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Next-Gen Smart E-Learning and Assessment Portal Using ML

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Abstract: *This paper presents the design and implementation of a next generation learning management system (LMS) that leverages advanced emerging technologies to provide a secure, automated and interactive digital education environment. The proposed system streamlines course enrolment and allows for real-time tracking of learner progress and offers biometric attendance verification. When learners complete assessment tasks, they receive digitally signed certificates stored on a blockchain, which provides an authentication that is not tamper-proof. The administration dashboard provides fast and efficient course management and performance reporting tools, while a GPT-4-powered chatbot helps the learner interact with the system in real-time. Advanced machine learning algorithms allow adaptive learning paths to be determined; predictive analytics identify students with advanced learning problems early enough to improve their performance and offer proactive remediation. Natural language processing enhances user interaction and real-time automated assessments reduce administrative costs and inefficiencies. A scalable data-driven solution with a mission to enable digital education to fulfill the real-world needs of modern learners and institutions, is showcased in this paper.*

Keywords: Learning Management System (LMS), Artificial Intelligence (AI), Machine Learning (ML), Generative Pre-trained Transformer 4 (GPT-4), Blockchain, Facial Recognition, AI Chatbot, Adaptive Learning, Predictive Analytics, Blockchain Certification, Digital Certification, Real-Time Monitoring, Automated Testing, Course Enrolment Automation

I. INTRODUCTION

This requires new generation learning management systems (LMS) to deliver learning materials in a timely, efficient, and scalable manner. Related studies and findings include: (10)-32 The rising demand for web-based education has driven the development of emerging technologies, such as: (11)-36 Traditional LMS platforms are not tailored to support today's needs of contemporary learners as well as educators, such as personalization of educational experience, effective test certification, and automation in administration. In this paper, we present a new learning management system that leverages advanced technologies including: (11)-21 AI-based registration for courses, targeted support, facial recognition-based biometric attendance, secure test certification, real-time monitoring and predictive analytics, and interactive AI chatbot for live support are used. This LMS is aimed at revolutionizing the education landscape, using personalization, security, and automation to provide a engaging, efficient and scalable learning environment.

II. RELATED WORK

Anjana, M. S., Aryadevi, R. D et al. [1] Multi-Model Energy Management System, which incorporates IoT enabled devices coupled with distributed learning for improving energy efficiency in buildings includes smart positioning to detect occupant locations, occupant-centric automation by using Markov models for learning user preferences and an equipment coverage model to optimize appliance utilization, especially lighting. The edge-fog-cloud architecture enables economical waste reduction and provides privacy as well as convenience through localized processing.

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Experimental evaluation results demonstrate a 25% energy savings and as high as 8% energy consumption reduction at high occupancy levels, which suggests strong potentials for carbon footprint reduction.

Arredondo, P., Katz, D et al. [2] Proposed Technical Report GPT-4 represents the development of a large-scale multimodal model capable of understanding and processing text and images in a consistent and predictable way. Its unique design allows for accurate prediction of performance even for models trained with far less computational resources. A GPT-4 system performs human-level execution on a variety of professional and academic tasks (including general purpose task scores), being well ahead of GPT-3. 5% by a significant number. Recurrent neural networks were employed to learn to match its behavior to what a human intends, which improves safety and factual accuracy, while also simplifying the decision about which learning algorithm to use.

Li, X., Jiang, P., Chen, T., et al. [3] Proposed: Smart Pool is a decentralized mining pool implemented in a smart contract on Ethereum. It's a replacement for traditional mining pools which use Ethereum consensus mechanism to share tasks and validate shares. Miners submit completed shares through a client and rewards are automatically distributed by contract. This design avoids need for a central pool operator and assures fair distribution of rewards. Smart Pool is decentralized mining pool (aka public miner network) with various improvements including decentralization, efficiency, security and reproducibility.

