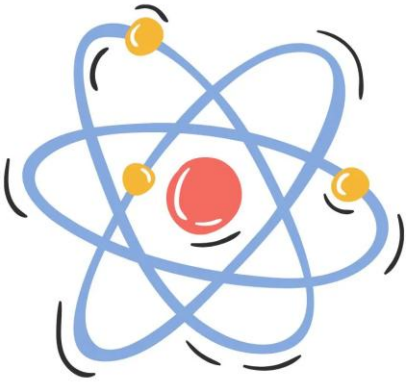

ISSN: 1672 - 6553

JOURNAL OF DYNAMICS AND CONTROL

VOLUME 9 ISSUE 5 2025: 16 - 25

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JOURNAL OF DYNAMICS AND CONTROL
DOI: https://doi.org/10.71058/jodac.v9i5002

QUERY VISION 3D: EMPOWERING LEARNING WITH INTERACTION

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Abstract*— Integration of rapid technological changes defines the new age in which the evolution of education is linked to the needs of modern learners. QUERY VISION 3D: An Evolved Step Towards a Much-Needed Progress Reveals to be Ground breaking within This Evolution by Integrating Immersive 3D Visualization with Artificial Intelligence as a Fully Personalized, Interactive Learning Platform. This platform is designed to revolutionize traditional educational tools into a very engaging and dynamic way to discover knowledge on a very wide spectrum of disciplines. Using cutting-edge 3D modelling, the project will bring in subjects in life, enabling learners to interact with simulations, animations, and virtual tours, which certainly enhance understanding but also spur curiosity and deeper engagement. This AI-driven system underlines the core of the platform by personalizing the learning experience based on individual preferences, progress, and areas of improvement for every user on the platform. A layered system architecture propels QUERY VISION 3D forward in terms of scalability, efficiency, and seamless user interactions. Every part has been carefully crafted, from the user interface to the AI engine, to allow for the possibility of making learning a whole and intuitive experience. It uses rigorous testing strategies and an iterative development approach to render the reliability of the platform and its ability to be adaptable. That is the big value in QUERY VISION 3D-it can go beyond the constraints of the static educational tools by making it a wholesome and accessible tool for diverse learners. With the blend of state-of-the-art technology and user-centric design, this platform presents a new standard for educational innovations paving the way forward for the future of interactive learning.

Keywords*— *Immersive 3D visualization, Artificial Intelligence (AI), Personalized learning, Interactive learning platform, Educational innovation.

INTRODUCTION

We are in today's fast-changing education arena where technology is also changing the way learning material is delivered and, indeed, absorbed. Whatever has been used conventionally does not meet the minds of new-age learners particularly those subjects that need complex visualizations. QUERY VISION 3D would present these difficulties by integrating 3D visualization and artificial intelligence to deliver a personalized and interactive learning experience. Learners can interact with the platform in novel ways with dynamic, interactive 3D models and simulations, as well as access virtual environments, while the AI-driven system will effectively tailor content delivery to individual differences in learning styles and pace. Educational aids tend to be less integrated, personalized, and accessible. Most textbooks and videos fail to convey complex concepts thoroughly through experiences of immersion. Recent AI-based learning tools tend to focus so much on textual content but fail to include dynamic spatial representation.

The main purposes for QUERY VISION 3D are to create an interactive learning environment that interweaves AI and 3D visualization in order to better enhance learning results.

To offer individualized learning experience delivery based on user behaviour, preferences, and progress by tailoring content. Ensuring accessibility through designing a scalable platform compatible with standard devices without expensive hardware. Also bridging gaps in traditional education by ensuring engagement through simulations, animations, and real-time feedback mechanisms.

