THE IMPACT OF USING ARTIFICIAL INTELLIGENCE AS A SUPPLEMENTARY TOOL IN CONTEMPORARY CHEMISTRY TEACHING: AN EXPERIMENTAL STUDY.

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Abstract

This paper addresses the impact of the use of artificial intelligence as a supportive tool in contemporary chemistry teaching, with a particular focus on the understanding of ionic and covalent chemical bonds. This research aims to evaluate whether the integration of artificial intelligence into the learning process can influence the improvement of students' learning, compared to traditional teaching methods without the support of artificial intelligence. The study was carried out as an experimental research with two comparable groups of students, selected after a preliminary test (pre-test). In the first group, teaching was conducted through a traditional approach with contemporary visual and explanatory methods, whereas in the second group, in addition to the same explanation, students were given the opportunity to use artificial intelligence as a supportive tool for self-learning and clarification of concepts. After the completion of the learning process, a final test (post-test) was conducted for both groups, with the aim of assessing the level of understanding. This research aims to contribute to discussions on the use of artificial intelligence in education, highlighting its potential as a tool that can increase engagement, conceptual understanding, and the independence of students in the process of learning chemistry.

Keywords: chemistry education, artificial intelligence, student achievement, ionic and covalent bonding.

Introduction

In recent decades, the development of digital technology has significantly influenced the teaching and learning process at all educational levels. The digital revolution has brought important changes in many spheres of human life, including the field of education (Priyadi *et al*., 2025).

In particular, artificial intelligence (AI) has emerged as one of the most transformative technologies in contemporary education. Due to its potential in the educational process, artificial intelligence, including ChatGPT, has attracted great interest from researchers in the field of education (Erümit & Sarıalioğlu, 2025).

Various sectors, including education, are undergoing significant transformations as a result of the rapid advancement of artificial intelligence. AI plays an important role in both general and higher education, influencing students' academic development through the opportunities and challenges it offers (Vieriu & Petrea, 2025). In the field of education, artificial intelligence has introduced new approaches and solutions for teaching and learning, which are being applied and tested in different educational contexts (Pedro *et al*., 2019).

Artificial intelligence can contribute to the continuous improvement of the learning environment by fostering students' motivation, initiative, and creativity (Huang, Saleh & Liu, 2021).

Understanding and mastering fundamental scientific concepts and principles, including those of chemistry, represents a challenge for many students. Numerous studies have identified significant difficulties in learning and have highlighted the main factors influencing these difficulties (Treagust, Duit & Nieswandt, 2018).

Due to its abstract nature, chemistry is often perceived as a challenging subject for students. In this regard, it can greatly benefit from the use of artificial intelligence tools. These tools enable interactive simulations, virtual laboratories, and personalized learning approaches, making the

learning process more engaging and more accessible, especially for students who face difficulties with traditional teaching methods (Mandina & Kusakara, 2025).
Artificial intelligence has great potential to facilitate the understanding of complex topics in chemistry and to improve the learning process, becoming an important component in contemporary educational research. In this context, tools such as ChatGPT have shown the ability to explain and solve chemistry problems, helping to strengthen conceptual understanding and improve the learning process among students (Daher, Diab & Rayan, 2023).
Teaching chemistry in relation to real-life situations and problems is considered an effective way to increase students' motivation and interest in this subject. The use of practical examples enables students to understand the interdisciplinary nature of chemistry and its relevance in everyday life, making the learning process more meaningful and closer to their experiences (Mandler *et al*., 2012).
The integration of artificial intelligence into natural science subjects such as chemistry, biology, and physics contributes to the development of students' skills, encourages collaboration during learning, and creates a more accessible and effective environment for research and learning (Bauyrzhan & Zhylysbayeva, 2025).
This study aims to analyze the impact of artificial intelligence as a complementary tool in contemporary chemistry teaching, with a particular focus on improving students' understanding of ionic and covalent chemical bonds. Through an experimental design, the study evaluates whether the integration of AI in the learning process has a positive effect on students' achievement compared to traditional teaching methods.

Methodology

2.1. Participants / Sample: The research was conducted at the secondary school "Kiril Pejçinoviq" in Tetovo, with first-year students aged 14–15. Initially, four classes (A, B, C, and D) were included in the study and were administered a pre-test to assess their initial knowledge of chemical bonding.

2.2 Research method: This study was designed as a comparative experimental research. Based on the pre-test results, classes A and B were selected as comparable groups for the experiment. Class A was assigned as the experimental group, while Class B served as the control group, in order to evaluate the impact of artificial intelligence on the teaching and learning process.

2.3. Teaching Unit: The instructional unit covered in this study was "Ionic and Covalent Chemical Bonds." The aim of this unit was to develop students' conceptual understanding of the main types of chemical bonds and the differences between them.

