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Genai-Based Question Paper Generation with Bloom's Taxonomy Alignment

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Abstract- ***Educational institutions still rely on manual question paper preparation, which is time-consuming and may lead to inconsistencies in syllabus coverage and difficulty levels. Conventional approaches often face difficulties in maintaining a proper balance among the cognitive levels specified in Bloom's Taxonomy. Although Generative Artificial Intelligence (GenAI) can automatically generate questions, many existing systems lack proper control over cognitive level, difficulty, and syllabus relevance. This study introduces an AI-driven Question Paper Generation system integrated with Bloom's Taxonomy alignment. The system takes syllabus topics or keywords as input and generates exam questions using a large language model. A Bloom's Taxonomy classifier ensures that questions match appropriate cognitive levels, while a difficulty estimation module classifies them into easy, medium, and hard levels. The system also uses semantic similarity analysis to avoid duplicate questions and applies both automated and human evaluation methods to assess quality. The proposed approach aims to generate balanced, syllabus-aligned question papers while reducing educators' manual workload and improving assessment quality.***

Keywords- ***Generative AI, Question Paper Generation, Bloom's Taxonomy, Large Language Models, Difficulty Estimation, Semantic Similarity, Educational Assessment.***

I. INTRODUCTION

Assessment methods play a major role in measuring student learning outcomes and academic performance. Question papers continue to be among the most commonly utilised methods for assessing conceptual understanding and subject knowledge in educational institutions. Traditionally, educators prepare examination papers manually, a process that is both time-consuming and highly dependent on individual expertise. Manual preparation may also result in repeated questions, inconsistent difficulty levels, incomplete syllabus coverage, and limited cognitive diversity.

Bloom's Taxonomy is widely adopted as a framework for developing balanced assessments by classifying learning objectives into cognitive levels, including remember, understand, apply, analyse, evaluate, and create. However, maintaining an appropriate distribution of these levels during manual question paper preparation is often difficult.

Recent advancements in Artificial Intelligence (AI), Natural Language Processing (NLP), and Large Language Models (LLMs) have enabled new possibilities for automated question generation. Transformer-based models such as GPT and BERT can generate human-like and contextually meaningful questions from educational content. In spite of these advancements, many existing AI-driven systems fail to effectively incorporate pedagogical constraints, syllabus relevance, and balanced difficulty distribution.

This research paper presents an intelligent question paper generation framework supported by Generative AI and structured according to Bloom's Taxonomy. The system combines AI-based content generation with classification, validation, difficulty estimation, and semantic filtering techniques. The primary objective is to generate high-quality examination papers that are syllabus-focused, cognitively balanced, and academically reliable.

II. LITERATURE SURVEY

K. Kim & D. Park et al. (2025) : Kim and Park analysed different algorithms used in automatic examination systems and highlighted challenges such as duplication, poor difficulty balancing, and lack of pedagogical consistency. Their research highlighted the importance of incorporating Generative AI along with enhanced evaluation strategies.

A. Gupta & P. Patel et al. (2024) : Gupta and Patel examined machine learning techniques for automated examination generation and emphasized the significance of syllabus coverage, question classification, and semantic similarity analysis.

S. Roberts & T. Wilson et al. (2023): Roberts and Wilson examined transformer-based architectures such as GPT and BERT for educational applications. Their work demonstrated that transformer models can generate meaningful questions due to their contextual understanding abilities, although additional educational constraints are still required.

H. Liu & E. Brown et al. (2022): Liu and Brown studied the transition from traditional rule-based assessment systems to modern deep learning approaches. They concluded that neural-network-based systems provide better adaptability, diversity, and personalisation in question generation.

J. Wang & L. Zhang et al. (2022) : Wang and Zhang investigated the role of NLP techniques in automated educational assessment. Their work discussed contextual analysis, semantic understanding, and transformer-based methods for generating relevant questions while also identifying challenges related to semantic correctness.

Ragasudha & M. Saravanan et al. (2021) : Ragasudha and Saravanan focused on secure automated paper generation systems that include randomization and configurable constraints such as topic weightage and difficulty levels.

Animesh Srivastava et al. (2020): Srivastava proposed a deep-learning-based system capable of generating questions from both textual and visual content using NLP and image-captioning methods.

III. RESEARCH GAP

Most currently available question paper generation systems apply AI and NLP methods for question creation, but many fail to accurately satisfy Bloom's Taxonomy and syllabus-related requirements. Many systems also do not maintain balanced difficulty levels or effectively prevent duplicate questions. Although Generative AI models can generate high-quality questions, important features such as cognitive classification, difficulty estimation, syllabus filtering, and similarity checking are usually handled separately instead of within a single framework. Additionally, existing evaluation methods primarily concentrate on accuracy and relevance, whereas aspects such as cognitive balance and syllabus coverage are frequently overlooked. Therefore, an integrated intelligent framework is required to automatically produce balanced, syllabus-oriented, and high-quality question papers.