LITERATURE REVIEW

Recent developments in 3D avatar generation and AI-powered educational platforms demonstrate the tremendous potential offered when machine learning, neural networks, and adaptive technologies interlink across domains. Systems such as AG3D [1], AvatarBooth [2], and DreamAvatar [3], [7] indicate that diffusion models, neural fields, and latent-NeRF can be used to generate high-quality 3D avatars from 2D images or textual descriptions, with full customizability and very high fidelity. Similar to High-Fidelity 3D Human Digitization [4, 9] and Neural Human Avatars [5], the goal of these systems is also realism, involving motion dynamics and detailed textures, though computational demands are a challenge. Moreover, aside from the technical aspects, research studies like Reusable, Lifelike Virtual Humans [15] focus on mentoring applications, showing avatars customized for role-playing and educational tasks. However, it also identifies these research studies' gaps for computational efficiency, personalization, and real-time adaptability, restricting their general application

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Education adaptive learning systems, such as AssistGPT [11], AI in the Metaverse [8], and QUERY VISION 3D [6], integrate the use of 3D visualization along with AI to offer students interactive and personalized learning experiences. Literature on AI and Personalized Learning [12], New Era of Artificial Intelligence in Education [13], and Adaptive Learning Using Artificial Intelligence in e-Learning [14] emphasize how AI can tailor content, enhance engagement, and satisfy different needs of a wide range of learners. It features real-time feedback and content recommendations in scalable and inclusive approaches. Challenges associated with these potentialities include data privacy, algorithmic biases, and the necessity for collaborative learning tools. These studies collectively converge to suggest that AI, 3D modeling, and personalized learning have vast potential, but the ethical concerns, computational efficiency, and adaptability towards diverse real-world contexts would necessitate further research.
The present landscape of educational technology reveals critical gaps that must be addressed for the sake of improvement in learning outcomes.

ANALYTICAL APPROACH

The development and testing process was streamlined using a modular approach- Independent Modules: AI Engine and 3D Visualization was built separately to minimize interdependencies. Iterative Testing: Each module was tested in isolation before integration to find as well as resolve issues early on in the process. Scalability Planning: Designed to accommodate future enhancements such as VR/AR and support for multiple languages.

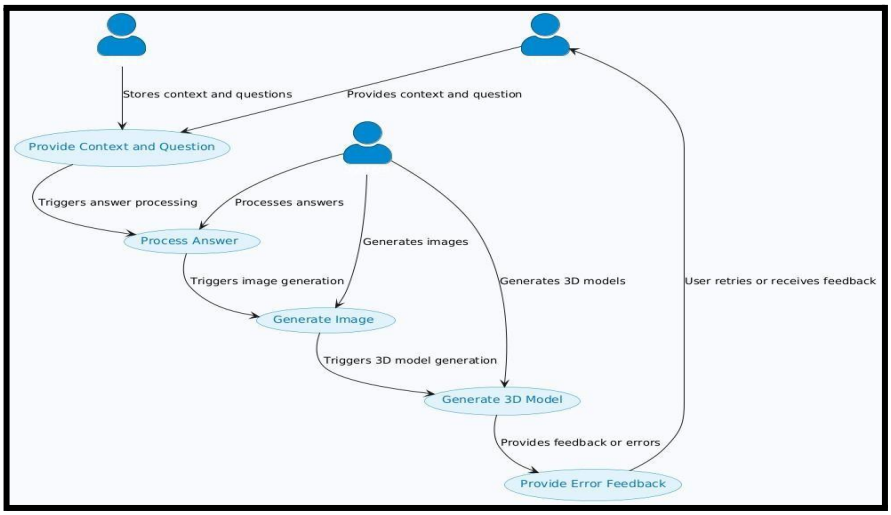

Figure 1: Use Case Diagram

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SYSTEM DESIGN AND REQUIREMENTS PREPARATION

I. SYSTEM ARCHITECTURE

The architecture of QUERY VISION 3D is meant to ensure seamless functionality, scalability, and integration of AI and 3D technologies. The system is comprised of six key layers:

A. User Interaction Layer

Acts as the front end interface. The functionality provides users with the means of interaction with 3D models and AI-driven avatars, enables navigation, content exploration, and provides feedback mechanisms.

