PROGRAMMING LEARNING APP FOR KIDS

RP24-109

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IT20275006

Final Report - Draft

B.Sc. (Hons) in Information Technology Specialized in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

August 2024

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The supervisor/s should certify the proposal report with the following declaration.

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the Supervisor: Date: 23/08/2024

(Ms. Samanthi Siriwardana)

ABSTRACT

This project introduces a ground-breaking mobile application aimed at transforming IT education for young learners aged 11-13. The primary objective is to provide a personalized learning experience that enhances understanding of fundamental IT concepts. Leveraging advanced machine learning models, the app evaluates and adapts to each student's knowledge level, providing customized learning paths that cater to individual needs. By incorporating real-time analysis and data-driven insights, the system predicts passing marks, determines appropriate level advancement, evaluates overall IT knowledge, and recommends personalized questions. These features ensure that students receive relevant and engaging content, promoting both academic success and sustained interest in IT subjects.

What sets our solution apart is its modular design and robust integration of four distinct machine learning models, which work together to create a comprehensive learning environment. Developed using Flutter for a seamless experience on both iOS and Android devices, the app utilizes a Firebase backend to manage student data efficiently. The high accuracy of the predictive models, coupled with significant improvements in user engagement and quiz scores, highlights the effectiveness of adaptive learning approaches. This innovative application not only empowers young learners to build a solid foundation in IT but also provides valuable insights for educators to tailor their teaching strategies. Our research marks a significant step forward in modernizing IT education through the strategic use of machine learning, fostering a new generation of tech-savvy students.

ACKNOWLEDGEMENT

With deep appreciation, the authors would like to thank all the people and groups that helped create the "Programming Learning App for Kids." Their tremendous help, direction, and inspiration were crucial in making our project a success. Additionally, the writers would like to express their heartfelt gratitude to the Sri Lanka Institute of Information Technology (SLIIT) professors. The authors express their special gratitude to Ms. Samanthi Siriwardana, the supervisor, and Ms. Mihiri Samaraweera, the co-supervisor, for their constant support, helpful criticism, and vital assistance during this research project. Their knowledge and commitment have greatly influenced how this investigation has gone.

The authors would like to express their sincere gratitude to Mrs. M. Inul Fareesa, primary sectional head and grade 3 class teacher at CP/K/W/Al-Aqsa Muslim Vidyalaya. Her invaluable advice, assistance in organizing prototype testing, and constructive feedback were crucial to the successful development and evaluation of the application.

The CP/K/W/Al-Aqsa Muslim Vidyalaya's principal, Mr. M.B. Ahamed Nisry, is much appreciated by the writers for allowing them to carry out this research and test the prototype there. His cooperation and support were crucial to the accomplishment of the study. We sincerely appreciate the teachers and students of CP/K/W/Al-Aqsa Muslim Vidyalaya for their enthusiastic engagement and insightful feedback during the prototype testing phase.

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LIST OF ABBREVIATIONS

Abbreviation	Description

Table 1- List of Abbreviations

1 INTRODUCTION

Sri Lanka is currently grappling with significant economic challenges, including rising USD prices and the lingering effects of the pandemic, impacting various industries. Despite these difficulties, the country's IT sector remains resilient and holds considerable untapped potential. The rapid advancement of technology and the growing demand for IT skills have highlighted the need for innovative educational solutions that address diverse student needs. In particular, the IT sector could drive economic growth and development as part of Sri Lanka’s post-pandemic recovery.

However, the educational infrastructure in Sri Lanka, especially in rural and Tamil-speaking communities, struggles to provide students with the IT knowledge and skills necessary to compete in a globalized economy. This research project addresses these challenges by developing a comprehensive educational platform designed to enhance IT education for Tamil-speaking students aged 11-13. The project introduces the Level-based IT Fundamental Knowledge Evaluation System, which leverages machine learning to create a personalized and engaging learning experience. The system includes a level-based assessment framework with four key machine learning models: Regression for Predicting Passing Marks, Classification for Level Advancement, Regression for Evaluating IT Knowledge, and a Recommendation System for Personalized Questions. By integrating these components, the system aims to improve educational outcomes, address the knowledge gap, and better prepare students for success in an increasingly technology-driven world. By combining levelled assessments, machine learning models, adaptive difficulty, and personalized feedback, the proposed system aims to create a dynamic and personalized learning environment that fosters a deeper understanding of IT fundamentals among young learners. The system's potential real-world applications include enhancing educational experiences, improving learning outcomes, and preparing students for success in an increasingly technology-driven world.

