

Artificial Intelligence in Education for Sustainable Development: Investigating Science Teacher's Perceptions

Ayat Kharroubi

Faculty of Education, Lebanese University, Beirut, Lebanon

ayat.hkh90@gmail.com

Abstract

The integration of artificial intelligence (AI) into education has been accelerating in recent years, driven by technological advancements and a growing attention on adjusting education with the three pillars of sustainable development —social, economic, and environmental. This study aims to explore the perceptions of science teachers (biology, chemistry, physics, science) in Lebanon regarding the use of Artificial intelligence (AI) in educational process and its role in promoting sustainable development. The guiding research question is: What are the perceptions of science teachers toward the use of AI in education for sustainable development? A quantitative approach was employed using the form of knowledge, attitudes and practices (KAP) survey consisting of 18 closed-ended items and two open-ended questions. 99 Science teachers from public and private schools in Lebanon completed this online survey. Findings showed that 95.9% of the participants presented a strong need for training in AI, emphasizing the critical role educational institutions play in offering professional development. While only 55.5% reported aligning AI into teaching practices for sustainability, 70% of respondents rated their knowledge of AI as adequate. Importantly 88.8% of the teachers expressed a positive attitude, agreeing that AI operates a significant role in progressing sustainable development. The primary challenges identified were the limited access to appropriate school's technological tools and the lack of training. Therefore, AI can enhance sustainable education by promoting the use of efficient resources, lifelong learning opportunities and personalized learning. To realize this potential, targeted investment and training in infrastructure are essential.

Keywords

Artificial intelligence, education for sustainable development, KAP survey, science teachers, perception

Résumé

L'intégration de l'intelligence artificielle (IA) dans l'éducation s'est accélérée ces dernières années, portée par les avancées technologiques et une attention croissante portée à l'adaptation de l'éducation aux trois piliers du développement durable — social, économique et environnemental. Cette étude vise à explorer les perceptions des enseignants de sciences (biologie, chimie, physique, sciences) au Liban concernant l'utilisation de l'intelligence artificielle (IA) dans le processus éducatif et son rôle dans la promotion du développement durable. La question centrale de la recherche est la suivante : Quelles sont les perceptions des enseignants de sciences à l'égard de l'utilisation de l'IA dans l'éducation en faveur du développement durable ? Une approche quantitative a été adoptée en utilisant un questionnaire de type connaissances, attitudes et pratiques (CAP) composé de 18 questions fermées et de deux questions ouvertes. 99 enseignants de sciences, issus d'écoles publiques et privées au Liban, ont répondu à cette enquête en ligne. Les résultats ont montré que 95,9 % des participants ont exprimé un fort besoin de formation en IA, soulignant le rôle essentiel des institutions éducatives dans le développement professionnel. Bien que seulement 55,5 % aient déclaré intégrer l'IA dans leurs pratiques pédagogiques liées au développement durable, 70 % des répondants ont évalué leurs connaissances en IA comme satisfaisantes. De plus, 88,8 % des enseignants ont exprimé une attitude positive, reconnaissant que l'IA joue un rôle important dans la progression du développement durable. Les principaux défis identifiés sont le manque d'accès aux outils technologiques adaptés dans les écoles et l'absence de formation. Ainsi, l'IA peut renforcer l'éducation au développement durable en favorisant l'utilisation de ressources efficaces, des opportunités d'apprentissage tout au long de la vie et un enseignement personnalisé. Pour concrétiser ce potentiel, des investissements ciblés et des formations en infrastructures sont indispensables.

