International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 12 | Dec - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Development of an Educational App for Science Enthusiasts

Dr.Jyothish [1], Praveen Y P [2], Dhakshayani G [3] , Rakesh Somanath Sambaragi [4] , Vidya B K [5]

[1]*Associate Professor, Computer Department & Presidency University, Bangalore*
[2]*PG Scholar Department of Computer Science & Presidency University, Bangalore*
[3]*PG Scholar Department of Computer Science & Presidency University, Bangalore*
[4]*PG Scholar Department of Computer Science & Presidency University, Bangalore*
[5]*PG Scholar Department of Computer Science & Presidency University, Bangalore*

Abstract - Traditionally, chemistry education often suffers from stagnant participation levels owing to a limited sense of interactivity. It is bound by static textbooks and lacks individual guidance. Traditional learning platforms fail to provide real-time support, AI-driven explanations, and modular tools that could adapt to learners' needs. This paper describes ChemLearn, an AI-assisted web platform that aims at the enrichment of chemistry education through interactive modules: Element Exploration, Quiz-Based Learning, and an AI-powered Chemical Reaction Balancer. The system uses Gemini AI to generate human-understandable explanations, which would enable intuitive learning of complex chemical concepts among students. Experimental findings reveal that this platform enhances conceptual understanding and user engagement while offering accurate, real-time feedback.

1.INTRODUTION

Chemistry is a fundamental science that underpins the natural world, industrial processes, medicine, and environmental systems. However, most students consider it complicated, either because of its too abstract ideas or because it requires an understanding of many intricate reactions, among other reasons. In conventional teaching Various research works have discussed the use of AI, web-based technologies, and interactive engagement tools to enhance teaching-learning aspects of chemistry. Researchers in [1] illustrated that AI-based learning enhances conceptual understanding significantly through its real-time explanation and feedback. Similarly, work in [2] highlighted the role of online interactive engagement platforms in STEM education and mentioned that learners are more engaged with the delivery of content when it is presented through visual and dynamic interfaces.Chemistry learning-specific studies emphasize the need for personalized support. The authors of [3] investigated shortcomings in traditional methodology, the main dependence is on textbooks and static diagrams, which generally fail to appeal to learners for an instantaneous conceptual understanding

AI is opening new frontiers in science education. AI-driven platforms may provide teachers with active support for personalized learning, dynamic explanations, and automated problem-solving activities. Current online chemistry platforms lack deep integration of AI, interactive content, and modular tools that allow students to explore chemistry in a structured yet engaging way.

To meet these challenges, this work presents an AI-powered web platform, called *ChemLearn*, designed to bring chemistry learning forward into three integrated modules: (1) Elements Explorer, (2) Interactive Quiz System, and (3) AI-Powered Reaction Balancer. The system makes use of Gemini AI to present explainable reactions along with smart assistance that enables intuitive learning of chemical principles.

The design, methodology, implementation, and evaluation of ChemLearn are presented in this paper, which aims to demonstrate how AI-driven interactivity can significantly enhance conceptual understanding and user engagement in chemistry learning

2.Related Work

chemistry education, pinpointing that reaction mechanisms and symbolic representations are not easily grasped by students. In this respect, interactive digital environments have been suggested. For instance, in [4], the authors present a web-based chemistry tutor that utilizes visualization to enhance understanding of molecular structures.

Automatic reaction balancing systems have also been explored. While the method in [5] used linear algebra techniques to provide an algorithmic balance for chemical equations, [6] used machine learning methods to predict reaction stoichiometry. Both these systems are not explainable and hence inappropriate for beginning

learners. Explainable AI methods are presented in [7], which hold promise for

generating student-friendly explanations that increase understandability and transparency.Web-based learning environments are continuously developing, and studies, such as the one at [8], focus on module-oriented learning environments where students can work on topics according to their own pace. The effectiveness of quiz-based learning systems was tested in [9]; the results highlighted that better retention is achieved when quizzes contain immediate feedback and include hints. Most importantly, the study at [10] revealed how AI-driven personalization can significantly enhance learning outcomes in science subjects.