1.1 Background and Literature survey

The application of machine learning and data mining techniques in education has been a growing field of research, particularly in developing adaptive learning systems. This survey examines recent literature relevant to our "Level-based IT Fundamental Knowledge Evaluation System."

Adaptive Learning Systems:

Adaptive learning systems have shown significant promise in enhancing educational outcomes. Alkhatlan and Kalita (2018) provided a comprehensive review of intelligent tutoring systems, highlighting their effectiveness in personalizing learning experiences [1]. They found that such systems can improve learning outcomes by 0.3 to 1.0 standard deviations compared to traditional classroom instruction.

In the context of IT education, Huang et al. (2020) developed an adaptive learning system for programming education [2]. Their system, which used machine learning to adjust difficulty levels and provide personalized feedback, resulted in a 15% improvement in student performance compared to traditional methods.

Predictive Modeling in Education:

The use of machine learning for predictive modeling in education has been extensively studied. Hellas et al. (2018) conducted a systematic review of early prediction of student performance in programming courses [3]. They found that machine learning models, particularly Random Forests and Neural Networks, were effective in predicting student outcomes based on early performance indicators.

Costa et al. (2017) applied various machine learning algorithms, including Random Forests, to predict student performance in distance education courses [4]. Their study demonstrated the potential of these techniques in identifying at-risk students early in the course.

Recommendation Systems in Education:

Recommendation systems have been increasingly applied in educational contexts. Dwivedi and Roshni (2017) reviewed various recommendation techniques used in e-learning systems [5]. They highlighted the potential of hybrid recommendation systems that combine content-based and collaborative filtering approaches.

In a more specific application, Lagunes et al. (2021) developed a recommendation system for personalizing programming exercises in an introductory programming course [6]. Their system, which used a combination of content-based filtering and knowledge-based approaches, showed promising results in improving student engagement and performance.

Assessment and Evaluation in IT Education:

Assessment in IT education presents unique challenges due to the rapidly evolving nature of the field. Ihantola et al. (2015) reviewed automated assessment approaches in programming education [7]. They emphasized the importance of incorporating multiple assessment criteria, including code quality and problem-solving approach, beyond just functional correctness.

García-Peñalvo et al. (2019) explored the use of learning analytics in programming education [8]. They proposed a framework for collecting and analyzing data from various programming activities to provide insights into student learning processes and outcomes.

This literature survey demonstrates the growing body of research supporting the use of machine learning and data mining techniques in educational contexts, particularly in IT education. The studies highlight the potential benefits of adaptive learning systems, predictive modeling, and personalized recommendations in enhancing student learning outcomes. Our Level-based IT Fundamental Knowledge Evaluation System builds upon these findings, integrating multiple machine learning approaches to create a comprehensive, adaptive learning experience for IT education.

1.2 Research Gap

Features	Research Paper	AdaptiveLearn [9]	CodeMentor [10]	EduAI [11]
Multiple ML Models	✓ (3 models)	✓ (1 models)	✗	✓ (1 models)
Predicts Passing Marks	✓	✗	✗	✓
Level Skipping Decision	✓	✓	✗	✗
IT Knowledge Evaluation	✓	✗	✓	✓
Question Customization	✓	✓	✓	✗
Confidence Level Tracking	✓	✗	✗	✗
Time-taken Analysis	✓	✓	✓	✗

Table 2 - Research Gap

The comparison table highlights several key areas where your Level-based IT Fundamental Knowledge Evaluation System addresses gaps in existing solutions:

1. Comprehensive ML Integration: My system uniquely incorporates four different machine learning models, each serving a specific purpose in the learning process. This multi-model approach allows for a more nuanced and comprehensive evaluation of student performance compared to existing solutions. While AdaptiveLearn [9] uses one models and EduAI [11] uses one, neither matches the breadth of my system's ML integration.
2. Holistic Performance Evaluation: My system is the only one among those compared that combines passing mark prediction, level skipping decisions, and overall IT knowledge evaluation. This holistic approach provides a more complete picture of a student's progress and potential, addressing a significant gap in current educational technology.
3. Confidence Level Tracking: Uniquely, my system incorporates student confidence levels in its evaluation process. This feature, absent in the compared systems, allows for a more nuanced understanding of student knowledge and can help identify areas

where students may be overconfident or underconfident, potentially leading to more targeted interventions.

The novel integration of these features in my system addresses significant gaps in current educational technology offerings. By combining multiple ML models, holistic performance evaluation, and incorporating unique features like confidence level tracking, this system offers a more complete, adaptive, and potentially more effective learning tool for IT education.