IV. PROPOSED SYSTEM

4.1 Proposed System Methodology

The proposed framework is developed as an AI-supported question paper generation system that combines Generative AI, NLP, and validation components within an organized workflow. The system generates examination questions according to user-defined academic requirements while ensuring syllabus relevance and cognitive balance.

4.2 System Architecture

The proposed system architecture is composed of several interconnected layers. The architecture ensures scalability, flexibility, and integration of multiple AI and NLP components.

1. Input Processing Layer

This layer handles syllabus input provided in different formats, including PDF documents, scanned images, and plain text. OCR techniques are applied to image-based content, while PDF documents are processed using text extraction and preprocessing techniques.

2. User Constraint Layer

This module allows educators to define parameters such as Question type, Marks allocation, Difficulty distribution, Bloom's Taxonomy levels, and topic-wise weightage. This ensures the system generates customized and structured question papers.

3. AI Generation Layer

The generation layer dynamically constructs prompts using syllabus topics and user constraints. The Large Language Model subsequently produces candidate

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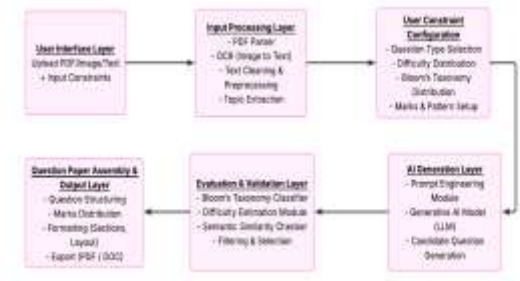
examination questions. This layer ensures context-aware and syllabus-aligned question generation.

4. Evaluation & Validation Layer
Generated questions pass through multiple validation stages:
i. Bloom's Taxonomy Classification
ii. Difficulty Estimation
iii. Semantic Similarity Checking

5. Question Paper Assembly Layer
Validated questions are organized into structured sections based on marks, question type, and cognitive distribution. The final output is generated in a formatted document.

4.3 System Diagram



V. SYSTEM WORKFLOW

The proposed system follows a sequential workflow consisting of the following stages.
1. Input Processing
Users can upload syllabus material in PDF, image, or text format. OCR and preprocessing methods extract and clean textual content before identifying important keywords and topics.
2. Constraint Configuration
The system collects user-defined constraints, including the number of questions, total marks, difficulty ratio, Bloom's level distribution, and question categories. This stage ensures that the generated paper follows institutional academic requirements.

3. AI-Based Question Generation
Prompt engineering methods are applied to direct the functioning of the Large Language Model. Each prompt specifies topic, difficulty level, cognitive level, and question type. The model produces multiple candidate questions for each configuration.

4. Bloom's Taxonomy Classification
A classification module analyzes generated questions and verifies whether they belong to the intended cognitive category.

5. Difficulty Estimation Module
Difficulty is determined using linguistic and semantic indicators such as sentence complexity, domain-specific terminology, readability, and conceptual depth

6. Duplicate Detection
Semantic embeddings and cosine similarity are applied to identify repetitive questions. Questions having high similarity scores are removed from the final output.

7. Question Paper Assembly
The validated questions are organized into sections and formatted into a complete examination paper.

VI. ADVANTAGES

1. Reduces manual effort in examination preparation.
2. Supports user-driven customization.
3. Ensures Bloom's Taxonomy alignment.
4. Provides objective difficulty estimation.
5. Maintains syllabus relevance.
6. Supports multi-modal input formats.
7. Eliminates duplicate questions.
8. Produces structured examination papers.
9. Improves consistency and reliability.
10. Enables real-time question paper generation.
11. Supports scalability and future expansion.
12. Enhances assessment quality and educational outcomes.

CONCLUSION

This research introduced an Intelligent Question Paper Generation framework that combines

Generative AI with Bloom's Taxonomy alignment and validation mechanisms. The proposed approach addresses limitations associated with traditional and existing automated assessment systems by integrating syllabus-based generation, difficulty estimation, semantic similarity analysis, and cognitive classification.

Unlike conventional systems, the framework enables educators to configure examination requirements according to difficulty level, cognitive distribution, question type, and mark allocation. The inclusion of validation modules improves reliability, academic relevance, and pedagogical accuracy.

The system also supports multiple input formats and automatically produces structured examination papers, making it suitable for practical educational environments. Overall, the integration of AI-driven generation and intelligent validation mechanisms demonstrates a scalable and efficient solution for modern assessment design.

Future work may include multilingual support, adaptive question generation, personalized assessment systems, and integration with learning management platforms.

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