Mots-clés

Intelligence artificielle, éducation au développement durable, enquête CAP, enseignants en sciences, perception

مستخلص

يشهد دمج الذكاء الاصطناعي (AI) في التعليم تسارعاً ملحوظاً في السنوات الأخيرة، مدفوعاً بالتطورات التكنولوجية والاهتمام المتزايد بمواءمة التعليم مع الركائز الثلاث للتنمية المستدامة — الاجتماعية، والاقتصادية، والبيئية. تهدف هذه الدراسة إلى استكشاف تصورات معلمي العلوم (الأحياء، الكيمياء، الفيزياء، والعلوم العامة) في لبنان حول استخدام الذكاء الاصطناعي في العملية التعليمية ودوره في تعزيز التنمية المستدامة. السؤال البحثي الرئيس هو: ما هي تصورات معلمي العلوم تجاه استخدام الذكاء الاصطناعي في التعليم من أجل التنمية المستدامة؟ تم اعتماد منهج كمي باستخدام استبانة حول المعرفة، والمواقف، والممارسات (KAP)، مكوّن من 18 سؤالاً مغلقاً وسؤالين مفتوحين. وقد شارك في هذا الاستبانة الإلكتروني 99 معلماً للعلوم من المدارس الرسمية والخاصة في لبنان. أظهرت النتائج أن 95.9% من المشاركين أعربوا عن حاجة قوية للتدريب في مجال الذكاء الاصطناعي، مؤكدين على الدور الحاسم الذي تلعبه المؤسسات التعليمية في تقديم التطوير المهني. بينما أشار 55.5% فقط إلى أنهم يدمجون الذكاء الاصطناعي في ممارساتهم التعليمية من أجل الاستدامة، رأى 70% من المشاركين أن معرفتهم بالذكاء الاصطناعي كانت كافية. ومن الجدير بالذكر أن 88.8% من المعلمين أبدوا موقفاً إيجابياً، ووافقوا على أن الذكاء الاصطناعي يلعب دوراً مهماً في تعزيز التنمية المستدامة. تم تحديد التحديات الرئيسية في قلة الوصول إلى الأدوات التكنولوجية المناسبة في المدارس، ونقص التدريب. وبالتالي، يمكن للذكاء الاصطناعي أن يعزز التعليم المستدام من خلال الترويج لاستخدام الموارد بكفاءة، وتوفير فرص التعلم مدى الحياة، والتعليم المخصص وفقاً لاحتياجات المتعلمين. ولتحقيق هذا الإمكان، من الضروري الاستثمار المستهدف في البنية التحتية والتدريب.

كلمات مفتاحية

الذكاء الاصطناعي، التعليم من أجل التنمية المستدامة، استبانة المعرفة والمواقف والممارسات (KAP)، معلمو العلوم، التصورات

1. Introduction

The integration of artificial intelligence (AI) into education has been speeding up, powered by innovations in technology and an increasing focus on sustainability in its three pillars economy, environment and society (Javkhedkar, S. R., Shrugarkar, A., & Kulkarni, A. P. 2023). The shift toward a future green planet involves that we all gain insights to live and pursue a career in sustainable practices. Worth mentioning that teacher Professional development and learning is essential for advancement and sustainability in our teaching and learning systems (Mulà, I., & Tilbury, D. 2023). This merging of AI into sustainable education practices holds both notable opportunities and significant challenges. As for the opportunities, it includes using AI to facilitate support to analyze complex environmental data, personalizing learning experiences targeted on sustainability topics and boosting school resource usage, for example water and energy. Add to this, AI can help make learning more engaging and designed to individual student needs, potentially fostering a deeper understanding of ecological and social problems. in addition, it can benefit teachers by developing experiments, collecting and analyzing data, highlighting new ideas for their classes, and expanding their knowledge opportunities. As for students, they can help them understand advanced ideas and concepts and widen their knowledge through self-teaching, an important skill in the 21st century. (Su & Yang, 2023) While for Key challenges involve ensuring equitable access to AI technologies to avoid widening the digital divide (Directory, 2025b). Moreover, the training of educators and learners is Effective in the usage of AI in education is essential to attaining certain sustainable development objectives and goals through (Isidori et al., 2024).