2.4. Procedure: The teaching process was conducted during a 45-minute lesson in both groups. In both classes, contemporary teaching methods were used, including a PowerPoint presentation and verbal explanation by the teacher.
In the experimental group (Class A), in addition to traditional teaching methods, artificial intelligence (ChatGPT) was used as a supplementary tool for concept clarification and self-learning for approximately 10-15 minutes of the lesson.
In the control group (Class B), artificial intelligence was not used. After the lesson, both groups completed a post-test lasting 10 minutes to evaluate their acquired knowledge.

2.5. Research tools: The tools used in this study included a pre-test and a post-test, which were used to assess students' initial knowledge and learning outcomes after the teaching process.

The tests included questions related to ionic and covalent chemical bonds and were used to analyze changes in students' understanding after the completion of the lesson.

Table 1: Comparison of pre-test and post-test

Section	Pre-test (General Chemistry)	Post-test (Ionic & Covalent Bonds)
Part I – Multiple Choice	Atomic number, acids, bases, electron configuration, basic chemistry concepts	Ionic bond formation, covalent compounds, properties of ionic compounds
Q1	What does atomic number represent?	In an ionic bond there is: transfer of electrons
Q2	Identify an acid	Identify a covalent compound
Q3	Formation of ionic bond	Properties of ionic compounds
Q4	Identify a base	—
Q5	Unit of substance amount	—
Q6	Formation of covalent bond	—
Section	Pre-test	Post-test
Part II – Short Answer / Classification	Atom particles, electron configuration of oxygen, acid-base reaction products	Classification of substances as ionic or covalent
Q7	Parts of an atom	Classify $MgCl_2$, H_2O, SO_2, KI
Q8	Electronic configuration of oxygen	—
Q9	Product of acid-base reaction	—
Section	Pre-test	Post-test
Part III – Problem Solving / Reasoning	Mole calculation (CO_2)	Conceptual explanation of ionic bond and comparison
Q10	Calculate moles in CO_2	Why NaCl is ionic
—	—	Differences between ionic and covalent bonds

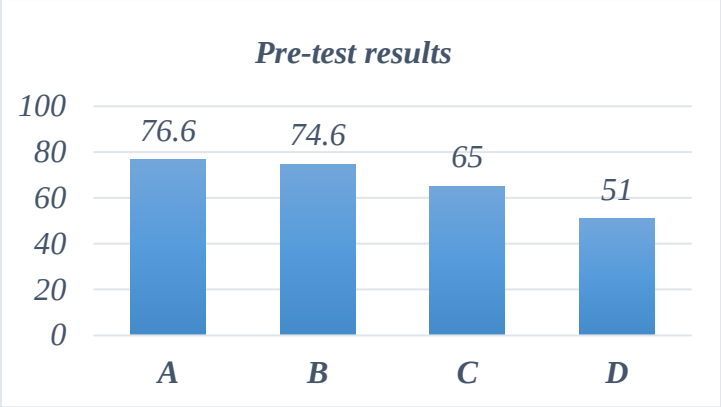
Results

To assess the initial level of students' knowledge on ionic and covalent chemical bonds, a pre-test was first conducted in four classes (A, B, C, and D). The results showed that Classes A and B had the most similar initial levels of knowledge; therefore, they were selected for the experimental study.

Table 2. Pre-test results

Class	Number of students	Total points	Average score	Percentage (%)
A	14	161	11.5	76.6%
B	20	224	11.2	74.6%
C	20	196	9.8	65%
D	25	192	7.68	51%

Based on the pre-test results, Classes A and B were considered the most comparable groups for conducting the experiment.



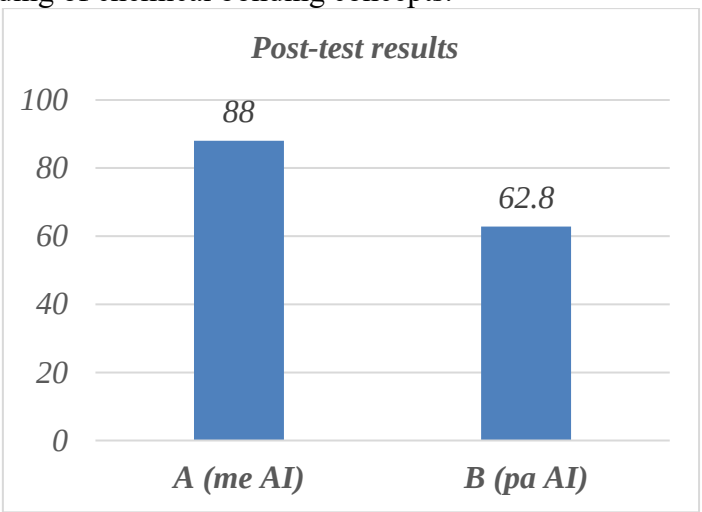
Graph 1. Comparison of pre-test results among Classes A, B, C, and D.