Dai, H. -N., Zheng, Z. & Zhang, Y., et al. [4] propose an architecture of blockchain of things (BCOT) consisting of five components: data, network, consensus, incentive and service. Each component has the specific purpose, such as encrypted data, P2P networking, distributed consensus (through PoW, PoS, etc.), reward mechanism, and blockchain based services using smart contracts. The IoT data is stored and encrypted, broadcasted over an overlay network, validated by consensus and stored in an immutable manner. Partitions of the data exist for a compact size of an IoT device, while the full nodes (cloud/edge servers) maintain complete copies of the entire blockchain. According to Dai's architectures, interoperability, security and automation of industrial IoT systems can be gained.

Ghasempour, A., et al. [5] The application of the Internet of Things (IoT) to improve power generation, transmission, distribution and consumption of the Smart Grid (SG), presents a layering architecture, by which smart meters, sensors and communication networks interact to provide real-time monitoring, efficient data transmission and demand response actions. Key technologies covered include advanced metering infrastructure, data fusion and energy harvesting. IoT applications, such as smart homes, managing of electric vehicles, and communication line monitoring are stressed. This application is intended to optimize energy use, increase reliability and reach sustainability goals.

Holmes, W., Bialik, M. & Fadel, C. et al. [6] Proposed: Algorithms for teaching and learning: applications to what, how, and how. Proposed as a new development in the use of AI in learning, Artificial Intelligence in Education proposes a transformed knowledge-based, competency-based curriculum that promotes combined knowledge in core subjects while developing 21st century skills such as critical thinking skills, character development, and meta-learning. AI related technologies such as intelligent tutoring systems and personalized learning technologies are recommended to advance deeper, more adaptive, and individualized learning. Human teachers should no longer be replaced but augmented with AI. Students should be able to build both expertise and transferable skills, to develop in a world that is changing rapidly due to changing technologies and changing social structures.

Chen, G., Xu, B., Lu, M. & Chen, N. S. et al. [7] Proposed how blockchain technology can revolutionize education by using smart contracts to manage teaching and learning activities, giving students the security of securely, traceable and undisturbed records of educational processes. Smart contracts can automate reward systems for students based on performance ("learning is earning") stored in a blockchain wallet. Blockchain can also protect degrees from fraud by validating academic records on decentralized ledgers. In addition, teacher evaluations and instructional plans can be properly monitored through blockchain. This makes education systems trustworthy, fair and accountable.

Sharples M., Domingue J. et al. [8] Experimentation with badge giving on a private blockchain Open Blockchain platform, operated on open source Ethereum infrastructure (Smart Contract support). The system allows students to log in and receive the badges, which can be consumed in a Learning Passport. Administrator interface allows awarding of badges with all transactions being timestamped and cryptographically signed. Such transactions are peer-to-peer and have no central authority to be accredited.

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Taigman, Y., et al. [9] The proposed Deep Face system was initially developed through robust 3D face alignment which utilizes the 67 fiducial points and general 3D shape model to generate a formalized view of the face with more than 120 million parameters, including convolutional, locally connected (non-shared) and fully connected layers. The network was trained on 4. 4 million labeled face images from 4, 030 identities by stochastic gradient descent. This representation is sparse, highly discriminative and normal. It achieves an accuracy of 97. 35% on the LFW benchmark with near human level performance.

Viola, P., & Jones, M. el al. [10] propose building a real-time face detection system with a boosted cascade of simple features. An essential feature of the proposed system is the "Integral Image", which provides a fast feature computation method, and AdaBoost to select a set of feature representations from the large feature space and efficiently build strong classifiers. The selected classifiers are organized in a cascade that can quickly discard non-face regions and focus the computation on likely candidate faces. It offers high detection accuracy and is extremely fast, processing up to 15 frames per second without using color or motion cues.

III. EXISTING SYSTEM

Currently existing e-learning infrastructures mainly use centralized server architectures to store and administer educational information, i. e. user profiles and certification records, although such centralized systems are technically effective and subject to numerous critical vulnerabilities. One of the major problems is inability to resist security attacks, such as unauthorized access of the data, exposure of the data, and certificate tampering. In addition, such platforms function through a network model where validation/access to data is conditioned on only a single centralized entity that not only creates a single point of failure but also undermines user trust by limiting transparency and user control of the data.