Artificial Intelligence technology is Spreading worldwide, leading to strong statement: "[AI] is going to change the world more than anything in the history of mankind", "it is more profound than even electricity or fire" (Toosi, et al., 2021). Defining AI is not simple; in fact, there is no generally accepted definition of the idea. Many different definitions are used, and this can easily lead to Uncertainty. (Russell & Norvig 2021). the term of AI is Designed by emeritus Stanford Professor John McCarthy in the summer of 1955, was defined by him as "the science and engineering of making intelligent machines". Much research has humans program machines to act in a smart way for example playing chess, but, today, we put focus on machines that can learn, At a minimum somewhat like human beings do (Manning, 2020). Over the past few decades (since the 1950s), artificial intelligence (AI) has gained revolutionary Focus and is seen as one of the Stimuli of the fourth industrial revolution

(Quiang, 2018). Marvin Minsky, who pioneered artificial intelligence, defined AI as “the science of making machines do things that would require intelligence if done by men “Minsky, M. L. (1969).

AI tools such as (ChatGPT, Gemini, copilot,) and technologies (machine learning, robotics, deep learning,) contribute to enhance educational outcomes by removing obstacles to educational equity and assisting lifelong learning and to the broader pillars of sustainability—economic, social, and environmental (AlSagri, H. S., & Sohail, S. 2024). AI is recognized as a powerful catalyst for change in education, significantly altering methods of knowledge delivery and acquisition. On the one hand, the integration of AI by educators enables a shift from traditional one-size-fits-all approaches to personalized and interactive learning experiences for students (Bawaneh, A. K.2025). Recently, organizations such as UNESCO (2019a,2019b) and the World Economic Forum (2020) have highlighted the importance of using AI for sustainable development. In 2019, two UNESCO conferences were named AI for Sustainable Development and International Conference on AI and Education: Planning Education in the AI Era: Lead the Leap (Ally, M., & Perris, K. 2022). Also, this Incorporation in science education marks a turning point in addressing global challenges within the framework of the 17 Sustainable Development Goals (SDGs) adopted by the United Nations in the Sustainable Development 2030 Agenda which includes 17 SDGs and 169 targets, specifically, within SDG4 (Quality Education) (AlSagri& Sohail, 2024, United Nations, 2015). SDG4 on education intend to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all” (Tonegawa, 2022).

AI in education for sustainable development (ESD) is above just a database of knowledge and applications associated with society, environment and the economy. It also incorporates training, increasing Degrees of awareness, learning skills, currents and ethics that lead and inspire people to explore diverse viewpoints. (Vinuesa et al., 2020). Elhajji et al. (2020) mentioned that education for sustainable development is teaching a broad and transformative potential that examines the contents and outcomes of learning, the teaching approach, and the learning environment; it accomplishes its aim by reforming society. Education empowers citizens of a country to deal address challenges, inequality, economy, natural heritage, culture, and society. AI in education prepares individuals for the future and enables education for everyone everywhere. AI in education has various features that allow it to attain sustainable development since it is based on four basic pillars: knowledge, living, passing on knowledge, and working. It is developed to keep pace with the change nature of sustainable

development; address issues built on the concept of teamwork and enhance the quality of life to reach sustainable development.

It is certain that AI technologies and tools have the power to Profoundly redefine our community and economy. AI provides both beneficial advantages (improved performance and efficiency in several duties and new career paths) and critical threats (the spread of false information, employment loss, moral concerns). The opportunities and risks of AI are linked, bringing up essential questions about how to maintain an equilibrium between possible benefits and harms. This balance is affected by a complex of various personal, societal, cultural and ethical considerations that guide people's attitudes towards AI technology. Importantly, understanding these attitudes and their causes is important for the further development and sustainable integration of AI in work and education (Pokrivcakova, S. 2023).

In 2018 a study examines the effects of AI teaching systems on students' environmental knowledge and attitudes, it didn't highlight on science teachers' attitudes toward AI (Huang, 2018), However, in 2023, the first article was published that directly addresses science teachers' attitudes toward using AI in science education—potentially including sustainability contexts, (Darayseh, A. A. 2023). In 2023, a study was conducted in Slovenia where it determines the level of knowledge and dominant attitudes of Pre-service teachers toward AI and its integration into EFL teaching and learning (Pokrivcakova, S. 2023). Surveys conducted internationally have found generally positive attitudes of science teachers towards AI and its implication in education and its role in sustainable development. Where as in Lebanon ,such research remains scarce, where it is primarily concentrated in medical schools due to AI's perceived potential in the medical field (Kharroubi, S. A., Tannir, I., Abu El Hassan, R., & Ballout, R. 2024).This paper aims to fill this gap in educational research knowledge in Lebanon, as knowing teachers' s attitudes towards AI in addition to their knowledge and practices, which can be a key factor in the success or failure of applying AI in education for sustainability which is a necessity as recommended by UNESCO.

