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Exploring Chemistry Teachers' Knowledge and Perceptions of AI: Opportunities and Challenges

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Abstract

In the field of education, the integration of technology has grown, providing new opportunities for teaching and learning. One emerging technology that has gained attention is Artificial Intelligence (AI). This study investigates Lebanese chemistry teachers' knowledge and perceptions of AI, examining the benefits and challenges they anticipate or experience in their teaching practices while integrating AI. This study adopted a descriptive analytical approach, and a questionnaire was used for data collection and analysis. A total of 285 chemistry teachers completed the questionnaire. Our findings revealed that teachers have limited knowledge of AI. Nonetheless, teachers' perception of AI was predominantly positive. Teachers view AI as beneficial for chemistry teaching, indicating the widespread recognition of its potential advantages. However, despite recognizing its benefits, teachers have also identified several challenges associated with AI integration. These results underscore the need for ongoing support and training for teachers to effectively integrate AI into their practice, addressing both technical and pedagogical aspects.

Introduction

In the field of education, the integration of technology has grown, providing new opportunities for teaching and learning. Artificial Intelligence (AI) is an emerging technology that has gained attention, especially since the closure of schools and universities owing to the COVID-19 pandemic (Al Darayseh, 2023). AI is a branch of science that attempts to simulate human problem-solving methods (Fissore et al., 2022). The term intelligence is defined as the ability to solve a problem, whereas artificial means any systematic human method used to achieve problem-solving goals (Kouveliotis & Mansuri, 2022). As AI technology continues to advance, discussions on its potential applications in education are multiplying (Talan, 2021). Within the domain of science education, AI has generated considerable interest among educators and researchers (Erduran & Levrini, 2024), and, particularly in chemistry, integrating AI holds promising potential for improving student learning (Araújo & Saúde, 2024).

A variety of AI tools and techniques have been developed and implemented in chemistry education to enhance and optimize various domains, including content delivery, personalized learning strategies, analysis of students' feedback, assessment of students' understanding of chemical concepts, and investigations of students' reasoning and cognitive processes during chemical tasks (Chiu, 2021; Clark, 2023). As AI plays an important and growing

role in education, teachers have started exploring the use of AI in their teaching practices; chemistry teachers in Lebanon are no exception. However, the successful adoption of AI in chemistry education depends largely on the knowledge, perceptions, and acceptance of chemistry teachers.

Several studies have shown that teacher preparedness, confidence, knowledge, and perceptions of AI are crucial components of successful AI integration in education (Chounta et al., 2021; Woodruff et al., 2023). Therefore, it is essential to examine teachers' knowledge and perceptions of AI, which can significantly benefit the educational domain. In light of these considerations, the focus of this study was to investigate the perceptions of Lebanese chemistry teachers regarding AI and its use in professional practice. It seeks to understand their level of knowledge concerning AI, the perceived benefits, and the challenges they anticipate or experience in their teaching practices while integrating AI.

Literature Review

Currently, knowledge of AI is vital for teachers, as it is central to their willingness and ability to implement it in teaching and learning practices (McGrath et al., 2023). Various AI tools and techniques have already been integrated into education and are likely to increase in the future, prompting the need to understand teachers' perceptions of this technological advancement. Several studies investigating teachers' perceptions of integrating AI into education have revealed both optimism about the potential positive impact of AI and concerns (Alenezi, 2024; Uygun, 2024). Teachers generally view AI positively regardless of generation and discipline (Annuš, 2024), they recognize its potential to enhance personalized learning and pedagogical outcomes (Alasadi & Baiz, 2023). Furthermore, they positively experience AI as a source of superior scaffolding in scientific writing and STEM education (Kim & Kim, 2022).

The research findings have also highlighted that integrating AI in education can assist teachers in various ways, including preparing teaching materials, creating presentation media, and conducting accurate evaluations, leading to an overall enhancement of teaching effectiveness (Nasir et al., 2024). Moreover, AI tools can significantly reduce the administrative workload of teachers by automating tasks (Qin et al., 2020), which can free time for teachers to focus more on their pedagogical responsibilities and meaningful interactions with students. Particularly in the field of chemistry education, research has shown that the use of AI has led to increased student motivation to learn practical chemistry and chemical concepts, as well as an improvement in their academic achievement (Chiu, 2021). Additionally, AI applications such as chatbots are perceived as beneficial for generating information and supporting chemistry learning (Pernaa et al., 2024).

