionalities tailored to their roles.

Figure 3.0 : The Use Case of IQBS for their functionalities.



The Admin holds full control over the system and interacts with several key functions. They begin by logging in to authenticate their identity and gain access. Once inside, they manage the overall system settings, ensuring smooth operation and proper configuration. After completing their tasks, the Admin logs out to maintain system security.

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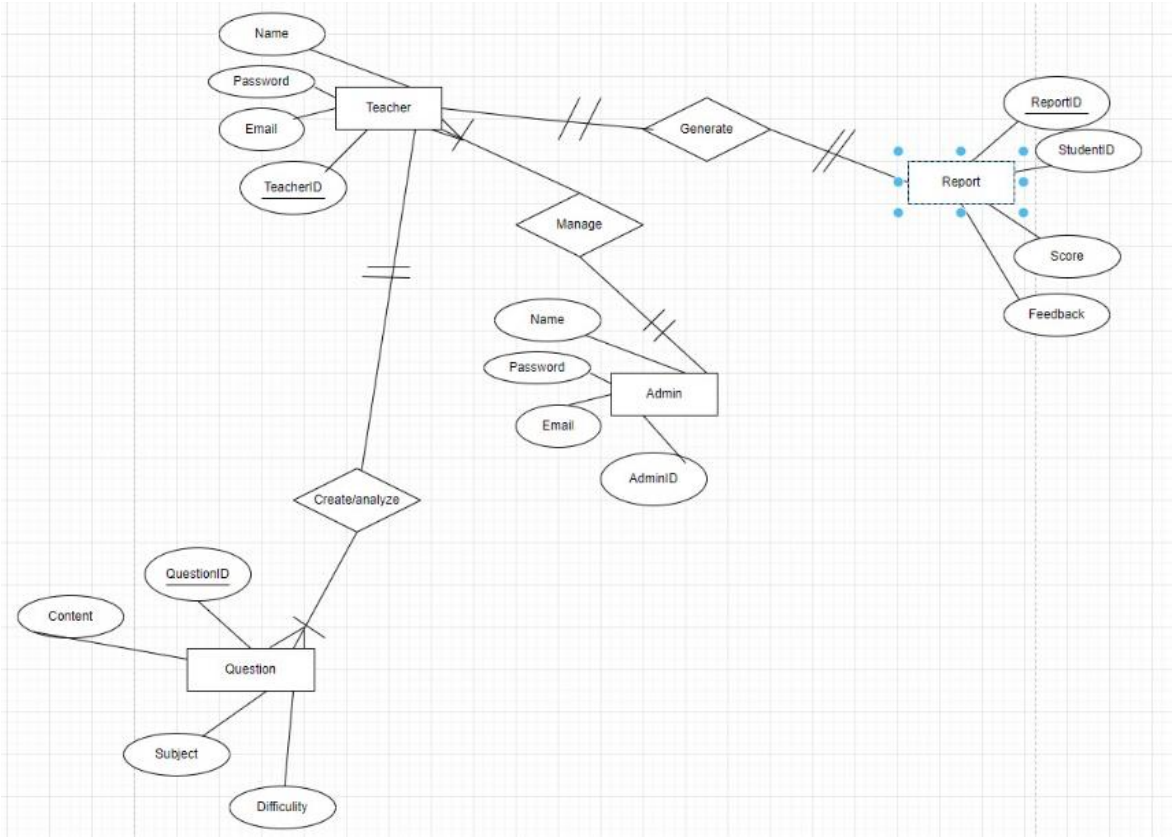
The Teacher focuses on managing questions and assessments within the system. They start by logging in to access their assigned features. Teachers can create, edit, or delete questions to maintain the question bank. They also view question analytics to understand performance patterns and generate detailed reports based on question outcomes. When finished, they log out to ensure secure access and protect system data.