In this research, we'll try to determine how the integration of AI impacts science teachers in the educational process, to answer the following questions: What are the perceptions of science teachers toward the use of AI tools / technologies in education for sustainable development?

What are the challenges that science teachers face in private and public- schools?

Therefore, the main goals of this study to explore the perceptions (KAPs levels) of science teachers (biology, chemistry, physics, science) in Lebanon regarding the use of AI tools / technologies in educational process and its role in promoting sustainable development.

We believe results will show, at the end of this research, that science teachers have a positive attitude toward using AI tools / technologies in sustainability. Most teachers will think that AI facilitates the learning process, but some training should be available and resources.

2. Methodology

2.1. Research design.

The type of research design is descriptive research design as the perceptions of science teachers are gathered toward the use of AI tools / technologies in education for sustainability.

The study employs a cross-sectional approach, where data is collected at a single point in time, mid-April 2025. The study is quantitative and adopts a close-ended Likert scale survey as the research tool.

2.2. Participants

A total of 99 science teachers (biology, chemistry, physics) from private and public schools all over Lebanon participated in the online survey.

2.3. Research tool

Data is collected through KAP survey (knowledge, attitude and practices) which is widely accepted in health sciences. The KAP survey was developed by the researcher based on a review of the available literature for research in education and teacher training.

KAP surveys are quantitative methods where information is collected via "predefined questions formatted in standardized questionnaires that provide access to quantitative and qualitative information (The Kap Survey Model - Knowledge Attitude and Practices - Médecins Du Monde, 2023). They aim "to elicit what is known (knowledge), believed (attitude), and done (practiced) in the context of the topic of interest" (Andrade et al., 2020). In addition, KAP surveys "reveal misconceptions of misunderstandings that may represent obstacles to the activities and potential barriers to behavior change" (The Kap Survey Model - Knowledge Attitude and Practices - Médecins Du Monde, 2023).

The KAP survey's reliability and validity was measured with Cronbach's alpha, which is valued as 0.754, indicative of a high internal consistency and then evaluated by two independent experts in educational research.

2.4 Survey format

The KAP survey consists of 20 items, 2 open ended questions and 18 closed-ended items as 4-points Likert scales which provided four answers: strongly disagree, disagree, agree and strongly agree. The items elicit responses for 4 categories: knowledge (6 questions), attitudes – benefits, attitudes – risks (6 questions), and practice of AI (6 questions) in education for sustainability.

It was divided into five sections. The initial section encompassed questions regarding respondents' sociodemographic attributes such as age, sex, and major, type of school, subject. The second section focused on the respondents' basic knowledge of AI. The next section included questions on the respondents' attitudes toward the role and implementation of AI in their teaching. The fourth section included questions on science teachers' practices of AI on education for sustainable development. The last section included open-ended questions to identify advantages of AI and potential challenges that may prevent science teachers from implementing AI. A pilot study was carried out on 10 science teachers to assess the clarity of the questionnaire. However, the data gathered during this pilot testing phase was not incorporated into the analysis.

2.5. Data collection

The survey link (in google forms) was sent out via several social media platforms such as WhatsApp, Telegram, and Facebook. Once science teachers read the consent, they began completing the survey which took approximately 5 min. Participation was completely anonymous and voluntary.

2.6. Data analysis

The questionnaire is studied through statistical descriptive analysis, using Statistical Package for the Social Sciences (IBM SPSS 27.0), according to the previously mentioned axes of analysis. For continuous variables, descriptive statistics, whereas for categorical variables, it included frequencies and percentages.

2.7. Ethics and limitations

The study adheres to ethical guidelines outlined by the Lebanese University and academic institutions; informed consent is obtained from all participants, and they were assured of confidentiality and anonymity. Data is stored securely and accessible only to authorized researchers.