Furthermore, legacy e-learning platforms are not generally designed to provide built-in mechanisms to maintain unalterable, permanent audit trails for all data exchanges. The lack of revocable audit trails seriously hampers the ability to authenticate the origin and authenticity of educational credentials. Automation capabilities for safe delivery of data, integrity verification and timely monitoring are also heavily limited. Thus, education institutions face ongoing challenges in terms of preserving the integrity of data, building trust in issuing certifications and expanding their current systems to accommodate the long term, secure management of educational data. These constraints are precisely what point the need for more robust, more transparent and decentralized management of academic records and credentials.

IV. PROPOSED SYSTEM

The recommended e-learning system offers several advanced features to offer a greater level of security as well as increased interactivity within the virtual learning environment. By using cutting edge technologies, the system overcomes a number of severe drawbacks present within traditional models. One of the main advantages of the system is that the management of the courses can be automated to provide a seamless user experience (enrolment, progression and completion of learning tasks) thereby reducing the administrative burden on learners as well as increasing their engagement and also for security reasons, to reinforce the user identification accuracy and accountability, a facial recognition technology is used for validating attendance in real-time to eliminate proxy attendance.

Once the system is deemed to have completed the course in full and completed any required test/evaluation, the following digitally signed certificate is generated by the system. This digital certificate is encrypted and stored on the blockchain to ensure that the academic credentials are authentic, that they are not manipulated or forgeries are not allowed. The implementation also offers administrators the ability to offer more comprehensive course management tools, student performance reporting and real-time data analysis capabilities which further support Data Driven Decision Making and reduce admin workload.

Additionally, a built-in intelligent chatbot provides 24/7 support and personalized interaction thereby providing an engaging and responsive user experience.Together, those features enable a secure and stable learning environment and a user-oriented learning environment that provides a foundation for a scalable and reliable e-learning infrastructure.

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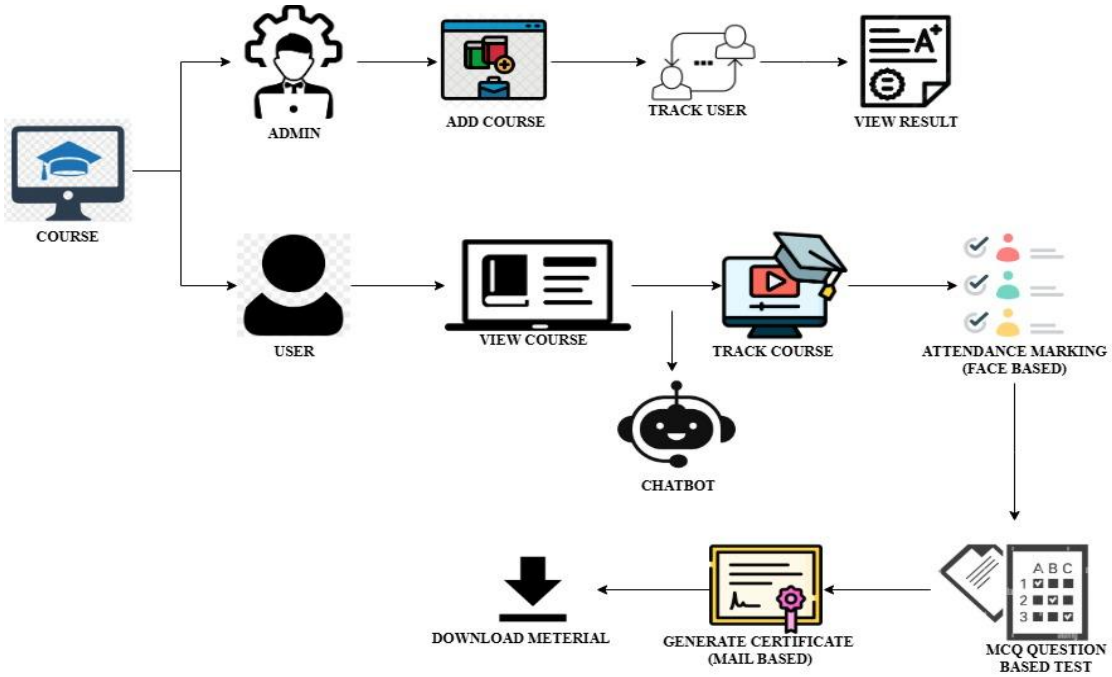