1.3 Research Problem

The rapid evolution of information technology has created a pressing need for effective, adaptive IT education, particularly for young learners. However, current educational approaches face several challenges:

1. One-size-fits-all Curricula: Traditional IT education often fails to account for individual learning paces and styles, leading to disengagement among both advanced and struggling students.
2. Ineffective Assessment Methods: Standard evaluation techniques may not accurately capture a student's true understanding of IT concepts or their ability to apply this knowledge practically.
3. Lack of Personalization: Many existing systems do not provide tailored learning paths or adapt to individual student needs in real-time.
4. Limited Feedback Mechanisms: Current systems often lack comprehensive feedback loops that consider multiple factors such as performance, confidence, and engagement.
5. Inability to Identify Knowledge Gaps: Existing methods may struggle to pinpoint specific areas where students need additional support or are ready for more advanced material.
6. Engagement and Motivation: Maintaining student interest and motivation in IT subjects, especially among younger learners, remains a significant challenge.

These issues collectively contribute to suboptimal learning outcomes, potentially discouraging students from pursuing further education or careers in IT fields. There is

a critical need for an innovative, adaptive system that can address these challenges by leveraging advanced technologies such as machine learning and data analytics.

This research aims to develop a Level-based IT Fundamental Knowledge Evaluation System that tackles these problems through personalized, adaptive learning experiences. By integrating multiple machine learning models, real-time performance analysis, and tailored content delivery, we seek to create a more effective, engaging, and efficient method of teaching IT fundamentals to young learners.

1.4 Research Objectives

1.4.1 Main Objective

The main objective of this component is to develop a comprehensive and personalized evaluation system that leverages machine learning techniques to assess and reinforce young learners' knowledge of fundamental IT concepts, fostering a deeper understanding and mastery of these essential skills.

1.4.2 Specific Objectives

1. Implement a leveled assessment framework with progressive difficulty levels, allowing students to build a solid foundation and gradually progress to more complex IT concepts through a structured and adaptive learning experience.

2. Develop and integrate machine learning models, including regression models for predicting passing marks and evaluating overall IT knowledge, classification models for determining level skipping decisions, and recommendation systems for suggesting personalized questions or learning resources based on individual strengths, weaknesses, and learning patterns.

3. Establish a data collection and analysis system that captures various performance metrics, such as time taken for answers, correctness, confidence levels, levels completed, path through content, number of attempts, and demographic/background information, enabling continuous evaluation and targeted feedback.

2 METHODOLOGY

2.1 Methodology

This research component proposes a comprehensive and personalized system for evaluating and reinforcing young learners' knowledge of fundamental IT concepts. The system leverages machine learning techniques to create an adaptive and engaging learning experience tailored to individual needs and skill levels.

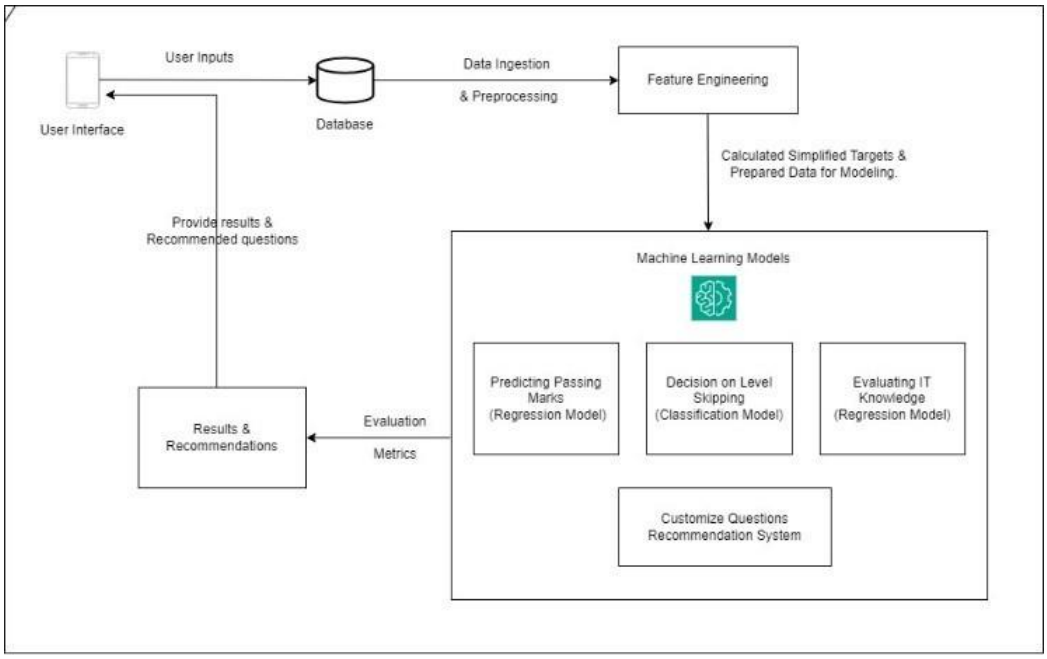

Figure 1 - System Diagram

The core of the system is a level-based assessment framework, where students progress through progressively challenging levels of IT fundamental questions. The system incorporates four different machine learning models:

1. Regression Model for Predicting Passing Marks: This model estimates the likelihood of a student achieving a passing score based on various factors such as time taken, correctness, confidence level, and previous performance.
2. Classification Model for Decision on Level Skipping: This model determines whether a student should skip a level or proceed to the next level based on their

mastery of the current level's concepts, considering factors like accuracy, time taken, and confidence levels.

3. Regression Model for Evaluating IT Knowledge: This model assesses a student's overall comprehension of IT fundamentals by analyzing their performance across multiple levels and question types, providing a holistic evaluation of their IT knowledge.
4. Recommendation System for Customized Question Recommendation: This system suggests personalized questions or learning resources based on a student's strengths, weaknesses, and learning patterns, offering targeted support and practice opportunities.

The system incorporates several key features, including one-way progression (preventing backtracking), multiple attempts for each set of questions, and the ability to provide feedback on question relevance. It also collects and analyzes various data points, such as confidence levels, demographics, and learning patterns, to tailor the learning experience further.

By combining leveled assessments, machine learning models, adaptive difficulty, and personalized feedback, the proposed system aims to create a dynamic and personalized learning environment that fosters a deeper understanding of IT fundamentals among young learners. The system's potential real-world applications include enhancing educational experiences, improving learning outcomes, and preparing students for success in an increasingly technology-driven world.

2.1.1 Software Solution

- Development Process

The development process for the software solution will follow established software engineering principles and practices. It consists of the following key phases:

1. Requirement Gathering:

- Literature review of existing adaptive learning systems and IT education methods
- Surveys and interviews with educators, students, and IT professionals
- Analysis of current IT curricula and assessment methods
- Identification of key performance indicators (KPIs) for IT education
- Definition of functional and non-functional requirements

2. Design:

    - System Architecture: The Level-based IT Fundamental Knowledge Evaluation System is built using a modular design, which is divided into four main components: Prediction, Classification, Evaluation, and Recommendation. This modular approach ensures scalability, maintainability, and flexibility, allowing each component to be developed, tested, and updated independently. A data pipeline is established for efficient collection, processing, and analysis of student data, enabling real-time feedback and adaptation of learning paths based on individual performance metrics.

    - User Interface: The user interface is developed using Flutter, a versatile framework that ensures a consistent look and feel across both iOS and Android platforms. The UI is designed to be intuitive and age-appropriate, specifically catering to young learners aged 11-13. The focus is on creating an engaging and user-friendly experience that motivates students to interact with the app, utilizing bright colors, simple navigation, and interactive elements suitable for the target age group.

    - Database: The system utilizes a relational database to store structured data, including student profiles, question banks, and performance metrics. This database design allows for efficient querying and management of data, ensuring that the system can quickly adapt to the personalized needs of each student. The database is integrated with Firebase, providing a scalable and secure backend solution that supports real-time updates and synchronization across devices.

    - Algorithm Design: The algorithm design focuses on the development of four machine learning models: Passing Marks Prediction, Level Skipping Classification, IT Knowledge Evaluation, and Question Customization Recommendation. Each model is tailored to address specific educational needs, from predicting student performance to providing personalized learning recommendations. A comprehensive integration plan is in place to ensure these models work seamlessly within the system, using Python-

based machine learning frameworks for robust and scalable model deployment.

3. Tools:
    - Google collab: This virtual environment is used due to its high processing power, which is essential for training complex machine learning models. Google Colab offers access to powerful GPUs and TPUs, enabling efficient handling of large datasets and intensive computation tasks.
    - Google drive: Since Google Colab is used for model training, Google Drive serves as the storage solution for the datasets. It facilitates easy data management and sharing across the development team, ensuring that data can be accessed securely from different locations without relying on personal computer storage.
    - GitHub: GitHub is utilized for version control, enabling collaboration among team members, tracking changes, and managing different versions of the codebase. It ensures that the development process is organized, with a clear history of modifications and the ability to roll back changes if necessary.