Entity Relationship Diagram

The Entity-Relationship Diagram (ERD) in Figure 4.0 represents the key entities and their relationships within the system, focusing on Admin and Teacher roles. The Admin manages the system, including user accounts, questions, and reports, ensuring the smooth operation of the question bank. The Teacher creates questions, and the system uses an AI-based Decision Tree algorithm to analyze the difficulty level of each question by evaluating its complexity and keywords. This classification is linked to Bloom's Taxonomy, assigning difficulty levels (Easy, Medium, Hard). The Teacher then uses the classified questions to create questions and generate reports, which provide insights into question usage and performance. The ERD connects these processes by establishing relationships between entities such as User, Question, Difficulty Level, Assessment, and Report.

Figure 4.0 : The Entity-Relationship Diagram (ERD) of IQBS for the key entities and relationships within the system.



Here's a detailed explanation of the components :

Entities and Attributes:

- Teacher
  Attributes: TeacherID, Name, Email, Password
- Admin
  Attributes: AdminID, Name, Email, Password
- Question
  Attributes: QuestionID, Content, Subject, Difficulty
- Report
  Attributes: ReportID, QuestionID, Score, Feedback

Relationships:

- Manage (between Admin and Teacher)
  Admins manage teachers, which involves adding, updating, or removing teacher records.
- Create/Analyze (between Teacher and Question)
  Teachers create and analyze questions. They can add, edit, or evaluate the difficulty of questions.
- Generate (multiple occurrences)
  Teachers generate questions by selecting questions and creating assessment documents.
- Questions generate reports for the difficulty levels.
  Admins and teachers generate various types of reports to analyze performance and question usage.