Figure 1 : Proposed architecture

V. METHODOLOGY

Based on the modular approach and integrating various cutting-edge technologies, the system offers intelligent, safe and interactive learning experiences. With a mix of functional modules – User Management, Course Management, Attendance Tracking, Assessment & Certification and Chatbot Support, all these modules are responsible for accomplishing specific tasks leading to the overall learning pipeline.

It uses the GPT-4 model for providing customized content presentation and smart chatbot responses, while Haar Cascade classifiers and DeepFace based facial recognition services to provide secure and automated attendance. The final certification process is done using blockchain integration which guarantees authenticity and tamper proof verification. The backend is implemented in Flask while the frontend is implemented using HTML, CSS and JavaScript.

VI. DATA COLLECTION AND PROCESSING

Attendance Dataset:

For facial recognition training we acquired a collection of facial images of enrolled users taken at various light conditions and orientations. We included several frontal and side profile images of each user to increase the recognition rate. The images were tagged with the user IDs and stored in a safe place. Preprocessing Techniques:

Aligning faces using Dlib

Normalization of lighting through histogram equalization

Face cropping and resizing to 160x160 pixels

Chatbot Query Dataset:

Besides 3, 000 user questions and their corresponding intents it was also based on:

Simulated student questions (e.g., uncertainty about the course, certificate issues)

Public educational Q&A datasets that are publicly available

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Manually annotated training objectives (e. g. "Course Inquiry", "Attendance Problem", "Uncertainty about Assessment")
Natural Language Processing techniques such as tokenization, stemming, lemmatization and vectorization (with BERT embeddings) were used for intent classification.

MCQ Assessment Data:
Dynamic quiz generation is supported by the system MCQs were generated and maintained from: Open educational repositories Manually created subject specific content (CS basics, AI, ML) JSON data storage in a structured form was used to support quiz delivery via the API.

VII. MODEL TRAINING

A. Face Recognition (Deep Face with Haar Cascade)
Model Employed: A pre-trained Deep Face models for facial recognition Haar Cascade classifier for face detection Graphical representation of webcam- captured face images pre-processed by grayscale conversion and Haar Cascade based region of interest extraction
Output: High-dimensional face embeddings generated by Deep Face
Matching: Cosine similarity thresholding for identity verification during attendance authentication
Training: Representation was adapted to user supplied facial images and subjected to diverse environmental conditions (e. g. lighting, angle of exposure, facial expression) to generate embeddings of facial information stored in the system and used for biometric authentication during class sessions.

B. Chatbot NLP (GPT-4 Fine-Tuning):
Framework: OpenAI GPT-4 API (prompt-based)
Training: Prompt-tuning (intent classification + response retrieval)
Functionality: Determines user intent (e.g., course enrolment, certificate support).
Responds with appropriate answers / directs question to admin if unclear.
In addition, the chatbot applied fallback rules and sentiment analysis for resolving ambiguous or emotional requests.

C. Blockchain Integration (Certification):
Hashes each certificate using Serialized and stores in a private blockchain (Hyperledger / Firebase DB mirror) for verification The validation is done by decrypting and checking the hash on-chain.