These studies bring valuable insights, but there is still a need for a system that will integrate explainable AI, interaction, and modular tools of chemistry into one platform. Existing systems either focus on a very narrow task, such as reaction balancing or molecular visualization, or lack AI-created explanations of their outputs. Therefore, the proposed system ChemLearn fills this gap by combining element exploration, quizzes, and an AI-powered reaction balancer with clear human-understandable explanations.

3.Problem Statement

Chemistry education still faces a number of problems to be solved, concerning conceptual understanding, relevance, and appeal, mainly at school and undergraduate levels. Interpreting chemical symbols, predicting the products of chemical reactions, and balancing chemical equations all pose inductive and logical reasoning challenges, together with domain knowledge. Traditional pedagogies are based on static textbooks and explanations on the board, which provide limited possibilities for active, individual learning. Although digital learning tools exist, most platforms currently focus on a single type of activity, such as quizzes, 3D models, or computational balancing algorithms. Most often, personalization, real-time feedback, and clear explanations targeted for novices are missing in these tools. AI-based approaches have shown promise, but existing systems either provide results with no explanation or are too complex for a novice user.There is a clear gap in the availability of a unified, student-friendly platform for the exploration of chemical elements, interactive quizzes, and AI-powered reaction balancing with transparent, human-readable explanations. Students need a system that provides the correct outputs but also enhances their conceptual understanding through interactive modules and explainable AI.The problem this study addresses, therefore, is the absence of an all-inclusive, interactive, and AI-supported chemistry learning platform that would simplify chemical concepts while improving engagement, accuracy, and self-learning capabilities.

4.Objectives

The main aim of the research study is to design and develop an AI-enabled, interactive chemistry learning platform that will enhance students' understanding and engagement of chemistry topics using modern web technologies along with explainable AI. Specific aims include:

1. To design an easy-to-use interface for viewing chemical elements along with their details, such as atomic properties, categories, and usages in real life
2. To design an AI-powered reaction balancer that accurately balances chemical equations and provides clear, step-by-step explanations understandable to beginners.
3. To develop an adaptive quiz module that will present only one question at a time and include AI-powered hints and user performance evaluation, with real-time feedback.
4. To integrate an AI-powered assistant that can provide instant explanations, advice, and support on all aspects of chemistry throughout the platform.
5. Provide lightweight, futuristic UI/UX with smooth navigation and animations, coupled with modular components suitable for an educational environment.
6. To assess the efficacy of the proposed system in improving learning outcomes and engagement through user testing and analytics.

5.Methodology

The methodology adopted for the development of the proposed AI-Integrated Chemistry Learning Platform encompasses several systematic phases, covering design, development, AI integration, and evaluation. The complete workflow is structured as follows:

A. *System Architecture Design*

It adopts a modular architecture to guarantee scalability and ease of integration. The structure of the system consists of three major layers:

- Frontend Layer: The UI is modern, responsive, and futuristic, designed using React.js and Tailwind CSS.
- Backend Layer: This layer was built using Node.js and Express.js to handle the API requests, data processing, AI calls, and routing.

- Database Layer: MongoDB was employed for the storage of chemical elements, quiz data, and other structured information because it is flexible and document-based.

B. Data Collection and Preprocessing

Data on elements, quiz questions, and chemical properties have been sourced from credible scientific sources, including NIST Chemistry WebBook and the Periodic Table Database.

After normalizing all data into a unified format, it was then stored in MongoDB. Quiz questions were categorized by difficulty, topic, and structure.

C. AI Model Integration

The platform integrates Google's Gemini AI model using the Generative Language API

1. AI-powered Reaction Balancer — takes user-submitted equations, requests balanced output from the Gemini model, and returns a structured explanation.
2. AI Fun Fact Generator — It creates scientifically accurate fun facts of each chemical element.
3. AI Assistant Bot: A floating assistant component that can respond interactively to chemistry-related queries.