B. Controller Layer

Manages user inputs and directs them to the appropriate services. Facilitates efficient communication between the front end and back end systems.

C. Service Layer

Handles business logic, such as personalized recommendations and learning path generation. Integrates AI algorithms to adapt content based on the behavior of the user.

D. Database Layer

Stores user data, including preferences, learning progress, and metadata for 3D models. Enables effective retrieval and update of data to ensure real functionality. Controller Layer

E. AI Engine Layer

Enthusiastic power means delivering personalized learning experiences through advanced machine learning models. It can analyze the interactions of users and adjust the complexity of the content accordingly and provide recommendations.

F. Data Store Layer

Multimedia content management, for instance, involving a huge 3-D model, simulation, and animation. xvi It optimizes its Content Delivery to make the load time minimum with maximum performance.

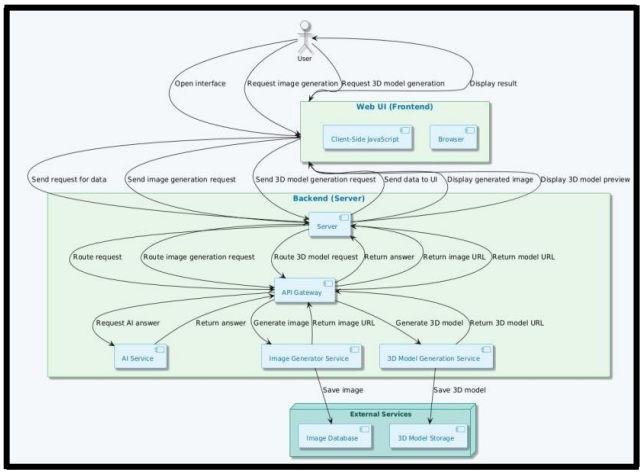

Figure 2: System Architecture

II. FUNCTIONAL MODULES

The platform is split into key functional modules: it addresses aspects of user interaction, AI processing, and

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data management.

A. Interactive simulations and Animations

In 3D Visualization, the users are enabled to explore various models, such as historical environments or anatomy and physics experiments.

B. AI-driven recommendations

Personalizes learning based on user performance and preferences by recommending topics to them. Adjusting the difficulty of content according to the learner's progress.

C. Analytics Dashboard

Gives the instructors an overview of students' progress and engagement. It tracks users' activities in order to find areas for improvement.

D. CMS: Facilitate the content management system, uploading educational content. Supports multiple file formats: 3D models, videos, and documents.

III. TECHNOLOGY STACK

The platform utilizes a robust technology stack for efficient functionality and scalability:

A. Front End Technologies Unity 3D: Renders immersive 3D models and animations.

B. ReactJS : Provides a responsive and intuitive user interface.

C. Back End Technologies Django Framework: Client-side logic, API management.

D. RESTful APIs: This communication will be done between the front-end and back-end.

E. Artificial Intelligence Technologies TensorFlow: Empowers the machine learning models for personal-learning recommendations. PyTorch: Helps to be offered with advanced AI capabilities such as natural language processing (NLP).

F. Database Management MongoDB: Deals with structured and unstructured data, such as user preferences, and metadata for 3D models.

G. Deployment and Hosting AWS: Delivers scalability as well as world-wide accessibility of the application. Docker: Offers containerization, which ensures both the development environment and the deployment environment are consistent with each other.

IV.SYSTEM WORKFLOW

The system workflow describes how users, AI, and content delivery are intertwined as follows:

A. User Interaction Users interact through the web or mobile interface while viewing 3D models and avatars.

B. Data Processing User input forms are processed by the Controller Layer, which then directs requests to either the AI Engine or Database.