VIII. IMPLEMENTED ALGORITHM

It is assumed that the proposed Learning Management System (LMS) uses a number of advanced algorithms to achieve efficient and secure performance across different functions such as GPT-4 for content generation and feedback, Face Net for face recognition and SHA256 encryption for blockchain certificate storage. All the algorithms have a significant impact on the system performance, from improving learner engagement to increasing security and authenticity of digital certificates. The detailed explanations of these algorithms are provided in the respective sections.
A. Content Creation and Comments: GPT-4 is a powerful language model developed by OpenAI to help students create interactive course content and feedback that supports effective learning. GPT-4's natural language generation and understanding capabilities help it serve learners with real-time, contextual assistance in a wide variety of scenarios. GPT-4 powers OpenAI's AI chatbot that provides users with answers to questions on course content, assignments and learning resources in the LMS. GPT-4 is also used for creating content for quizzes, assignments and discussion questions to provide a highly interactive and engaging learning environment. The model is trained on large datasets so that it can give human - like answers which relate to the user's query, which in turn improves the interactivity and support experience in general. Also, thanks to GPT-4, the learners get immediate, tailored feedback about assignments/questions to help them stay focused and organized throughout the learning process.

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B. Face Recognition: The proposed LMS includes a two-step face recognition system for biometric attendance marking based on Haar/Cascade classifiers for face detection and DeepFace for facial recognition, which offer a lightweight and rugged solution for identity verification in real time.

Haar Cascade is a machine learning-based object detection technique that is used to rapidly and efficiently detect human faces in live webcam feeds by discriminating features, such as edges and line segments in a grayscale image, using a cascade function trained with positive and negative images. Its computational efficiency makes it suitable for fast face detection on low-performance devices.

Once a face is detected, the system uses Deep Face (a deep learning based facial recognition framework) to authenticate the user. DeepFace maps facial features into a high-dimensional vector space (using a deep convolutional neural network) and performs face matching by computing the cosine similarity between embeddings. This method achieves high accuracy and reliability across different lighting conditions, facial orientations and expressions.

Together Haar Cascades and DeepFace enables a secure, non-intrusive, highly accurate attendance mechanism that significantly reduces the risk of proxy attendance with minimal administrative burden when compared to manual verification. Also, because these biometric aggregators are integrated into the LMS at all times, the Learner Authentication can be performed securely as well, thus contributing significantly to the automation and security of the platform.

C. Blockchain: SHA256 encryption used to store certificate storage: SHA256 is used in the LMS to securely create and store digital certificates in the blockchain. After a learner completes an assessment or course, the system generates a certificate that contains the learner's name, course, and grade, and it is hashed using the SHA256 algorithm to generate a cryptographically secure, tamper-proof, fixed-length string that is unique. The certificate is hashed and stored on a blockchain, and it is a tamper-evident and transparent record of the learner's achievement. SHA256 guarantees that any tampering or modification of the information in the certificate would result in a completely different hash, thus ensuring resistance against fraud. Blockchain - protected storage of the certificate guarantees authenticity, verifiability and long-term integrity of academic credentials.

IX. MODULE OVERVIEW

The Learning Management System (LMS) implemented will combine different core modules to develop a seamless management and better learning experience overall. Each module plays a significant role in improving the user experience, enhancing admin efficiency and optimizing the system for guaranteeing the secure and personalized learning experience in this system. The following descriptions describe the core modules of the LMS: User Management, Course Management, Attendance Management, Assessment & Certification, Admin Dashboard, Chatbot and Reporting & Analytics.

A. User Management Module: The User Management module is at the heart of the LMS facilitating the management of the instructors and students. Among other things, it facilitates the registration of users, profile management, and the allocation of roles (e. g. student, teacher, administrator). The user can easily create and update their profiles. Administrators can control access levels so as to have appropriate levels of access throughout the system. The user management module is compatible with external authentication systems such as Single Sign-On for increased security and user convenience.

B. Course Management Module: The Course Management module allows instructors and administrators to create, organize, and maintain courses in a streamlined fashion. Courses can be constructed using various forms of content, such as quizzes, video lectures, assignments, and discussion forums. Courses can be categorised by topic, difficulty level, or learning outcome. Instructors can also create syllabi, set prerequisites, and monitor enrolment; students can easily browse and enroll in courses, view course content, and track progress in real-time.