However, challenges exist, and educators express concerns about ethical issues, changes in teacher roles, transparency in AI decision-making processes, teachers' lack of confidence in AI content mastery, teacher training needs, technical limitations, overreliance on technology, limited access to educational AI resources, and potential replacement of human interaction in the learning process (Kim & Kim, 2022; AlAli & Wardat, 2024; Elam, 2024; Eden et al., 2024; Kurtz et al., 2024). As AI continues to transform education, understanding teachers' perceptions is essential for the successful implementation and development of guidelines for AI integration in diverse

educational contexts.

Significance of the Study

Despite the substantial literature on the use of AI in education, research focusing on teachers' knowledge and perceptions of AI integration into specific fields, such as chemistry education, is not as abundant. The Lebanese context is an example of an environment in which teachers' knowledge and perceptions of AI in chemistry education remain underexplored or even unexplored. To the best of our knowledge, this is the first study to explore chemistry teachers' knowledge and perceptions of AI in Lebanon, revealing insights into the potential benefits and challenges that arise in their professional practice. This is set against the backdrop of a global digital shift in education, where the benefits and drawbacks of AI integration are still being explored and debated. The findings of this study can greatly benefit the field of education and scholarly research, and contribute to a more comprehensive understanding of how AI can be integrated in a way that ensures its effectiveness for all stakeholders while taking into account teachers' perceptions.

Research Questions

This study sought to identify Lebanese chemistry teachers' knowledge and perceptions of AI integration in their professional practices by answering the following questions:

- What is the level of knowledge among Lebanese chemistry teachers regarding AI and its applications in chemistry education?
- How do Lebanese chemistry teachers perceive AI in their professional practice?
- What are the perceived benefits and challenges of integrating AI into their professional practice, according to Lebanese chemistry teachers?

Methodology

The current study used a descriptive analytical approach and targeted Lebanese chemistry teachers in both private and public schools in various Lebanese regions to identify their knowledge and perceptions of AI integration as well as the perceived benefits and challenges associated with AI in the context of chemistry teaching. To achieve the research objectives, a questionnaire that was piloted before being implemented in Google Form was used as a tool for data collection and analysis. It was distributed to teachers via WhatsApp in both French and English, given that the Lebanese education system is structurally bilingual and chemistry is taught in Lebanon in both languages (depending on whether the school is French or English speaking).

The questionnaire was designed after reviewing previous studies such as those conducted by Lindner and Romeike (2019), Chounta et al. (2021), and Woodruff et al. (2023). It was divided into two sections. The first contained general information such as age, gender, teaching experience, academic level, school type (public or private), AI training, and AI knowledge. Based on Likert scale questions, the second section, titled "perceptions of AI and its use in the context of chemistry teaching", consists of 13 items and was used to determine the general perceptions

of chemistry teachers toward AI, the benefits and challenges of using AI in their professional practices.

The research instrument was face- and content-validated by three experts in the field of chemistry education and AI, respectively, to ensure validity. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) software. A total of 285 chemistry teachers completed the questionnaires.

Results

Demographic and Professional Background of Chemistry Teachers

The demographic and professional backgrounds of the Lebanese chemistry teachers participating in the study, shown in Table 1, indicate a balanced representation across different age groups. The majority of teachers fall within the age brackets of 26-35 years (35.2%) and 36-45 years (35.9%), suggesting a relatively young-to-middle-aged teaching workforce. Teachers aged 46-55 years constitute 16.9% of the sample, while those aged above 55 years represented a smaller proportion (4.6%). The youngest group, aged 18-25 years, comprised 7.4% of respondents. This distribution reflects a diverse range of teaching experiences and potentially varying levels of familiarity with emerging educational technologies including AI.

