IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, June 2026
Impact Factor: 8.2

Awareness, Perception, and Integration of Artificial Intelligence in Chemical Sciences Education: A Comparative Study of Undergraduate Students, Postgraduate Students, and Teachers

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Abstract: *The study examined the awareness, usage, benefits, challenges, and preparedness for the future in the context of AI in Chemical Sciences education. The study was conducted through a structured survey with a total of 117 respondents. Of these, 79 were undergraduate students in chemistry, 26 were postgraduate students in chemistry, and 12 were educators in chemistry. The survey was conducted via Google Forms. The 50-item survey questionnaire was conceptually grouped into AI awareness, theoretical and practical training, research applications, assessment, ethics, and student perspective. Research shows that all undergraduate students correctly identify AI as a machine-based, data- driven system. Undergraduate students, of whom more than 53% reported infrequent or no usage of AI technologies for academic reasons, whereas postgraduate students and instructors highlighted pedagogically integrated interaction with AI. The general view of AI in chemistry was positive among teachers (91.7% considered it highly advantageous) and postgraduate students (73.1%), whereas undergraduate students had a mostly neutral attitude (50.6%).*

Keywords: Artificial Intelligence, Chemical Sciences, Virtual Laboratories, Undergraduate Chemistry, Postgraduate Students.

I. INTRODUCTION

Chemistry is recognized as the "central science" for its role in connecting the physical and life sciences, facilitating a thorough understanding of matter and its transformations [1,2]. Chemistry education at advanced levels poses numerous problems that can impede successful learning [3-6]. A significant challenge for students is visualizing molecular structures, bonding, and reaction mechanisms [3-9].

In recent years, use of Artificial Intelligence (AI) has become one of the important tools in higher education across the world [8-29]. Incorporation of AI in higher education of chemical science results in creating new opportunities in teaching and learning of chemical science [7, 23, 30]. Use of AI in chemical science teaching results in an increase in the level of students' understanding as well as enhancing overall classroom engagements [7, 23, 30]. Applications of artificial intelligence in the chemical sciences are numerous and becoming more significant [15,18,31]. Use of AI is

DOI: 10.48175/IJARSCT-37361

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bridging the gap between theory and practical's by optimizing synthetic routes, reaction predictions, machine learning in cheminformatics and analyzing chemical data [1,5,8-10, 15,21,27,32,33].

The problems related to lack of physical infrastructure can be easily solved by using virtual laboratory and AI simulation platforms [34,35]. Students can easily and immediately get explanations, problem solving by using AI supported chatbots, such as ChatGPT which also helps students to generate study materials instantly [14,18, 20, 27,36]. Undergraduate and graduate students carry a different level of proficiency in AI technologies [8-29]. Use of AI in higher education is highly dependent when students use these tools with critical thinking and with greater responsibility [37-42].

For effective teaching in the classroom, it is necessary for teachers to use AI in chemistry instructions. Many teachers are using the AI as pedagogical methods effectively in the teaching while some teachers faces the hurdles due to access restrictions, insufficient training about AI technology and some are reluctant to adapt the new technologies in the teaching. Enhanced visualization, increased conceptual understanding can be easily achieved by incorporation of AI into chemistry education[8-29,37-41].The use of AI in chemistry teaching is still in its infancy in higher education, particularly in developing countries like India.

There is still a large study gap regarding chemistry students' and teachers' awareness and perceptions of AI. The study's objectives are to assess AI product awareness, usage trends, perceived benefits, and challenges. By providing insights into the successful integration of AI and enabling the creation of creative educational approaches, the findings are expected to improve chemistry teaching.

II. METHODOLOGY

Research Design

Descriptive survey methodology based on a quantitative framework is used in the present research with themes based on the role and integration of Artificial Intelligence in Chemical Sciences education. The research is empirical and non-experimental, focused on outlining current attitudes and practices instead of evaluating causal hypotheses.

Population for Study and Sampling Methods

The target population included Undergraduate (UG) chemistry students, postgraduate (PG) chemistry students, and UG/PG chemistry educators associated with higher education institutions in India was included in the target population while conducting the survey research. Data were gathered via the online distribution of Google Forms survey links. Participants included the current enrolled UG and PG Chemistry students and teachers who are currently involved in UG or PG chemistry teaching. **Table 1** summarizes the details of respondent group

Participant Group	**n**	**No. of** Questionnaire	**Method**
Undergraduate (UG) Chemistry Students	79	UG Questionnaire (50 items)	Google Forms
Postgraduate (PG) Chemistry Students	26	PG Questionnaire (50 items)	Google Forms
UG & PG Chemistry Teachers	12	Teacher Questionnaire (50 items)	Google Forms
Total	117	Three separate instruments	Online

Table 1. Allocation of participants among the three survey groups.