C. Attendance Management Module: Biometric facial recognition to automatically mark students attendance for each class and an attendance record of the student for each class can be maintained by a biometric system integrated with the LMS with very little pain and problems. The attendance log of students can be stored forever at low cost and clear with no possibility of tampering. The attendance system is integrated easily with the LMS without any issues. It has no issue with roll calls or other forms of paperwork, thus eliminating the cost of manual roll calls.

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D. Assessment & Certification Module: The assessment & certification module offers simple and consistent process of student evaluation. It allows creation of various types of evaluations (like multiple choice questions (MCQ), essays and interactive assignments). After successful completion of assessments, the system automatically issues certificates (digitally signed and permanently stored on the blockchain) with guaranteed authenticity and security. This enables that learners get a tamper-proof, verifiable certificate upon successful completion of the course which can be securely accessed and shared through LMS.

E. Admin Dashboard Module: The Admin Dashboard module provides total control over the entire LMS. With a straightforward web-based interface, administrators can view the usage of the system, manage courses and users and access real-time learner performance data. The dashboard gives administrators an overview of the success of the courses, of learner's progress and areas where additional support may be needed by the students. Administrators can also control user requests, approve course content and approve the certificate issuing. F. Chatbot Module: The chatbot module gives student real time, personalized support during their learning journey. It provides contextual support throughout the learning journey. It can guide students through the course, answer common questions, provide assignment details and even recommend additional learning resources based on students' progress. The availability of the chatbot 24/7 ensures that learners get ongoing support, increasing engagement and reducing frustration.

X. EXPERIMENTAL RESULT

The implementation of the system described herein demonstrates remarkable improvements over traditional e-learning sites in many respects, including automation, security and user interaction. See examples of effectiveness in track and trace functions Experience shows improvements in tracking and maintaining course effectiveness. Students are better placed to enrol, engage with study material and sit for tests, thus optimizing learning.

Face recognition method of attendance has been successfully used for correct and real time verification of learner presence. The biometric way of attendance involves minimal instances of proxy attendance and the involvement of the authorities. One such innovation is the use of automated multiple-choice question (MCQ) tests that not only save students' grading time but also offer them immediate feedback thus strengthening concepts and helping students to develop adaptive learning.

But one of the key results is the use of blockchain technology to issue and store certificates which guarantees the tamper-proof authentication of the credentials so that the credentials may be independently verified without recourse to central authorities and also the immutability of the entries in the blockchain can reduce the risk of certificate forgery and thus institutional credibility. On-going dashboard for administrative users to monitor learner progress, exam performance and other engagement metrics. To help make data-driven decisions and work efficiently with our courses.

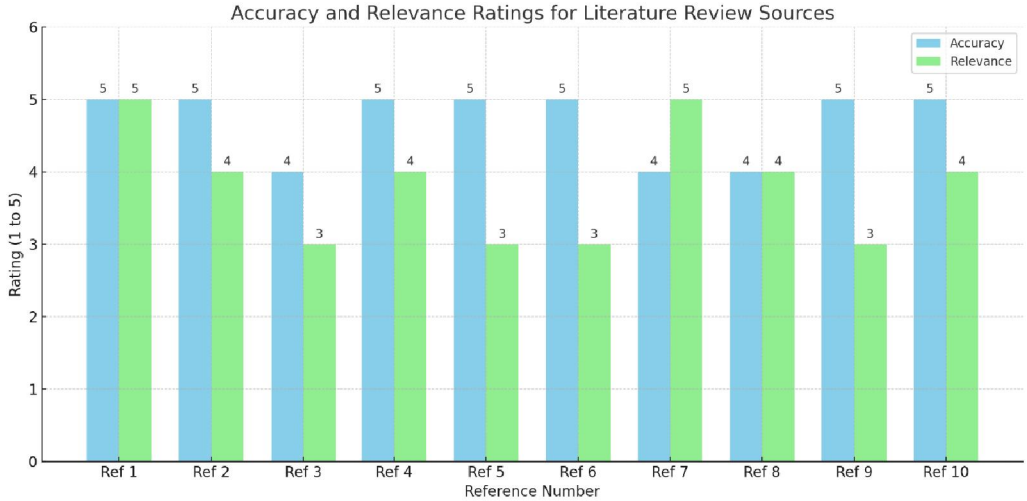

Figure 2

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We will also feature an AI chatbot embedded in the UI to further increase user satisfaction by providing 24/7 access to support, personalized interaction & continued learning over learning cycle. Compared to the existing centralized system, the proposed system is more reliable, the stored data is protected better, and the user experience is significantly higher; in other words, it has proven to be an all-round solution for modern education ecosystems.