Table 1. Participant Demographics and General Information

Variable	Category	**Percentage**
Age	18-25	7.4
	26-35	35.2
	36-45	35.9
	46-55	16.9
	above 55	4.6
Gender	Male	28.9
	Female	71.1
Highest degree obtained	Bachelor	26.4
	TD	.7
	Master	70.4
	PhD	2.5
Number of years teaching chemistry	Less than 5 years	18.0
	5-10 years	31.7
	11- 20 years	28.2
	over 20 years	22.2
Type of school	Public	56.0
	Private	44.0
Attended any training course(s) on the use of artificial intelligence (AI) in education	Yes	34.5
	No	65.5

The gender distribution showed a significant majority of female teachers (71.1%) compared to male teachers

(28.9%). This gender disparity may influence perspectives on AI integration, as previous research has noted gender differences in technology adoption and usage in educational settings (e.g. Cai et al., 2017). A substantial proportion of Lebanese chemistry teachers held advanced degrees, with 70.4% having obtained a master's degree. Bachelor's degree holders made up 26.4% of the respondents, while those with a PhD accounted for 2.5%. A minimal percentage (0.7%) had TD (Teaching Diploma). The high percentage of teachers with master's degrees suggests a well-qualified teaching workforce, which could be beneficial for the integration of complex technologies, such as AI, in educational practices.

The number of years teaching chemistry among the respondents varied, with a notable portion having 5-10 years (31.7%) and 11-20 years (28.2%) of teaching experience. Teachers with over 20 years of experience constituted 22.2%, while those with less than five years of teaching experience accounted for 18.0%. This distribution indicates a mix of seasoned and relatively newer educators, potentially reflecting a range of pedagogical styles and openness to adopting new teaching tools, such as AI. A small majority of respondents (56.0%) were taught in public schools, while the remaining 44.0% were employed in private schools.

The difference in school types might influence the availability of resources and support for AI integration, as private schools in Lebanon may have more access to advanced technologies than public schools. A significant proportion of the teachers (65.5%) did not attend any training courses on the use of AI in education, while 34.5% had participated in such training. This indicates a substantial gap in professional development related to AI, underscoring the need for more widespread and accessible training programs to equip teachers with the skills and knowledge necessary to effectively integrate AI into their teaching practices.

The demographic and professional backgrounds of Lebanese chemistry teachers reveal a diverse and highly qualified workforce, with significant portions having substantial teaching experience and advanced degrees. However, the findings also highlight the need for more targeted training in AI to bridge the gap in knowledge and skills, particularly given the high interest in and perceived usefulness of AI in professional practice. Addressing this need can facilitate the effective integration of AI in chemistry education and enhance teaching and learning outcomes across different school types and age groups.

Cronbach's alpha coefficient for the 36-item scale used in this study was 0.789 (see Table 2). This value indicates good internal consistency reliability for the scale. Cronbach's alpha is a measure of how closely related a set of items is as a group, and values closer to 1.0 suggest higher reliability. A value of 0.789 suggests that the items on the scale are reasonably consistent in measuring the underlying construct, thus providing confidence in the reliability of the data collected using this scale. This level of reliability is acceptable for most research purposes, indicating that the scale is a reliable tool for assessing Lebanese chemistry teachers' perceptions of AI integration in their professional practices.

Table 2. Cronbach's Alpha

Cronbach's alpha	N of Items
.789	36

Results related to Research Question 1: What Is the Level of Knowledge among Lebanese Chemistry Teachers regarding AI and its Applications in Chemistry Education?

The study revealed that the majority of Lebanese chemistry teachers possess only limited knowledge of AI and its applications in chemistry education, as shown in Table 3.

Table 3. What do you know about AI?

Level of Knowledge	Percentage (%)
I've never heard of AI	6.3
I'm not sure what AI is	5.3
I have limited knowledge about AI	69.4
I'm well informed about AI and its applications	19.0

Specifically, 69.4% of the respondents indicated that they had limited AI knowledge. A smaller segment (19.0%) reported being well-informed about AI and its applications. In contrast, a significant minority, comprising 6.3% and 5.3% of the teachers, stated that they had never heard of AI or were unsure what AI is, respectively. These results highlight a gap in the comprehensive understanding of AI among chemistry educators, suggesting the need for targeted professional development programs to enhance their knowledge and proficiency in AI applications within the educational context.

Results related to Research Question 2: How do Lebanese Chemistry Teachers Perceive AI in Their Professional Practice?