Regarding limitations, although our research was designed to reflect the opinion of a large group of science teachers in cycle 2,3 and 4 in public and private schools in Lebanon, we should still consider that our sample was not big enough. Hence the results may not be applicable to all science teachers' perceptions.

3. Results

3.1. Sociodemographic Characteristics of Participants

Table 1 presents the sociodemographic characteristics of the participants. Results showed that the higher percentage of participants were females (80.2%), and half of the respondents were between 25 and 35 years old (51.1%), and. The higher frequency of the teachers who responded to the survey were biology and chemistry teachers. Regarding the level of experience, about half of the teachers (51.5%) had 6-10 years of experience in teaching. The study sample comprised teachers from public (47.5%) and private schools (44.4%). Almost more than half of the science teachers were pursuing a master's degree (58.6%). As for the address, most of the science teachers participated were from south Lebanon (41.1%).

Table 1. Sociodemographic characteristics of participants (n = 99)

Characteristics	n (%)	
Gender	Male	19 (19.2%)
	Female	80 (80.2%)
Age	Under 25	9 (9.1%)
	25-35	51 (51.1%)
	36-45	25(25.1%)
	46-55	12 (12.1%)
	55+	2(2%)

Subject	Biology	46 (46.5%)
	Chemistry	43 (43.4%)
	Physics	25 (25.3%)
	Science	23 (23.2%)
Level of experience	0-5	9 (9.1%)
	6-10	51 (51.5%)
	11-15	25 (25.3%)
	More than 15	12 (12.2%)
Type of school	Public	47 (47.5%)
	Private	44 (44.4 %)
	Both	8 (8.1%)
Cycle	2	36 (36.4%)
	3	72 (72.7%)
	4	25 (25.3%)
Educational Level	Bachelor	35 (35.4%)
	Master	58 (58.6%)
	PHD	6 (6.1%)
Adress	Beirut	16 (16.2%)
	Mount Lebanon	18(18.2%)
	North Lebanon	10 (10.1%)
	Bekaa	7 (7.1%)
	South Lebanon	41 (41.1%)
	Nabatiyeh	7 (7.1%)

3.2. Basic AI Knowledge

Table 2 summarizes the basic AI knowledge of science teachers. The majority (78.8%) of the participants knew what AI is. Most of them (85.8%) can combine science and AI technology to teach sustainability concepts, and the majority (83.4%) agreed about the importance of educational institutions to provide AI-related professional development (funding, collaboration with AI experts). Whereas 75.5% agreed that AI integration requires training programs and professional development.

Table 2. Questions related to science teachers' AI knowledge

Question	Disagree	Agree
You feel prepared to integrate AI into your science teaching	15 (15.1%)	84 (84.9%)
You can combine science and AI technology to teach sustainability concept.	14 (14.1%)	85 (85.8%)
AI integration requires training programs and professional development	4 (4%)	75 (75.9%)
It is important for educational institutions to provide AI-related professional development (funding, collaboration with AI experts)	4(4%)	95(95.5%)
As a science teacher you feel confident in using AI tools/technologies in your science teaching	14(14.1%)	85 (85.8%)
You are familiar with the concept of AI in education	21 (21.3%)	78 (78.8%)