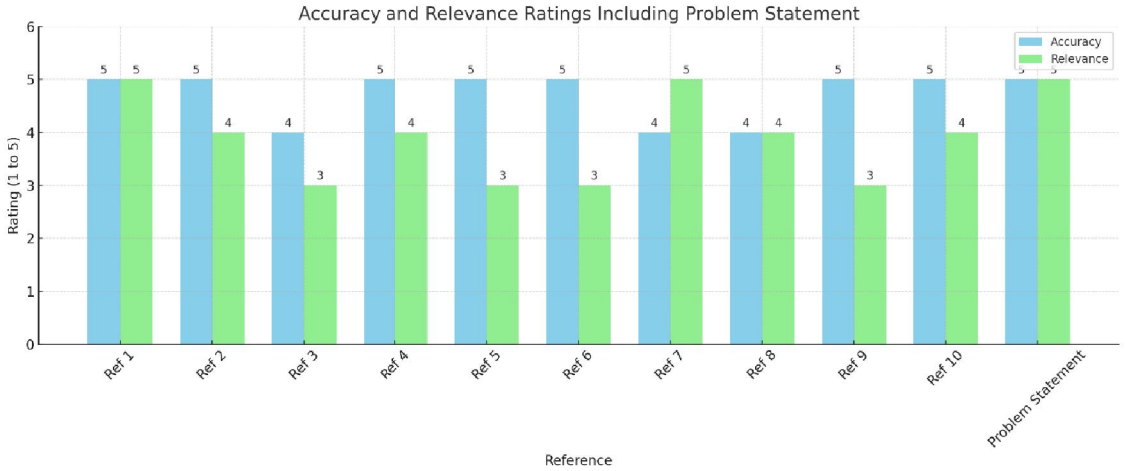

Figure 3

XI. CONCLUSION

Finally, the proposed e-learning platform is a highly sophisticated and secure solution for online education in today's world. Through its face recognition for attendance monitoring, automated grading, blockchain-based certificate issuing, and an AI-based chatbot for interacting with users, the system addresses the high-level limitations of traditional learning platforms. The proposed solution provides timely, accurate learner verification through automation and testing, and tamper-evident and secure credential management that will boost academic integrity and administrative efficiency. It also enables flexible course and user administration by simplifying course and user administration, and creates dynamic and real-time support operations, which translates into improved engagement and engagement through a dynamic, real-time responsive implementation. Impact The combination of these technologies creates an extensible, user-centered and secure system for schools and universities, especially those that adopt safe and effective digital learning modes. For potential future growth, the system can be extended to include predictive analytics to provide student-specific learning pathways, natural language processing to enhance rich interactions with chatbots, and multi-language support to allow for widespread access. Wider institutional adoption can be realized by interoperability with existing learning management systems (LMS) and government certification standards. This will enable seamless integration and broader adoption.

XII. FORTHCOMING DEVELOPMENT

The development of the proposed system in the future may involve the use of AI-based personalized learning paths to automatically provide course material that meets the individual student's performance and preferences.

Advanced analytics can be added to predict learner success and suggest improvement.

Multi language capability will make it available in any language to all users Mobile application development to enable on the go learning and attendance marking. Data management and scalability will be increased through cloud storage integration.

Also, the chatbot can get voice interaction and emotional profiling to get more engagement.

These additions will further enhance the user experience, system intelligence and platform global reach to enable a more dynamic and interactive environment.

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