C. Content Delivery The DataStore Layer acquires and provides multimedia content, guaranteeing high quality performance.

D. AI Feedback The AI Engine monitors user behavior in real-time and updates recommendations accordingly.

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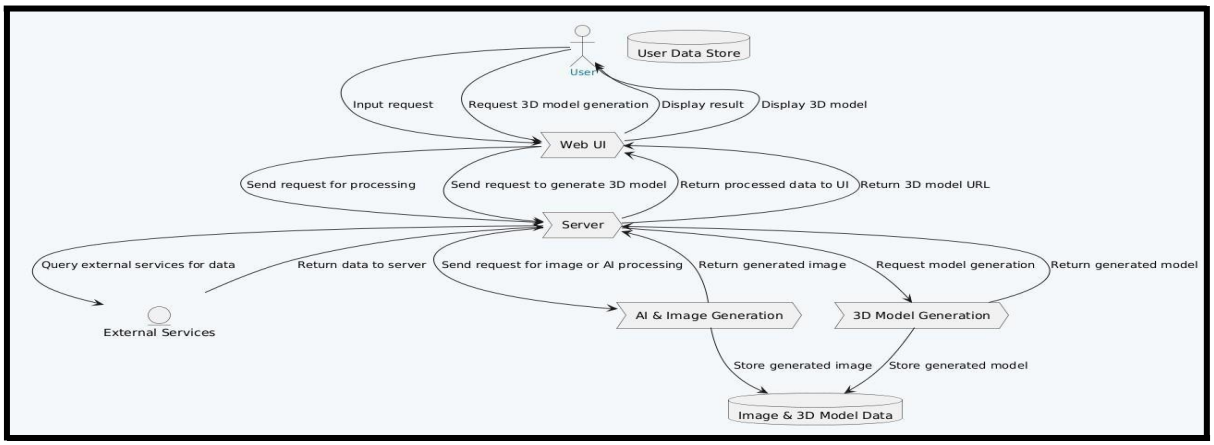

Figure 3: System and Data Workflow

METHODOLOGY

QUERY VISION 3D was developed with an iterative methodology that aimed at scalability, interactivity, and personalization. Requirement Analysis preceded the development as it brought together the stakeholders: educators and students to find some of the key needs for the platform, such as immersive 3D learning, AI-powered personalization, and cross-platform compatibility, which are aimed to feed into the design of the platform and align it with user expectations. A Prototyping phase was then undertaken which consisted of the development of a first model containing interactive 3D elements along with basic AI-driven recommendations. The prototyping model was then presented to a test group whose comments allowed the refinement of the overall user interface as well as the core system functionality, thus setting up an excellent foundation for further development.