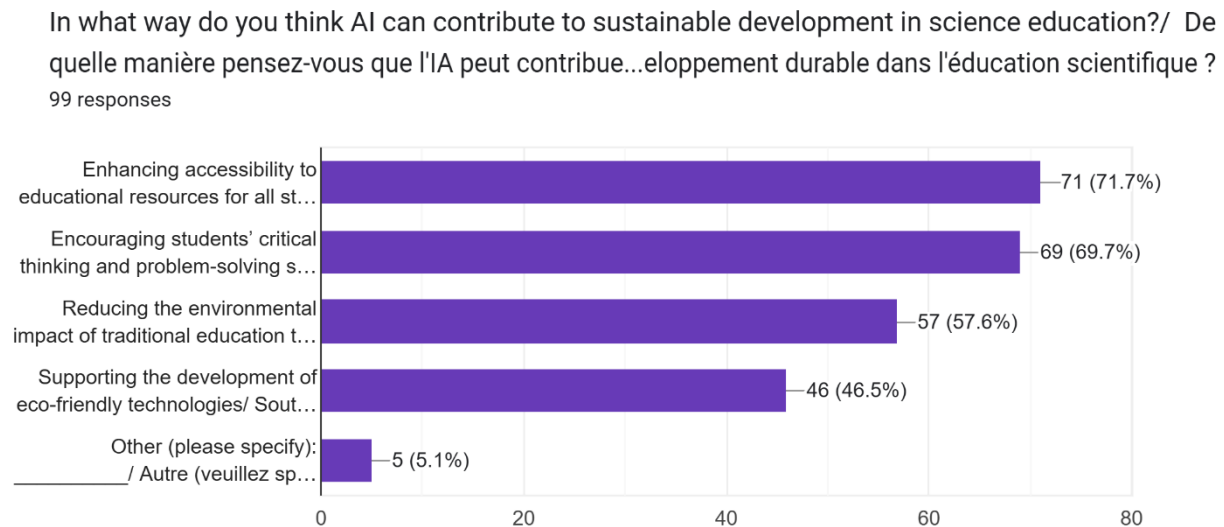
3.3. Attitude toward AI

Table 3 summarizes science teachers' attitude toward the implementation of AI in their education for sustainability. About 87.9% of the participants agreed that AI tools- technologies can promote sustainability in science education were in favor of implementing AI in their field. Also (88.9%) saw that it is important for teachers to integrate AI tools to teach sustainability concepts in science. Whereas (88.9%) agreed that the role of AI is very effective in enhancing student engagement and learning outcomes in science education. Moreover, more than 90% of the participants saw that AI can personalize learning experiences for students in science education, about 94.9 % of the science teachers were in favor of using AI tools in complex scientific inquiries related to sustainable development. Regarding the question of the contribution of AI in science education, about more than half of the teachers answer about enhancing accessibility to educational resources for all students, encouraging students' critical thinking and problem-solving skills, reducing the environmental impact of traditional education tools (e.g., paper, lab chemicals), supporting the development of eco-friendly technologies.

Table 3. Questions related to science teachers' AI attitudes

Question	disagree	Agree
AI tools- technologies can promote sustainability in science education	12 (12.2%)	87 (87.9%)
It is important for teachers to integrate AI tools to teach sustainability concepts in science	11 (11.1%)	88 (88.9%)
The role of AI is very effective in enhancing student engagement and learning outcomes in science education	11(11.1%)	88 (88.9%)
AI can personalize learning experiences for students in science education	8 (8%)	91 (91.9%)
AI tools can facilitate complex scientific inquiries related to sustainable development	5 (5%)	94(94.9%)

Figure 1. Science teachers answer to contribution of AI in sustainable development



3.4. AI Practices

Table 4 summarizes some AI practices among science teachers. Only 25.3% of the participants have received any training on the use of AI tools. about 56.6% of the teachers used AI-based tools or technologies in their Education for sustainability. Regarding the selection of AI tool/technologies

82.9% of science teachers agreed they can select the appropriate tool. Furthermore, approximately equal percentage were for the challenges such as Lack of training or knowledge about AI tools, Insufficient resources or funding for AI tools/, Lack of student access to necessary technology (e.g., computers, internet. However, 53.3% of the participants use AI-powered simulations or virtual labs and about 28.3 % use chatbots like ChatGPT, Gemini, copilot).

Table 4. Questions related to science teachers' AI practices

Questions	Yes	No
Have you received any training on the use of AI tools	25 (25.3%)	74(74.7%)
Have you used AI-based tools or technologies in your Education for sustainability?	56(56.6%)	43 (43.4%)

Figure 2. Science teachers answer to selection of AI tool

You can select AI tools and technologies to enhance teaching sustainability in science education/
 Vous pouvez sélectionner des outils et technologies...ment de la durabilité dans l'éducation scientifique
 99 responses