III. RESULTS AND DISCUSSION

Present study includes the challenges, perceptions and awareness of Artificial Intelligence (AI) in teaching and learning of chemical science subjects. Respondents include 79 UG, 26 PG chemistry students and 12 UG/PG chemistry teachers

Understanding and Awareness of Artificial Intelligence Concepts

Research indicated that awareness of AI as a machine-based intelligent system was uniformly high among all respondents. All UG respondent students, 65.4% PG students 100% teacher group has knowledge that AI is a machine-based intelligent systems

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Concerning previous exposure to AI, 70.9% of UG students indicated that they possessed in-depth knowledge of AI before the survey. PG students similarly demonstrated high awareness.

All teachers agreed (100%) that ChatGPT is an AI tool and based on data-driven models. **Table-2** Collectively summarizes the AI across all groups.

Table 2: Awareness of AI – Comparative Summary (%)

Question / Parameter	UG Students (n=79)	PG Students (n=26)	Teachers (n=12)
AI defined as machine-based intelligent systems	100.0	65.4	100.0
ChatGPT identified as AI tool	96.2	92.3	100.0
AI applications based on data-driven models	97.5	84.6	100.0
Prior AI knowledge (detailed or basic)	97.5	~96.0*	91.7
AI awareness described as essential	—	—	91.7

*Table 2. Comparative understanding of Artificial Intelligence among UG students, PG students, and educators. (*PG insights derived from accurate identification trends across various questions.)*

Patterns of AI Utilization in Chemistry Education

As summarized in **Table-3** 45.6% UG students occasionally use AI while 20.3% say they never use such tools.

Table 3: AI Usage Frequency and Purpose – UG Students

Usage Frequency	Percentage (%)
Regularly	1.3
Occasionally	45.6
Rarely	32.9
Never	20.3

Table 3. Frequency of AI tool usage for chemistry study among undergraduate students (n = 79).

AI in Theory Teaching with Conceptual Understanding as well as Practical and Laboratory-Based Learning

87.3% of undergraduate students affirmed that AI could help solve both theoretical and numerical issues. An impressive 69.2% of postgraduate students reported that AI supports understanding reaction processes and spectroscopy. AI is taking a big role in chemistry practical education as summarized in **Table.4**. All UG students agree that use of AI-based virtual labs results in safe experimentation. Ai is helping in reducing the experimental eros and improves efficiency in practical teaching. Particularly in the context of the Indian education system these impacts will be high.

Table 4: AI in Practical/Laboratory Teaching – Comparative Data (%)

Parameter	UG Students (%)	PG Students (%)	Teachers (%)
AI assists via virtual simulations / virtual labs	100.0	88.5	100.0
AI assists in data analysis of experiments	70.9	~88.5*	100.0
AI reduces experimental errors / risks	~91.7*	84.6	91.7
AI improves accuracy and efficiency in practical work	100.0	92.3	100.0

*Table 4. Perceived function of AI in both practical and laboratory chemistry instruction among respondent categories. (*Estimated values derived from the nearest corresponding question answers)*

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Benefits of AI in Chemistry Education

As summarized in **Table-5** all teachers (100%) agree that use of AI will save time, improves teaching effectiveness with instant feedback. 81.0% of UG says AI will help slow learners and weak students

Table 5: Perceived Benefits of AI – Comparative Summary (%)

Benefit Parameter	UG (%)	PG (%)	Teachers (%)
AI saves time / automates routine tasks	58.2 (all)	~88.5*	100.0
AI provides instant / real-time feedback	83.5	88.5	100.0
AI supports personalized learning	81.0 (weak students)	80.8	91.7
AI enhances research productivity / teaching effectiveness	~69.6*	92.3	100.0
AI enables remote / online learning	55.7	76.9	100.0

*Table 5. Comparative overview of perceived advantages of AI among various respondent groups. (*Estimated values derived from the nearest relevant questions.)*

Obstacles and Constraints of AI in Chemistry Learning.

The finding of the research indicates **(Table 6)** that students say AI generated data can be occasionally wrong. Verifying the accuracy and inaccuracy of AI generated data is a major challenge before students. Majority of the respondents are concerned about data privacy.