After the teaching process was completed, a post-test was conducted for both groups. In both classes, the same contemporary teaching method was used, supported by a PowerPoint presentation and verbal explanation by the teacher. In Class A, students were given approximately 10 minutes to use ChatGPT as a supportive tool for self-learning and clarification of concepts, while Class B continued only with the traditional teaching method. After the lesson was completed, both groups took a post-test to evaluate the knowledge acquired.

Table 3. Post-test results

Class	Teaching method	Number of students	Total points	Average score	Percentage (%)
A	Teaching + AI + post-test	15	198	13.2	88%
B	Teaching + post-test	26	245	9.42	62.8%

The post-test results show that Class A, in which artificial intelligence was used as a supportive teaching tool, achieved significantly higher results compared to Class B. The average score in Class A was 13.2 points (88%), while in Class B it was 9.42 points (62.8%).
The comparison between pre-test and post-test results shows a noticeable improvement in the experimental group, suggesting that the use of artificial intelligence had a positive impact on students' understanding of chemical bonding concepts.



Graph 2. Comparison of post-test results between Class A and Class B.

Discussion

The results of this study show that the use of artificial intelligence as a complementary tool in chemistry teaching has a positive impact on students' understanding of chemical concepts.

Students who used AI achieved higher post-test results compared to those who were taught using only traditional methods.

ChatGPT in chemistry education, when used under proper guidance and supervision, offers significant opportunities for innovation and supports more interactive, adaptive, and technology-based learning (Priyadi *et al*., 2025). However, its use still faces challenges, particularly regarding the potential dependency of students on artificial intelligence and the accuracy of the information provided (Priyadi *et al*., 2025).

In a previous study, it was reported that ChatGPT, when tested on solving 30 chemistry problems, successfully solved 13 of them (43.33%) without showing conceptual difficulties. These results suggest that ChatGPT can serve as a supportive tool for students in solving chemistry problems and improving the learning process. In this context, its integration into chemistry teaching is recommended as support for student learning (Bauyrzhan & Zhylysbayeva, 2025).

During the implementation of the research, it was observed that although both groups (class A and class B) completed the post-test within the same time duration of 10–15 minutes, students in class A, who used artificial intelligence as a supporting learning tool, completed the test faster compared to students in class B. This may indicate that the use of AI contributed to better understanding and greater efficiency in problem-solving.

Furthermore, during the research process, it was observed that students in the experimental group (class A), when instructed to use artificial intelligence as a learning aid, did not show confusion or hesitation in its use. They immediately engaged in the learning process and explored the content with ease, demonstrating a high level of acceptance and interest in the use of AI in education.

In the post-test, a significant difference was observed between the experimental group and the control group regarding questions involving examples of ionic and covalent bonds that had not been explicitly covered during the lesson. In the experimental group (with the use of artificial intelligence), 2 out of 15 students (13.3%) provided incorrect answers, while 13 students (86.7%) answered correctly. In the control group (without the use of artificial intelligence), 10 out of 26 students (38.5%) gave incorrect answers, while 16 students (61.5%) answered correctly.

A considerable performance gap was observed, expressed as a **25.2 percentage-point difference** in favor of the experimental group. This indicates that students exposed to artificial intelligence demonstrated a higher ability to transfer knowledge to new problem-solving contexts.

In this regard, the findings suggest that the use of artificial intelligence had a positive impact on the development of conceptual understanding and problem-solving skills for tasks not directly covered in classroom instruction, making the learning process more flexible and more oriented toward the practical application of knowledge.

Overall, the findings of this study support the idea that artificial intelligence should be used as a complementary tool in chemistry teaching, contributing to improved learning outcomes and the modernization of the educational process.

Conclusions

This study demonstrates that the integration of artificial intelligence as a supplementary tool in chemistry education can significantly enhance students' understanding of chemical concepts, particularly ionic and covalent bonding. The experimental results indicate that students who had access to AI-supported learning achieved higher performance compared to those who followed traditional instructional methods only. This suggests that AI can serve as an effective

bridge between abstract chemical concepts and students' comprehension by offering immediate explanations, interactive support, and personalized learning experiences.

Beyond improved academic achievement, the findings imply broader educational benefits. Artificial intelligence has the potential to transform the learning environment into a more dynamic and student-centered process, where learners are encouraged to explore, question, and learn independently. However, this does not reduce the importance of the teacher; rather, it highlights the teacher's role as a guide who ensures the correct and responsible use of technology in education.

In the future, the use of artificial intelligence in science education is expected to expand further, especially through more advanced adaptive systems and virtual learning environments. Therefore, educators and institutions should consider integrating such tools in a balanced way, combining traditional teaching methods with modern digital technologies. Overall, this study supports the idea that AI should not replace teaching, but rather complement it to improve the quality and effectiveness of education.

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