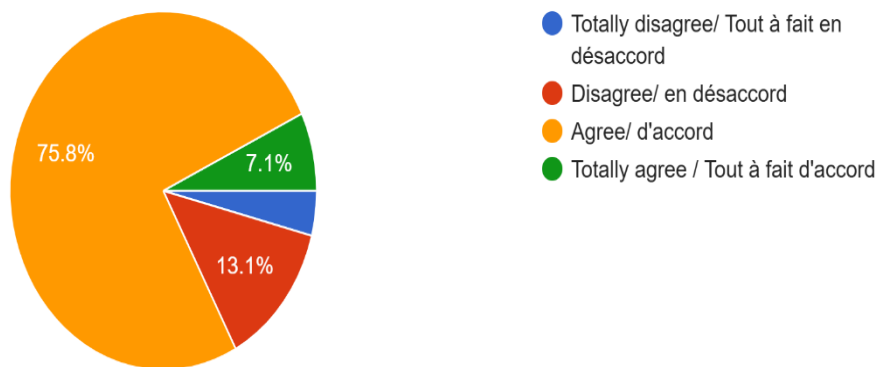


Figure 3. Science teachers answer to of AI tool familiar with

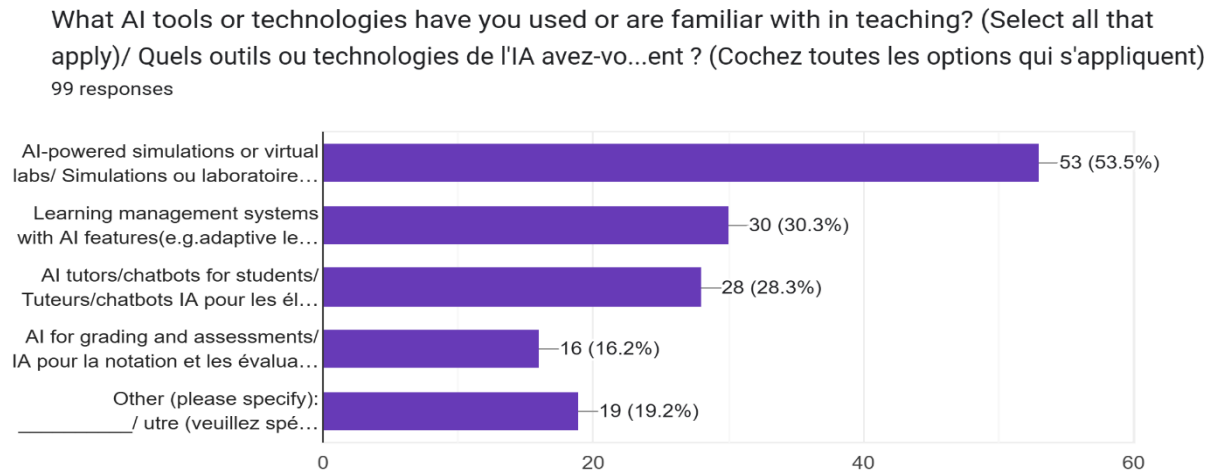
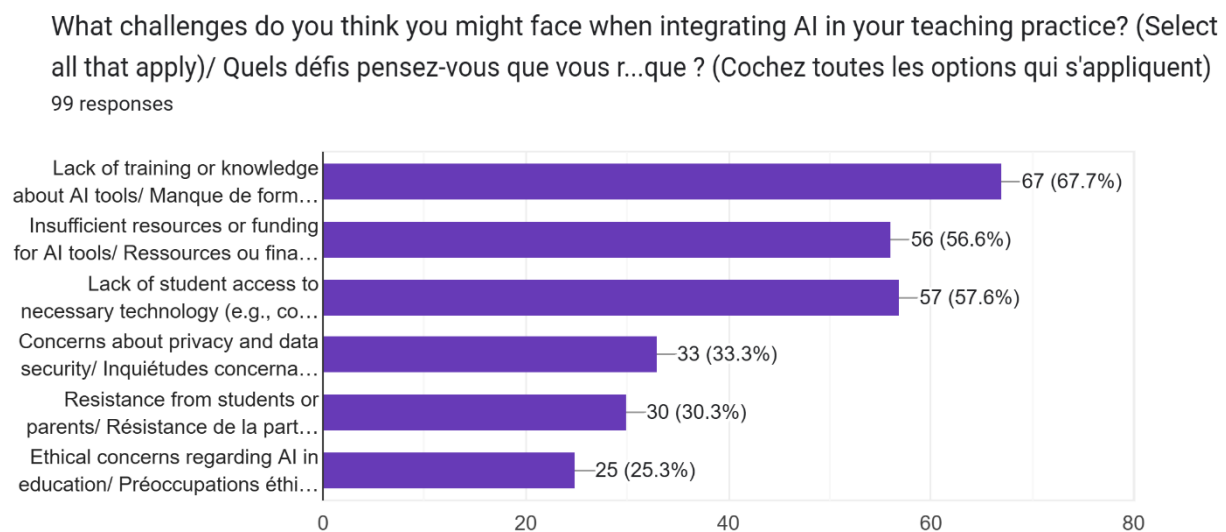