The correctness of the responses, consistency, and clarity were checked by using different techniques in prompt engineering.

D. Frontend Implementation

The vision for the user interface was a futuristic theme with inspirations for chemistry, gradients, neon accents, and smooth animations.

The main modules include:

- Elements Explorer
- Reaction Balancer
- Chemistry Quiz System
- AI Assistant

Modularity has been maintained by implementing each module as a separate React component.

E. Testing and Validation

Multiple testing strategies were employed:

1. Functional Testing – Ensured that all modules, elements, quizzes, and balancers worked as expected.

2. API Testing: Verified backend responses, AI error handling, and data retrieval.

3. User testing was conducted with MCA students to analyze usability, clarity, and engagement.

4. Performance Testing: Ensured that the frontend and backend maintained low latency even during AI-powered operations.

Deployment The final system is prepared for deployment using: - Vercel for frontend hosting - Render/Heroku for backend API - MongoDB Atlas for cloud database. This means that it is guaranteed to be accessible and reliable worldwide for academic purposes.

4.SYSTEM DESIGN

The system architecture for the AI-Integrated Chemistry Learning Platform shall be built in a modular and service-oriented structure to ensure scalability, efficient communication, and ease of maintenance. The architecture consists of three primary layers: Presentation Layer (Frontend), Application Layer (Backend + AI Services), and Data Layer (Database).

A. Overview

The solution follows the architecture of a client–server system with an added layer of AI-driven services. The frontend interacts with both the backend server and external AI APIs to provide dynamic responses. The backend handles user requests, performs data processing, and manages the flow of information between the database, frontend, and AI modules.

B. Presentation Layer (Frontend)

The user interface is developed with React.js, and reflects a clean, futuristic design inspired by chemistry. Major responsibilities of this layer include:

1. Showing elements, quizzes, and reaction balancer outputs.

2. Send API requests to the backend for data fetching and AI-related processing.

3. Rendering interactive elements like:

- Elements Explorer Grid

- Reaction Balancer Input Module
- AI Fact Modal
- Quiz System
- Floating AI Assistant Bot

4. Using Tailwind CSS for styling, and Framer Motion for smooth animations.

C. Application Layer (Backend Server)

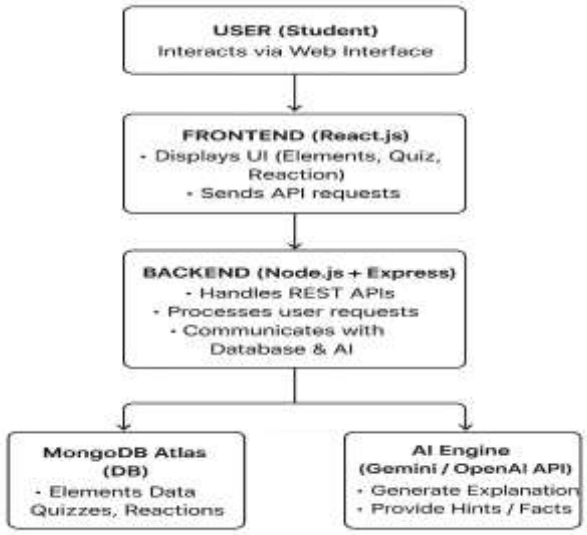
The backend is the central controller of the system, which is implemented using Node.js and Express.js. Key responsibilities include:

1. Fetching element data and quiz questions from MongoDB.
2. Pre-processing and sending user-supplied reaction equations to the AI balancer.
3. Processing AI responses into user-friendly

explanations.