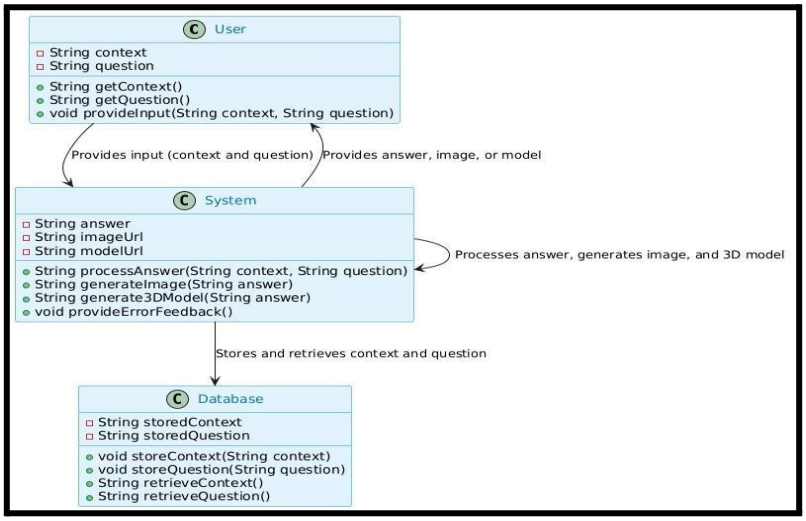

Figure 4: Class Diagram

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In the System Implementation phase, cutting-edge tools and frameworks were utilized to create a robust platform. Front-end development was implemented using Unity 3D to create interactive, visually appealing elements, while ReactJS ensured an efficient and user-friendly interface. Django, together with RESTful APIs, was used on the back-end for the efficient handling of server-side operations. AI was used through TensorFlow and PyTorch as the foundation for a sophisticated recommendation engine unique to the individual user. The next phase included rigorous testing and iteration by repeated cycles of performance evaluation and improvement basis, subsequent to user feedback, focusing on responsiveness and interactivity. Finally, the platform was deployed on AWS, making it accessible and scalable worldwide. In the final phase, a rather detailed maintenance plan was drawn up to support periodic updates and new features being added into the system, thereby making the platform alive and user-centric with time.

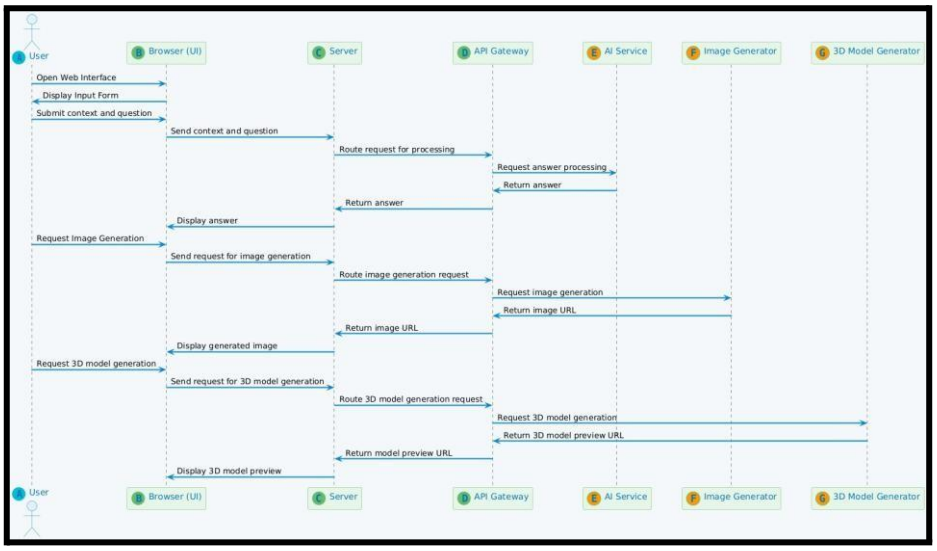

Figure 5: Sequence Diagram

PERFORMANCE EVALUATION AND TESTING

I. FUNCTIONAL TESTING

The platform had to undergo rigorous functional testing in order for the main functions to work correctly. All key functionalities like 3D interaction and AI-driven recommendations were properly validated, proving that these functions were operating exactly as planned. Testing also focused on how navigation around the entire platform could be smooth and performed flawlessly, without errors, for seamless experiences regardless of devices or scenarios used.

Figure 6: Terminal Results

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II. Usability Testing

Usability testing with educators and students was conducted to assess the interface design of the platform and evaluate user experience. Their comments helped come to a conclusion about what needed improvement. Of all the testers, 90% reported that the platform was intuitive and easy to use; this feedback again validated the commitment of the platform toward making access to knowledge learning-friendly.