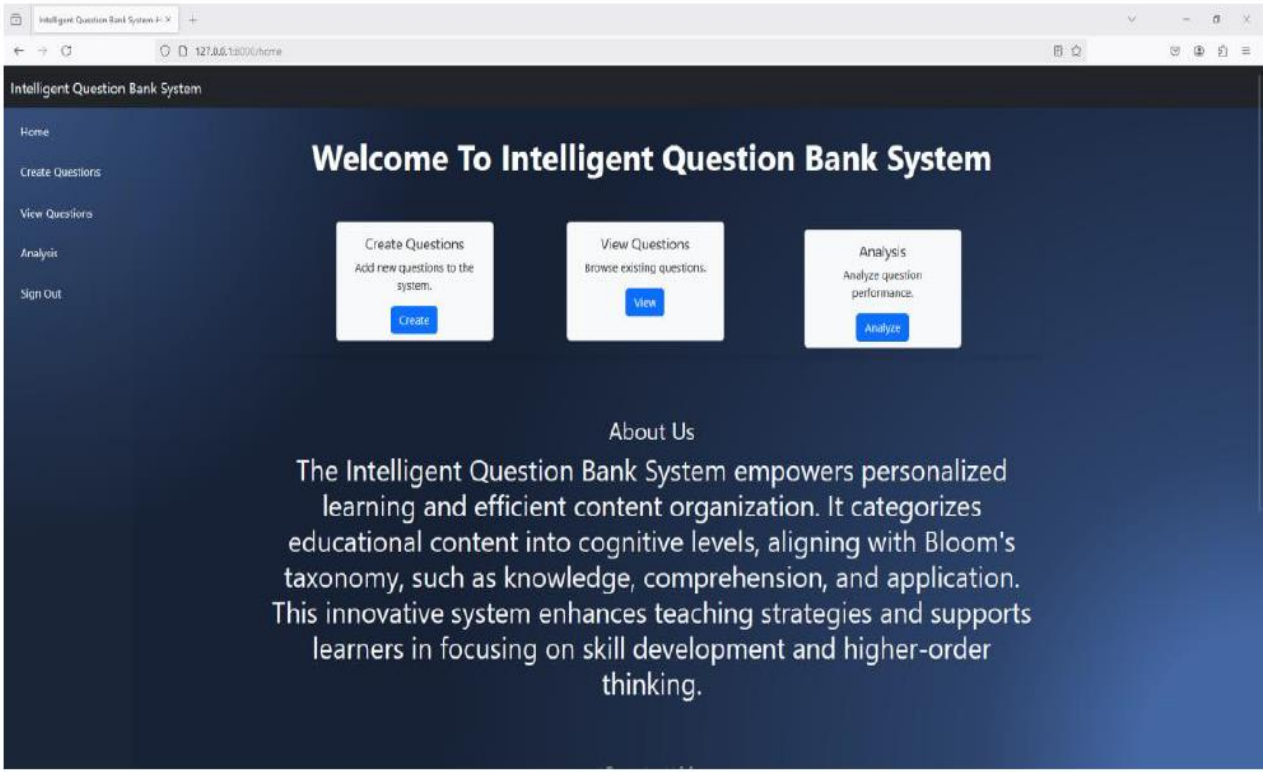
RESULT

The results show how the question analysis feature examines question structure, content, and expected student responses by identifying themes, assessing complexity, and predicting areas where students may struggle across hard, medium, and easy categories. It also explains how these insights connect with the system's automatic difficulty classification to give a more complete understanding of each question.

The Frontpage of the Intelligent Question Bank System (IQBS)

Figure 5.0 showcases the homepage of the Intelligent Question Bank System (IQBS), designed for user-friendly navigation and highlighting its core functionalities. The page features a prominent welcome message and three interactive cards: "Create Questions," "View Questions," and "Analysis," each with a brief description and a call-to-action button. Below, an "About Us" section explains the system's purpose, emphasizing personalized learning, efficient content organization, and alignment with Bloom's Taxonomy to enhance teaching strategies and support higher-order thinking. A left sidebar provides navigation links to the different sections of the IQBS, including a "Sign Out" option for secure user sessions. The overall design aims to clearly communicate the system's capabilities and facilitate easy access to its key features.

Figure 5.0 : The homepage of the Intelligent Question Bank System (IQBS), designed for user-friendly navigation and highlighting its core functionalities.



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This project delves into the challenges faced by educators in creating and managing assessments, particularly the time-consuming and often inconsistent process of classifying questions based on difficulty.

Classification base on Bloom taxonomy

Figure 6.0 displays the classification results of a set of questions based on Bloom's Taxonomy. Each

question is assigned a Bloom level (C1-C6) and a corresponding keyword that indicates the cognitive level required to answer it. For example, questions involving "solve" or "solve the following" are classified under C3 (Applying), while questions asking to "Define" something fall under C1 (Remembering). Similarly, "Explain" leads to "Understanding" at C2, and "Design" leads to C6 (Creating).

Figure 6.0 : Classification result of a set of questions based on Bloom's Taxonomy.

Questions

uestion ID	Subject Code	Question	Bloom Keyword	Bloom Level
1	BQT4773	solve the issue using genetic algorithm	solve	C3
2	BJT4223	Define the meaning of classification	define	C1
201	"CS201"	"Explain the CSS box model"	"Understanding"	C2
203	CS203	Design the card	design	C6
204	CS204	Define program	define	C1
301	CS301	solve	solve	C3
501	CS501	solve the following	solve	C3

This table provides a structured overview of the cognitive demands of different questions, aiding assessment design and curriculum planning.

CONCLUSION

The Intelligent Question Bank System (IQBS) serves as an advanced tool for managing and categorizing exam questions efficiently by subject, topic, and difficulty level. Utilizing a Decision Tree algorithm aligned with Bloom's Taxonomy, it automatically classifies questions into Easy, Medium, and Hard categories based on cognitive complexity. The system enables teachers to create, organize, and tailor questions to student needs while offering integrated reporting and analytics tools to track performance and enhance learning outcomes. Administrators oversee system security and scalability, ensuring support for future subject expansions. As development continues, the IQBS aims to include JSU/JSI reporting features that will allow educators to analyze syllabus effectiveness and student performance, contributing to improved teaching strategies and academic achievement.

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