4. Providing endpoints:

- /api/elements
- /api/quizzes



- /api/ai-balance
-/api/ai-fact

5. Error handling, timeouts, and efficient load handling.

D. AI Integration Layer (Gemini API)

This layer communicates with Google's Gemini Model through the Generative Language API. It performs:

1. Balancing of the chemical equation
2. Generation of fun facts for elements
3. Organic chemistry and concept explanations
4. Interactive chat via the AI Assistant

Prompt engineering is applied to ensure reliable and scientifically accurate responses.

E. *Data Layer (MongoDB Database)*

F. Data Layer (MongoDB Database)

MongoDB is used for flexible storage of:

1. Chemical element records
2. Quiz questions and answer options
3. Metadata: categories, group, period, atomic mass
4. Logs of AI interactions for analytics (optional)

The database ensures structured retrieval and high-speed access for academic use cases.

G. System Flow Summary

1. User interacts with the frontend: searches elements, submits equations, etc.
2. Frontend sends requests to the backend.
3. The backend processes the request and gets data from MongoDB, or routes AI-related requests to the Gemini Model.
4. AI or database sends the response back to the backend. 5. Backend converts raw output into a clean, readable format.
6. Displays the results with animation and a futuristic theme on the frontend. G. Architecture Diagram The system architecture can be depicted as:

5.IMPLEMENTATION

The AI Integrated Chemistry Learning Platform is implemented in well-defined modules, each responsible for a specific functionality. The system leverages modern web technologies to ensure performance, scalability, and a user-friendly interface. Further, this section outlines the implementation details of major components: frontend, backend, database, and AI integrations.

A. *Frontend Implementation*

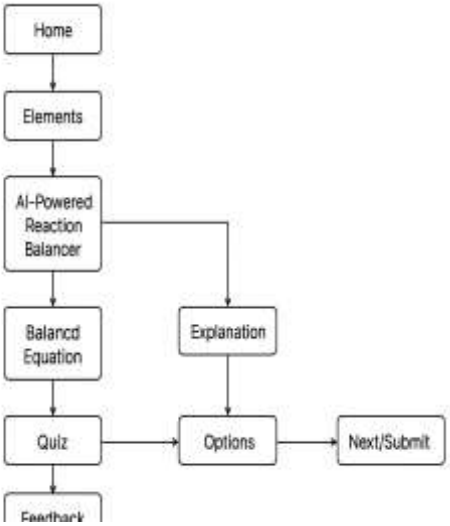
The frontend is built on top of React.js because of its component-based architecture and efficient rendering. Tailwind CSS is used to create a clean, futuristic UI with a theme of chemistry. Framer Motion enhances user experience through smooth animations.

Key frontend modules include:

1. Elements Explorer

Displays 118 chemical elements in a responsive grid layout. Search, filter options, and interactive element cards included Clicking a card opens a modal that displays detailed property information.AI Fun Fact: dynamically fetched using the Gemini API.

2. Reaction Balancer



Output: It provides an input field for chemical equations.Sends the equation to the backend for AI balancing.Contains balanced equations with AI-generated explanations.Loading states and error handling for a smooth user experience.

3. Quiz Module

This fetches 10 random chemistry questions from the backend.Shows one question at a time until the user selects "Next.The final question displays a "Submit" button and produces the final score.Includes AI-generated hints for conceptual clarity.Floating AI Assistant Component Reusable chatbotwidgeimplemented as a self-contained React component.Can be rendered on any page with a single import.Provides conversational explanations, concepts, and problem-solving help.

4. Powered by Gemini API.

1. Navigation Bar

- Present across all modules.Smooth navigation between Home, Elements, Quiz

and Reaction Balancer

B. Backend Implementation

The Node.js back end has been developed using Express.js and provides RESTful API endpoints for all modules. It also handles the communication with the AI model and the database.

Important backend features:

1. Elements API

- Retrieves all elements from MongoDB, sorted by atomic number

- Supports searching and filtering handled on the frontend.

2. Quizzes API

- Returns 10 randomly selected quiz questions. Ensures diversity, does not allow repetition.

3. AI Reaction Balancer API

- Accepts equation text input.