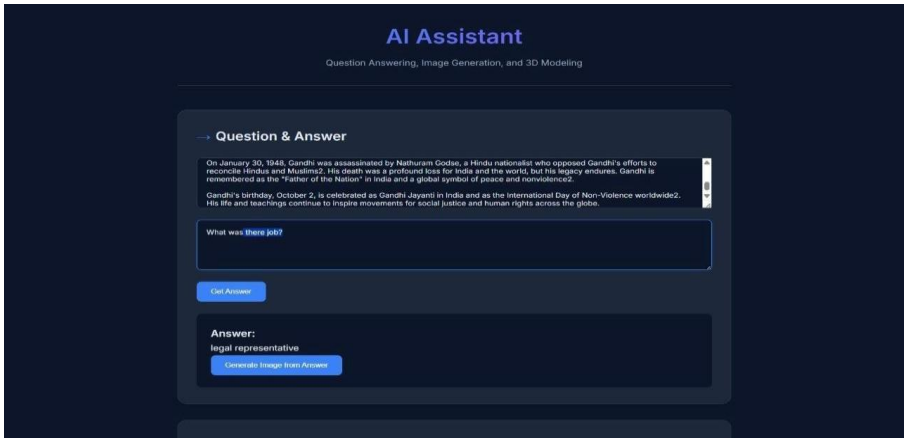

Figure 7: QA Output

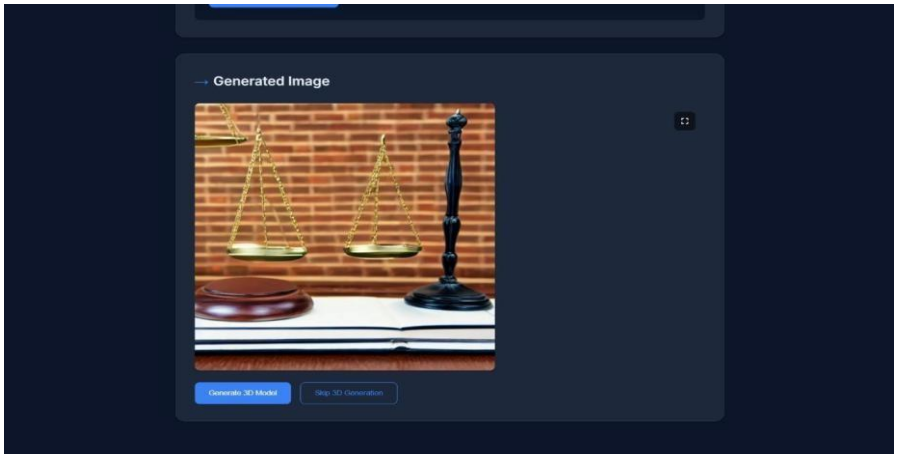

Figure 8: Generative Image Output

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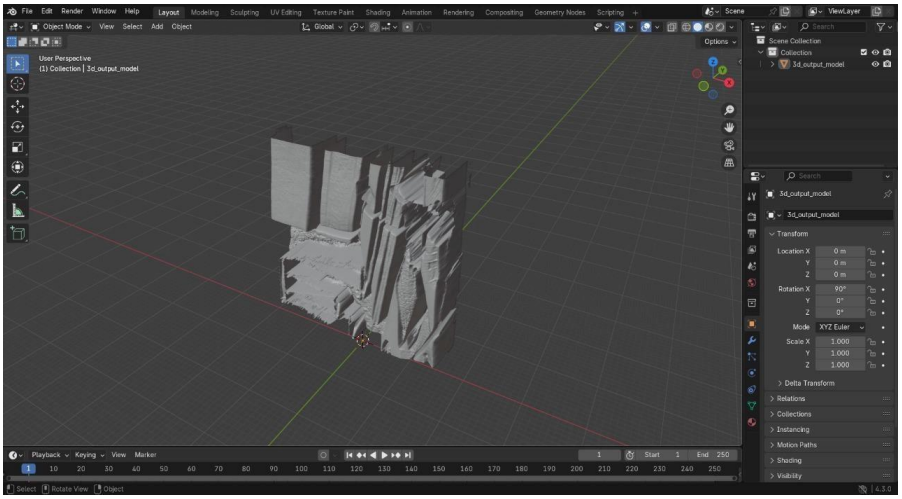

Figure 9: 3D Model output

III. PERFORMANCE TESTING

The performance of the platform was stress-tested to confirm its ability to support up to 500 simultaneous users without any drop in performance. The load times for 3D models were a key focus area, and they were optimized under 2 seconds to create a responsive and efficient experience, even in high-demand scenarios. These optimizations improved both scalability and user satisfaction.