Table 6: Key Challenges – Comparative Summary (%)

Challenge	UG (%)	PG (%)	Teachers (%)
Overdependence / laziness in thinking	77.2	65.4	41.7
AI-generated content may be inaccurate	83.5	73.1	83.3
Data privacy as a concern	82.3	88.5	91.7
Plagiarism issues	53.2	76.9	91.7
Teachers / students need AI training	—	69.2 (proper training needed)	91.7

Table 6. Identified obstacles and constraints of AI incorporation in chemistry teaching among participant groups.

AI in Assessment and Evaluation and Ethical Factors in AI Application

All responders endorse AI help in automation of assessment. All teachers (100%) agree that AI helps in automatic grading, faster assessment, question paper generations and puzzle preparations. Additionally, 91.7% of educators concurred that AI provides unbiased assessment, and 100% validated that AI assists in monitoring student progress.In the educator community, 91.7% declared that AI applications must follow ethical guidelines; all 12 collectively agreed that content produced by AI needs verification instead of being accepted blindly; and 91.7% recognized plagiarism as a possible problem arising from AI utilization.

Overall Perceptions

All responder groups were highly positive about perceptions of AI in chemistry education as given in **Table 7**. All respondents (100%) agree that AI improves teaching effectiveness and AI will help in transforming chemistry education.

Table 7: Overall Perception of AI in Chemistry Education (%)

Perception Category	UG Students (%)	PG Students (%)	Teachers (%)
Highly beneficial	44.3	73.1	91.7
Neutral	50.6	26.9	8.3
Harmful / Not useful	~5.1	0.0	0.0
AI essential for modern teaching/PG studies	62.0 (AI literacy important)	76.9	83.3

AI improves teaching / research quality	87.3 (learning easier)	100.0	100.0

Table 7. General views on AI in chemistry education among different respondent groups. Values indicate the most positive response category.

Future Scope and Transformative Potential

Comparative Summary of the future scope of AI *in chemistry education and research is elaborated in* **Table-8**

Table 8: Future Scope of AI – Comparative Summary (%)

Future Scope Parameter	UG (%)	PG (%)	Teachers (%)
AI will transform education / chemical research	49.4	65.4	66.7
AI will create new opportunities	51.9	73.1	100.0
AI literacy essential for students/future chemists	62.0	80.8	83.3
AI can only partially replace traditional methods	59.5	73.1	91.7

Table 8. Comparative views on the future potential of AI in chemistry education and research.

Critical Analysis: Awareness-Usage Gap and Readiness for AI Adoption.

All the responders yet not use the AI tool in chemistry this indicates insufficient institutionally directed AI incorporation in curricula, restricted knowledge of chemistry-specific applications. The preparedness for AI implementation in chemistry education seems most robust at the postgraduate level. Among educators, preparedness is pedagogically robust but may be limited by institutional training deficiencies and the lack of official AI literacy structures within chemistry degree curricula.

IV. SUMMARY OF KEY FINDINGS, IMPLICATIONS, AND RECOMMENDATIONS

The research indicates that awareness of AI is significant among chemistry educators and students, with considerable backing for virtual laboratories and data analysis aided by AI. Participants acknowledge the significance of ethical AI application, especially concerning data privacy, plagiarism, and content verification, with undergraduate students needing more organized training. The majority of participants view AI literacy as crucial, suggesting a willingness to incorporate it into chemistry education. Consequently, the research suggests implementing AI literacy programs for undergraduates, AI-centric research methods courses for postgraduates, and broader utilization of AI-powered virtual lab platforms.

V. CONCLUSION

Among the 117 respondents, AI awareness was strong and consistent. Undergraduate students showed irregular and disorganized usage, while postgraduate students participated in research-driven and technically savvy applications. Postgraduate students (92.3%) and educators (100%)—assert that the educational justification for AI incorporation is strongly supported by the experiences and expectations of stakeholders. 81.0% of undergraduate students recognize AI's ability to help academically disadvantaged learners. Few students; worry about content precision. All respondents agreed that there is a requirement for the development of organized ethical guidelines and institutional protections to facilitate any AI incorporation effort.

Acknowledgement:

The authors, Dinesh Navale and Prasanna Ranade, gratefully acknowledge the support and access to the Central Instrumentation Facilities funded by DST-FIST at Vivekanand Education Society's College of Arts, Science and Commerce (Autonomous). The authors also acknowledge the financial and infrastructural support provided under the DBT STAR College Scheme. Further, the authors sincerely thank the RUSA grant under PM-USHA for their support in facilitating this work.

Conflict of Interest:
All authors declare no conflicts of interest.

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