The perception of AI among the Lebanese chemistry teachers was predominantly positive (Table 4). A majority of the respondents (58.5%) found AI to be "Useful" for chemistry teaching. This suggests a strong positive perception of the integration of AI into chemistry education. An additional 19.4% of respondents perceived AI as "Very Useful". Combining these two categories, 77.9% (58.5% + 19.4%) of the respondents viewed AI as beneficial for chemistry teaching, indicating a widespread recognition of its potential advantages. On the other hand, only a small percentage of respondents consider AI "Not at all useful" (9.5%) or "Slightly useful" (2.8%), collectively accounting for just 12.3% of the total responses. A neutral stance was held by 9.9% of respondents, suggesting that nearly one in ten individuals are undecided or believe that the benefits and drawbacks of AI are balanced. This positive outlook suggests that most teachers recognize the potential benefits of AI integration in their teaching practice. However, the presence of some skepticism indicates that there are still reservations or challenges that need to be addressed to maximize the effectiveness of AI in education.

Table 4. To what extent do you think AI could be useful for chemistry teaching?

Perception	Percentage (%)
Not at all useful	9.5

Perception	Percentage (%)
Slightly useful	2.8
Neutral	9.9
Useful	58.5
Very useful	19.4

Moreover, we can answer this research question by investigating the data in Table 5.

Table 5. What is your general perception of the use of AI in the context of your teaching?

Perception	Frequency	Percent
Extremely negative	13	4.6
Somewhat negative	12	4.2
Neither positive nor negative	62	21.8
Somewhat positive	174	61.3
Extremely positive	23	8.1
Total	284	100.0

A substantial majority of respondents (61.3%) have a "Somewhat positive" perception of AI in the context of their teaching, as shown in Table 5. This indicates a generally favorable view of AI in educational contexts. Additionally, 8.1% of respondents hold an "Extremely positive" perception. When combined, 69.4% (61.3% + 8.1%) of the respondents exhibited a positive outlook toward the use of AI in teaching.

A notable portion (21.8%) had a neutral stance, indicating that they perceived AI neither positively nor negatively in their teaching context. This suggests that a significant number of respondents see a balance between the advantages and disadvantages, or they might not have enough information to form a strong opinion. A smaller segment reports negative perceptions: 4.6% have an "Extremely negative" view and 4.2% have a "Somewhat negative" view, totaling 8.8% who hold unfavorable opinions regarding AI in their teaching. Overall, the data indicate a predominantly positive perception of AI's use in teaching and a prominent inclination toward the belief that AI could play a significant role in enhancing chemistry teaching, with a majority recognizing its potential benefits and usefulness and only a small minority expressing negative perceptions.

Results related to Research Question 3: What Are the Perceived Benefits and Challenges of Integrating AI into Their Professional Practice, according to Lebanese Chemistry Teachers?

Perceived Benefits

As shown in Table 6, Lebanese chemistry teachers identified several benefits of integrating AI into their professional practice. The most frequently acknowledged benefit was the ability of AI to help save time when searching for materials/content/resources for courses, cited by 81.3% of the respondents. Additionally, 72.9% believed that AI makes chemistry teaching more interactive and engaging, while 71.4% noted its timesaving

potential when creating course schedules. Other notable benefits include the capacity of AI to create innovative learning situations (70.1%), help teachers acquire new skills and rethink pedagogical approaches (67.6%), and simulate and model complex chemical phenomena (66.6%). These findings underscore the multifaceted advantages of AI in enhancing teaching efficiency, engagement, and the overall educational experience.

Table 6. In Your Opinion, What Are the Positive Aspects of Using AI in the Context of Your Teaching?

Benefit	**Percentage (%)**
Helps save time when creating a schedule for my course	71.4
Helps save time when searching for materials/content/resources for my course	81.3
Helps save time when correcting homework	28.5
Helps make fewer mistakes	41.6
Helps personalize learning according to students' needs	51.8
Helps create innovative learning situations	70.1
Helps simulate and model complex chemical phenomena	66.6
Helps make chemistry teaching more interactive and engaging	72.9
Helps assess student performance	54.3
Helps acquire new skills and rethink pedagogical approaches	67.6

Perceived Challenges

Despite recognizing its benefits, the teachers also identified several challenges associated with AI integration, as shown in Table 7. The most significant challenge was the lack of skills needed to use AI effectively, as reported by 73.4% of the respondents. Additionally, 60.0% were concerned about the ability to engage in continuous learning to stay updated with rapid AI developments, and 59.9% were concerned about adapting to the constant evolution of AI-based technologies.