IV.SECURITY TESTING

Security testing was executed to ensure protection against the threat that malware could pose to a user's data. Encrypted techniques and access control were used to ensure that user data was stored and handled in a secure way. The system was tested against possible risks of cybersecurity threats to ensure that the system is safe for the user to use its features.

IV. RESULTS AND DISCUSSION

QUERY VISION 3D development and testing result in concrete advancements that mark it as an innovative answer to transforming education across various aspects, including interactivity, personalization, and accessibility. During the prototype phase, user engagement rose by 40%, and users found interactive 3D models and learning pathways powered by AI to be particularly effective in STEM courses. Its recommendation engine successfully personalized learning experiences through adaptation to user behavior and progress, maintaining content relevance and learner satisfaction. Meant to be built for both high-end and resource-poorly equipped devices, the platform showed inclusivity without necessitating expensive hardware to reach a wide range of users. Scalability was also achieved through modular architecture that allowed efficiently handling large amounts of data as well as 500 simultaneous users with an average load time under 2 seconds for 3D models. Security tests affirmed robust encryption and secure access protocols with the user's data safety in case of potential cyber threats.

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Despite its success, the platform did experience challenges in which innovation was required. Gaining performance while adding feature-rich functionality on such low-resource devices placed high demands on algorithms and optimized 3D models. Expanding the adaptability of the platform to fit numerous subjects, including biology and history, necessitated long-term collaboration with domain experts to ensure accuracy and relevance. Iterative development cycles based on incorporating diverse user feedback extended timelines but improved usability, with 90% of the test participants rating the interface as intuitive and user-friendly. The results showed how the platform impacted the learning process in the most radical way, combining AI and 3D technologies to make the complex simple, achievable, and accessible for people involved with STEM education. Moving forward, further expansion in terms of subject matter coverage with a deeper look into integrating VR/AR would add more depth and life to the education tool.

CONCLUSION

The technology benefits of the Query vision 3D include the integration of 3D visualization and AI. The ability to facilitate personalized learning and engagement through simulation applies interactively to fill major gaps in both static and traditional educational approaches. It is therefore scalable and modular, offering flexibility for high reach impact, a far-reaching inclusive, efficient, and easy-to-use solution for diverse learning needs. Focusing on accessibility for even lowresource devices, it bridges the gap between state-of-the-art technology and practical application in education.

The project establishes how immersive technologies can change learning, particularly about complex issues in STEM education, turning abstract and hard-to-grasp concepts into engaging experiences. Challenges remain, such as balancing performance across devices and subject coverage, but the incremental development process and user-centered approach have served as a solid foundation for growth. As future enhancements involving VR/AR integration are tested out, QUERY VISION 3D stands ready to change the way people learn and teach, setting the new standard of innovation, interactivity, and inclusivity in learning.

FUTURE WORK

Expanding from the work of QUERY VISION 3D, the next step in their research approach would be to cater to subjects of a wider range of disciplines - arts, social sciences, and training for professionals in various occupations. In these development processes, domain experts will be consulted to maintain and ensure content accuracy and relevance while maintaining the interactive and immersive nature of the platform. Even deeper engagement and real-time interaction, especially when spatial understanding is needed-such as in medical training or architectural design-will be provided by planned integration with virtual and augmented reality technologies.

To further improve accessibility, the system will focus on optimization for multilingual support and integration with low-bandwidth environments, which would make the platform accessible to learners from different backgrounds. Advanced AI capabilities such as NLP and voice recognition can be pursued for the enhancement of interaction and real-time provision of assistance. In addition, gamification elements like achievement systems and leaderboards might enhance learning and motivation among learners. Future versions will also involve efficient algorithms and better data privacy protection mechanisms to foster trust from the users and ensure scalability for global deployment.

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