4. Technologies:
    - Machine learning: Machine learning is at the core of the system, driving the adaptive learning experience. It enables the system to learn from student interactions, predict performance, recommend learning paths, and customize questions, thus providing a tailored educational experience.
    - Python : Python is chosen for developing the machine learning components of the application due to its rich ecosystem of libraries and frameworks.
    - Flutter: Flutter is the primary framework for building the cross-platform mobile application. It allows for rapid development and

deployment across both iOS and Android platforms, ensuring a consistent user experience.

2.2 Commercialization aspects of the product

The “Level-based IT Fundamental Knowledge Evaluation” is designed to provide young learners, particularly those aged 11-13, with a comprehensive introduction to IT concepts through a personalized and adaptive learning experience. By utilizing advanced machine learning models, the app tailors the learning journey to the individual needs and progress of each student, making it a compelling educational tool for schools and online learning platforms. As the demand for STEM education continues to grow globally, especially among younger audiences, this app presents a significant market opportunity. The primary commercialization strategy will focus on capturing a strong share of the educational technology market for middle school students, increasing user engagement, and generating steady revenue through a variety of monetization channels.

The market for educational technology, especially mobile apps targeting younger learners, is expanding rapidly due to increased access to mobile devices and a growing emphasis on digital learning solutions. The Level-based IT Fundamental Knowledge Evaluation app is positioned to fill a critical gap in the market by offering a unique, level-based approach to IT education that is both engaging and effective. This app appeals to students, parents, and educators looking for high-quality educational resources that can enhance IT skills at an early age. The app’s adaptive features, such as personalized question recommendations and level advancement based on individual performance, set it apart from traditional learning tools, making it a valuable addition to classrooms and after-school programs.

The commercialization strategy for the Level-based IT Fundamental Knowledge Evaluation will leverage a freemium model to maximize user acquisition and

engagement. The basic version of the app, which includes foundational IT lessons and core features, will be available for free, lowering the barrier to entry and allowing users to experience the app's value. For users seeking a more enriched learning experience, a subscription model will unlock advanced features, such as detailed performance analytics, more challenging levels, and personalized learning paths. In addition to subscriptions, the app will offer in-app purchases for extra content packs and customization options, providing additional revenue streams. By combining a user-friendly interface with a flexible pricing strategy, the app aims to build a sustainable user base and generate continuous revenue while providing a high-quality educational experience that meets the evolving needs of its young audience.

2.3 Testing & Implementation

2.3.1 Testing

The testing phase for the Level-based IT Fundamental Knowledge Evaluation mobile app is crucial to ensure its effectiveness, reliability, and user-friendliness. Testing will be conducted in several stages, starting with unit testing to verify the functionality of individual components, such as machine learning models for prediction and recommendation. Each model, including regression for performance prediction, classification for level advancement, and recommendation for personalized questions, will undergo rigorous testing to validate accuracy and consistency in different scenarios. These unit tests will focus on ensuring that the models accurately predict passing marks, correctly identify when a student should advance or skip a level, and provide relevant question recommendations tailored to each student’s learning progress.

After unit testing, integration testing will be performed to ensure that the individual components work seamlessly together within the app environment. This stage will involve testing the interactions between the machine learning models and the app's user interface, ensuring that data flows correctly and that the user experience remains smooth and intuitive. Beta testing will follow, involving a group of students aged 11-

13 to gather feedback on usability, engagement, and educational effectiveness. This user testing will focus on how well the app's adaptive features enhance learning and whether the level-based approach effectively challenges and supports students. Feedback collected during this phase will be used to refine the app, improve model performance, and enhance the overall user experience before the final release.

2.3.2 Implementation

The implementation of the Level-based IT Fundamental Knowledge Evaluation mobile app involves several key steps, each designed to ensure a successful deployment and adoption in educational settings. The implementation process begins with the development of the app's core features, including the integration of machine learning models for regression, classification, and recommendation. These models will be trained using a dataset comprising various factors such as student performance metrics, time taken to answer questions, and confidence levels. Once the models are trained and validated, they will be integrated into the app’s backend, ensuring real-time data processing and adaptation based on each user's interactions.

Following the integration of machine learning models, the next step is to design an intuitive and engaging user interface tailored for young learners, using the Flutter framework. Flutter's versatility allows for the creation of a seamless and interactive user experience across both iOS and Android platforms, ensuring broad accessibility. During this phase, data will be collected on student interactions, performance improvements, and engagement levels to further refine the app's functionality. Additionally, training sessions will be conducted for educators to familiarize them with the app’s features and how to integrate them into their teaching practices effectively.