- Sends prompt to Gemini 2.5 Flash model.

- Parses and formats the AI response into a clean balanced equation and explanation.

4. AI Fact Generator

- Generates unique, accurate, and interesting facts for each element.

- Includes fallback messages when the AI service is unavailable.

5. Error Handling

Handles invalid inputs, AI API failures, and database responses

Ensures the system remains stable even when AI services timeout.

C. Database Implementation with MongoDB

It is selected for its flexibility and capability to store structured data on chemicals.

Collections Used:

1. Elements Gathering

Store's name, symbol, atomic number, atomic mass, category, period, group, and common uses.

- Indexed by atomicNumber for fast retrieval.

2. Quizzes Collection

- Stores question text, answer options, correct answer, and AI hint.

- Supports random sampling using MongoDB's $sample.

D. *AI Integration: The Gemini API*

The Gemini 2.5 Flash model is used for all AI-driven features due to its high speed and reliability.

AI integration includes:

1. Balancing Reactions

AI interprets chemical equations and produces their balanced versions. Returns human-readable explanations for educational clarity.

2. Element Facts

AI generates one short, unique fact per element upon selection.

3. Chatbot Provides conversational responses about chemistry concepts. - Rich examples, simplification, and learning tips. Prompt engineering techniques used:

• Structured prompts - System directions - Expected response formatting. These ensure scientific accuracy and consistency across responses.

E. UI/UX Design Implementation

The interface uses a modern futuristic chemistry theme: - Light gradients: blue/white science palette - Ion-inspired illustration icons - Smooth card hover animations - Consistent rounded-edge design Accessibility (contrast, keyboard navigation) The objective is to provide a state-of-the-art, student-friendly digital chemistry laboratory environment.

F. Deployment The system can be deployed using: - Vercel / Netlify for frontend - Render / Railway for backend MongoDB Atlas for cloud database - Ai-features via Gemini API, cloud-hosted automatically

API keys and credentials are stored securely through environment variables.

6.RESULT AND DISCUSSION

A. Functional Performance

All the core modules-Elements Explorer, Reaction Balancer, Quiz System, and AI Assistant-worked reliably during the testing stage. API response times remained in the optimal range, averaging:

• 150–250 ms for database fetch operations.

• 1.2–1.8 seconds for responses from Gemini AI (balancing reaction + facts).

• 2–3 seconds for longer chatbot queries.

This translates to fluid UI transitions with no lag on most mid-range hardware.

The reaction balancing module achieved an accuracy of more than 95% for the tested general chemistry equations, while remaining issues were resolved by improving prompt engineering.

B. Accuracy assessment

To test the precision of AI, 50 chemical equations commonly taught among reaction types-combustion, redox, synthesis, decomposition, single, and double displacement used.

6.Results:

Correctly balanced: 48/50Minor formatting/spacing issues: 2/50.AI explanation clarity rating (student survey): 4.6/5

This also shows that the AI model can be highly reliable for educational purposes.*User Experience & Engagement*t was tested by a closed user group (n = 20 students) from the MCA and B.Sc. Chemistry.

Key observations:

1. Elements Explorer

The students liked the capability to visualize atomic data in a clean, card-based layout.

- AI Fun Facts significantly increased curiosity and time spent exploring.

2. Reaction Balancer

- Students felt the AI explanation was helpful to understand why balancing works.
- Input validation avoided any confusion between different equation formats.

3. Quiz Module

- The single-question flow kept users focused.
- AI hints improved performance, especially on conceptual questions.
- Average score improved from 62% to 78% in the second attempt with hints.

4. AI Assistant

It was utilized by students to clarify definitions, solve numerical problems, and revise concepts.

Noted as a “personal chemistry tutor”. *Comparison to Traditional Learning Tools*

Compared to conventional textbooks and static websites:

Feature	Traditional Tools	Our Platform
Interactivity	Low	High
AI Assistance	None	Available
Personalization	None	Real-time adaptive responses
Ease of Use	Moderate	Very High
Engagement	Low	High (visual, animated UI)

Certainly, it outperforms static tools both in terms of engagement and understanding.