Other notable challenges include the risk of over-reliance on technology (54.2%), technical complexity of AI tools (52.1%), and potential loss of constructive and creative critical thinking (46.1%). Furthermore, concerns about losing control over the teaching process (38.8%) and replacing teachers with AI (36.6%) were also highlighted. These challenges indicate the need for ongoing support and training for teachers to effectively integrate AI into their practice, addressing both technical and pedagogical aspects.

Table 7. In Your Opinion, What Are the Challenges of Using AI in the Context of Your Teaching?

Challenge	**Percentage (%)**
Technical complexity of tools	52.1
Lack of skills needed to use AI effectively	73.4
Risk of AI replacing teachers	36.6

Challenge	Percentage (%)
Risk of losing control over the teaching process	38.8
Risk of lacking constructive and creative critical thinking	46.1
Risk of over-reliance on technology	54.2
Ability to adapt to the constant evolution of AI-based technologies	59.9
Ability to engage in continuous learning to stay updated with the rapid developments of AI	60.0

Conclusion

This study is, to the best of our knowledge, the first to provide valuable insights into Lebanese chemistry teachers' knowledge and perceptions of AI integration in education, and it therefore is a valuable contribution to the literature. By synthesizing the results, several key conclusions can be drawn.

1. Limited knowledge about AI: The research findings indicate that the majority of Lebanese chemistry teachers have only limited knowledge of AI and its applications in chemistry education. This result is consistent with that of Chounta et al. (2021), who showed that teachers have limited knowledge about AI and how it can support them in their teaching practices. To address this issue, it is necessary to foster awareness and general knowledge about AI to enhance the effectiveness of AI in education.

2. Positive perceptions of AI: The study revealed that the perception of AI among Lebanese chemistry teachers was predominantly positive. Similar findings have been reported previously (Kim & Kim, 2022; Alasadi & Baiz, 2023; Annuš, 2024; Uygun, 2024). Indeed, a significant challenge to be addressed before the successful integration of AI into chemistry education is teachers' perception of AI. Positive perceptions of AI are essential to enable the effective and successful integration of AI into education.

3. Perceived benefits and challenges: Chemistry teachers acknowledge the potential benefits of AI in saving time when searching for course materials/content/resources, and making chemistry teaching more interactive and engaging. Additionally, they recognize AI timesaving potential when creating course schedules and AI's capability to create innovative learning situations, help teachers acquire new skills and rethink pedagogical approaches, simulate and model complex chemical phenomena, help teachers assess student performance, and personalize learning according to students' needs. However, concerns have been raised regarding the lack of skills needed to use AI effectively, the ability to engage in continuous learning to stay updated with rapid AI developments, and the ability to adapt to the constant evolution of AI-based technologies. Other notable challenges include the risk of over-reliance on technology, technical complexity of AI tools, and potential loss of constructive and creative critical thinking. Some chemistry teachers also expressed apprehension about losing control over the teaching process and the potential marginalization of their roles or even their replacement by AI in the presence of advanced AI tools and techniques. While these findings align with previous studies investigating teachers' perceptions of the benefits and challenges associated with AI (Alasadi & Baiz, 2023; AlAli &

Wardat, 2024; Eden et al., 2024; Nasir et al., 2024; Kurtz et al., 2024), they emphasize the need for training and support, considering all these challenges, to harness the potential of AI in education.

In sum, understanding Lebanese chemistry teachers' perceptions of AI is essential for informed decision making. While there is general acknowledgment of the potential benefits of AI, significant knowledge gaps and challenges remain. Addressing these issues through targeted professional development and support initiatives is crucial to fully leverage AI's capabilities in enhancing chemistry education. The conclusions drawn from this study have implications for educators, educational policymakers, curriculum developers, and teacher-training program designers in the field of chemistry education. Therefore, clear and coherent policies on the integration of AI into education are needed. These policies must define the objectives, resources, and training needed to support teachers in their adoption of new technologies.

As AI continues to evolve, it is essential to continue research to keep pace with the latest technological advances and their implications in education. Future research exploring the integration of AI into education is encouraged, not just in Lebanon but across different cultural and educational landscapes, to better understand the challenges and opportunities of AI in education and foster a future where technology and human expertise merge to empower learners and educators.

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