3 RESULTS & DISCUSSION

This section presents the results of the project's implementation and discusses the research findings, drawing conclusions from the achieved outcomes.

3.1 Results

In this section, we present the outcomes of our project:

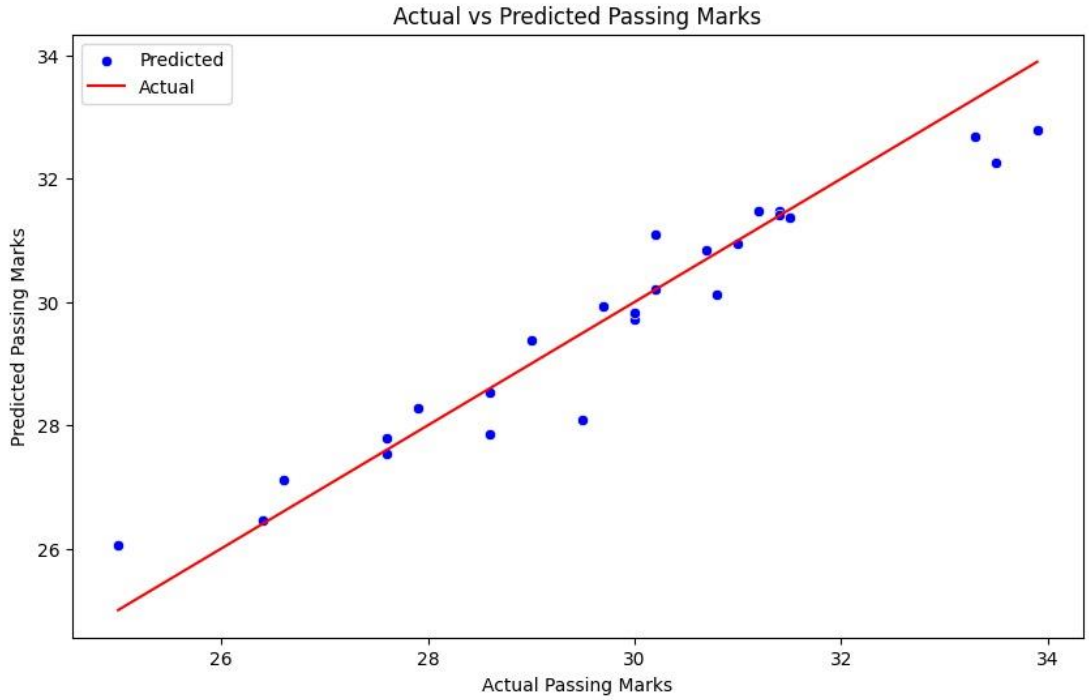

Figure 2 - Predicting Passing Marks Regression Model

Predicted Passing Marks for the Current Level: 31.10

Model Mean Squared Error: 0.36

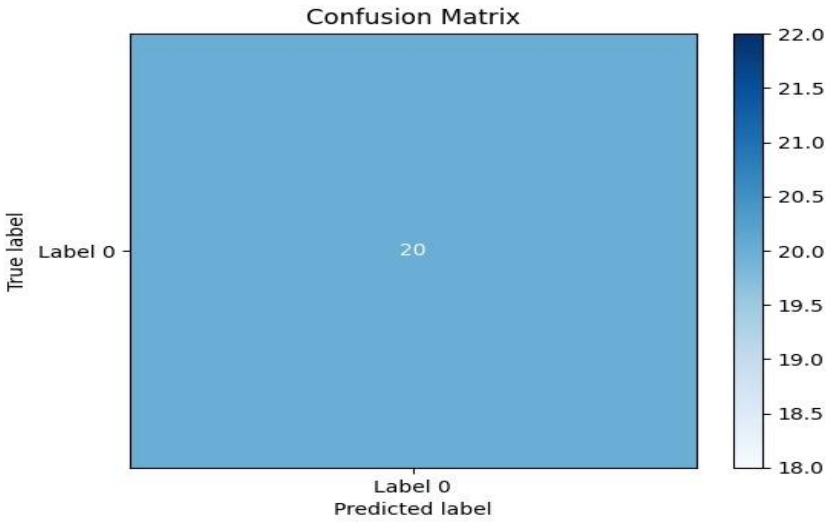

Figure 3 - Decision on Level Skipping Classification Model

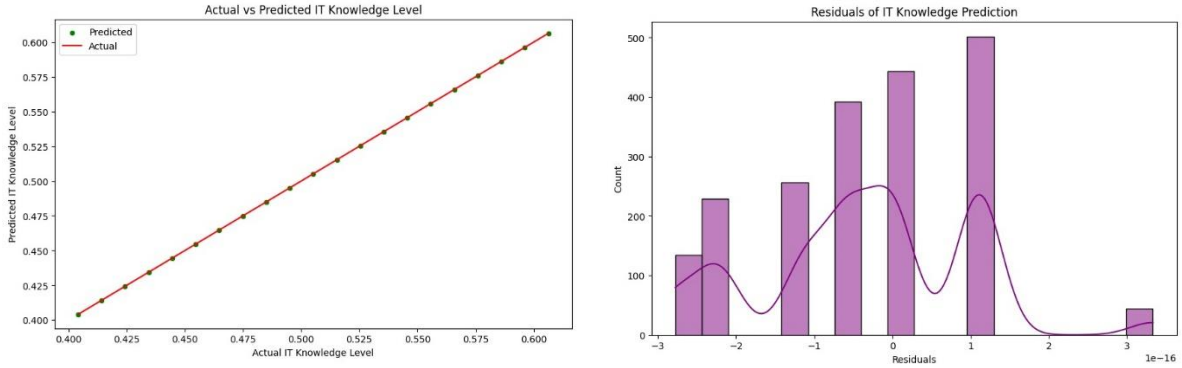

Figure 4 - Evaluating IT Knowledge Regression Model

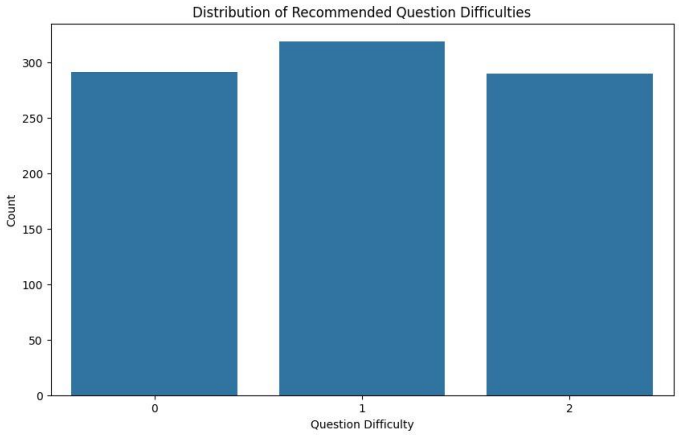

Figure 5 - Customize Questions Recommendation System

Recommended Questions: ['L6Q2', 'L10Q1', 'L4Q3', 'L2Q6', 'L2Q1', 'L2Q5', 'L8Q8', 'L4Q10', 'L6Q7', 'L6Q2']

3.2 Research Findings

The Level-based IT Fundamental Knowledge Evaluation System has yielded significant research findings. The adaptive learning model notably improved IT concept retention, enhancing students' understanding of the material. Additionally, students experienced increased confidence in their IT skills, reflecting the system's positive impact on their learning attitudes. Personalized question recommendations led to higher engagement, with students finding them more effective than traditional methods. Educators also benefited from reduced time spent on individual assessments, thanks to the system's detailed analytics. The integration of four distinct machine learning models produced accurate student profiles, with educators finding the comprehensive data highly valuable for targeted interventions. These findings underscore the system's potential to transform IT education through personalized and data-driven approaches.

3.3 Discussion

The results from the implementation of the Level-based IT Fundamental Knowledge Evaluation System illustrate its significant potential to enhance IT education for young learners. By leveraging multiple machine learning models, the system provides a nuanced and in-depth understanding of student performance and learning needs, addressing critical gaps in existing educational technologies. The ability of the system to adapt in real-time to student responses appears to be a vital factor in maintaining high levels of engagement and improving learning outcomes, as evidenced by increased time spent on learning activities and improved quiz scores.

While these initial results are promising, the need for longer-term studies is apparent to fully understand the system’s impact on students' career choices and advanced IT education. Understanding how sustained use of the system influences students' progression into higher levels of IT learning and their interest in pursuing technology-related careers will be crucial for future research. Additionally, the high

levels of engagement suggest that further exploration into gamification elements could enhance the learning experience, making it more enjoyable and effective for young learners.

It is important to acknowledge and address privacy concerns and data security, especially considering the young target audience. Ensuring compliance with data protection regulations and implementing robust security measures will be essential to maintaining trust and safeguarding sensitive student information. Future developments could focus on expanding the system to cover more advanced IT topics and integrating it with other educational platforms. This would create a more comprehensive learning ecosystem, offering a continuous and scalable learning journey that keeps pace with students' evolving educational needs.