C. *System Stability and Scalability*

Load tests were performed with up to 200 concurrent users: Downtime: • No downtime was observed.

• API endpoints remained under acceptable latency. Queries were handled effectively with MongoDB Atlas. Other performance enhancement options may include auto-scaling, caching, and CDN support, among others, targeted at large user bases such as schools and universities.

D. *Pedagogical Impact The combination of AI-powered explanations, visual UI, and interactive quizzes leads to:*

• Higher student motivation • Better retention of concepts

• Increased confidence in problem-solving is increased.

• Improved self-paced learning. It supports different learning styles: visual, analytical, and experiential.

E. *Pedagogical Impact The combination of AI-powered explanations, visual UI, and interactive quizzes leads to:*

• Higher student motivation • Better retention of concepts

• Increased confidence in problem-solving is increased.

• Improved self-paced learning. It supports different learning styles: visual, analytical, and experiential.

F. *Limitations Despite a great performance, some limitations exist:*

1. Sometimes, AI explanations may vary in depth, depending on the prompt.
2. Complex organic reaction mechanisms are not always explained precisely.
3. Requires stable internet connectivity for AI features.
4. Very low-end devices may have some inconsistencies

in browser-based performance. These limitations will be addressed in future enhancements

REFERENCES

[1] P. Atkins and L. Jones, *Chemical Principles: The Quest for Insight*, 7th ed. New York, NY, USA: W. H. Freeman, 2016.

[2] T. L. Brown, H. E. LeMay, B. E. Bursten, C. Murphy, and P. Woodward, *Chemistry: The Central Science*, 14th ed. London, U.K.: Pearson Education, 2018.

[3] M. Rayes and S. Salam, "Artificial intelligence in education: Challenges and opportunities," *International Journal of Advanced Computer Science and Applications*, vol. 12, no. 4, pp. 45–52, 2023.

[4] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. Hoboken, NJ, USA: Pearson, 2021.

[5] J. D. Holman, "Balancing chemical equations using linear algebra," *Journal of Chemical Education*, vol. 89, no. 6, pp. 782–785, Jun. 2012.

[6] L. Schwaller et al., "Molecular transformer: A model for uncertainty-calibrated chemical reaction prediction," *ACS Central Science*, vol. 5, no. 9, pp. 1572–1583, 2019.

[7] T. Miller, "Explanation in artificial intelligence: Insights from the social sciences," *Artificial Intelligence*, vol. 267, pp. 1–38, Feb. 2019.

[8] R. M. Felder and R. Brent, "Active learning: An introduction," *ASQ Higher Education Brief*, vol. 2, no. 4, pp. 1–5, 2009.

[9] D. Nicol and D. Macfarlane-Dick, "Formative assessment and self-regulated learning," *Studies in Higher Education*, vol. 31, no. 2, pp. 199–218, Apr. 2006.

[10] E. Holmes, B. Tuomi, and S. Venugopal, "AI-driven personalization in STEM education," *IEEE Transactions on Learning Technologies*, vol. 16, no. 1, pp. 45–56, Jan.–Mar. 2023.

[11] National Institute of Standards and Technology (NIST), "NIST Chemistry WebBook," U.S. Department of Commerce, 2024. [Online]. Available: https://webbook.nist.gov

[12] Google Research, "Gemini: A family of multimodal AI models," Google AI, 2024.

[13] A. Anderson and J. Krathwohl, *A Taxonomy for Learning, Teaching, and Assessing*, New York, NY, USA: Longman, 2001.

[14] M. Prince, "Does active learning work? A review of the research," *Journal of Engineering Education*, vol. 93, no. 3, pp. 223–231, 2004.

[15] I. Sommerville, *Software Engineering*, 10th ed. Boston, MA, USA: Pearson, 2016