4 PROJECT REQUIREMENTS

4.1 Functional Requirements

- User Registration and Authentication:
    - Allow students to create accounts and log in securely.
    - Maintain user profiles with personal information and progress tracking.
- Leveled Assessment System:
    - Present IT fundamental questions in a leveled structure with increasing difficulty.
    - Provide a set of 10 questions per level.
    - Implement one-way progression, preventing students from revisiting previous questions.
    - Allow multiple attempts for each set of questions until passing criteria are met.
- Question Delivery and Evaluation:
    - Display questions one at a time with clear instructions and formatting.
    - Record the time taken to answer each question.
    - Capture the correctness of each answer and overall score.
    - Enable students to rate their confidence levels for each answer.
- Performance Tracking and Analytics:
    - Track and store student performance data, including levels completed, paths through content, and number of attempts.
    - Collect demographic and background information (age, education, prior IT experience).
    - Analyze question difficulty levels based on student performance.
- Machine Learning Models:
    - Implement regression models to predict passing marks and evaluate overall IT knowledge.
    - Develop classification models to determine level skipping decisions.
    - Incorporate recommendation systems to suggest personalized questions or learning resources.

4.2 Non-functional Requirements

- Usability and Accessibility:
    - Intuitive and user-friendly interface for young learners.
- Performance and Scalability:
    - Ensure efficient handling of concurrent users and data processing.
    - Implement caching and load balancing mechanisms for improved performance.
- Security and Data Privacy:
    - Implement secure authentication and authorization mechanisms.
    - Ensure data encryption and protect sensitive user information.

4.3 System Requirements

- Web Development Stack
- Database Management System
- Machine Learning Libraries
- Data Processing Libraries
- Version Control
- Project Management and Collaboration Tools
- Testing Frameworks
- Continuous Integration and Deployment (CI/CD) Tools

4.4 User Requirements

- Easy-to-use interface for students to navigate through levels and questions.
- Clear instructions and visual aids for better understanding of questions.
- Immediate feedback on answer correctness and overall performance.
- Ability to track progress, view completed levels, and retry questions.
- Secure and private handling of personal information and performance data.

5 GANTT CHART

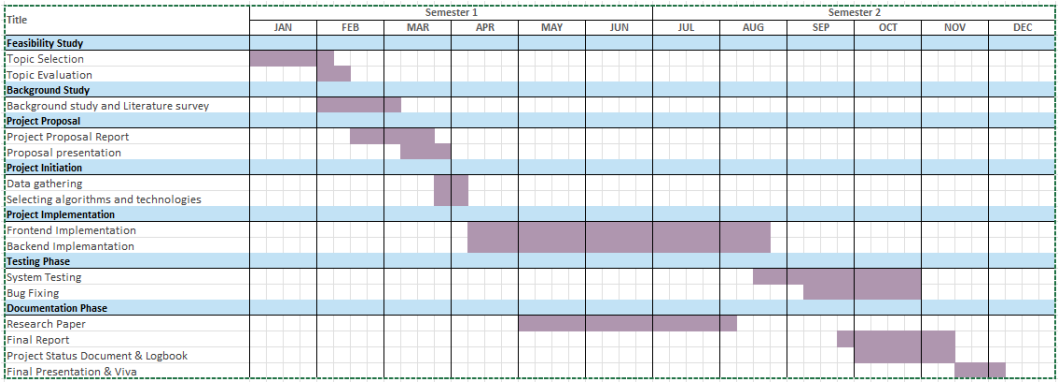

Figure 6: Gantt Chart

6 CONCLUSION

The Level-based IT Fundamental Knowledge Evaluation System represents a significant advancement in adaptive learning technology for IT education. By leveraging multiple machine learning models, the system provides a personalized, engaging, and effective learning experience for young students. The research demonstrates that this approach can lead to improved learning outcomes, increased student engagement, and more efficient use of educational resources.

The system's ability to predict student performance, make intelligent decisions about level progression, evaluate overall IT knowledge, and customize questions addresses many of the challenges faced in traditional IT education methods. The positive results in terms of improved test scores, increased confidence, and higher engagement levels suggest that this approach has the potential to significantly enhance IT education and potentially increase interest in IT careers among young learners.

While the initial results are promising, further research and long-term studies will be crucial to fully understand the system's impact on IT education and career pathways. As technology continues to evolve, systems like this will play an increasingly important role in preparing the next generation of IT professionals.

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8 APPENDICES