Figure 4. Science teachers answer to challenges they face in integration of AI in sustainability



2.5 open ended questions

Most respondents mentioned that the challenges they face are lack of training and resources. However, the benefits, personalized learning, Improved engagement and motivation, saving time and enhancing productivity.

4. Discussion

The findings from this study revealed moderate levels of knowledge regarding AI among the survey participants. About 78.7% of the science teachers stated that they understood the term “artificial intelligence”, and the majority (83.4%) agreed about the importance of educational institutions to provide AI-related professional development (funding, collaboration with AI experts). Whereas 75.5% agreed that AI integration requires training programs and professional development. Considering that knowledge about AI is difficult to assess due to the progressive advancement of new technologies and their expanding tools, similar findings were reported in the study by Lin et al. (2022) and Al-Muqbil (2024) where the training programs incorporates AI and higher-order thinking skills, thereby improving teachers ‘thinking capabilities and promoting the transfer of these skills to their students.

Regarding their attitude toward AI science teachers, they expressed positive attitudes towards AI, which aligns with the findings of several studies that explore attitudes towards AI across various samples and communities. Those beliefs were shared with other studies where science teachers exhibit a positive attitude toward using AI in sustainability and for personalized learning, allowing students to obtain support as study and improving learning outcomes in Chile and Italy a (Silva Alé, 2024, Isidori, M. V., Muccini, H., Santelli, A., & Evangelista, C. 2024, Vinkóczy et al. 2023). And as the results in the comprehensive study done across the US, UK, Germany, and Switzerland revealed that many scholars hold a favorable view of AI, recognizing it as a tool with the potential to bring transformative benefits across various fields. These scholars emphasize the importance of trustworthy AI principles and highlight AI's potential to transform everyday life by enhancing efficiency and encouraging creativity (Gerlich, 2023). Also, A study on clinical researchers in Saudi Arabia, Sulthan, (2022) concluded that most researchers had a good attitude towards the use of AI in clinical trials, despite their relatively limited knowledge of AI and its uses.

Regarding the question of the contribution of AI in science education , about more than half of the teachers answer about Enhancing accessibility to educational resources for all students, encouraging students’ critical thinking and problem-solving skills, Reducing the environmental impact of traditional education tools , Supporting the development of eco-friendly technologies as in chapter 16 in a book “The Role of Sustainability and Artificial Intelligence in Education Improvement” (Harish et al., 2023) and as in study in Slovenia ,(Savec, V. F., & Jedrinović, S. 2024).

When it comes to practices of science teachers' high percentage of teachers uses AI in their sustainable education, as study made in Jordan in which the researchers concluded that integrating AI has become a necessity rather than an option (Bawaneh, A. K. 2025).

These findings revealed that some challenges face science teachers like initial technological learning curves and resource limitations, the same as findings in were observed in a study performed in Arab emirates by (Alneyadi et al., 2024) also another study in Mindanao shows a significant barriers like limited technological infrastructure, insufficient training, and ethical concerns related to plagiarism and over-reliance on automation (Mangubat & Paglinawan, 2025).

And for the teachers who received any training on the use of AI tools /technologies in their educational practices, only 25.3% received training in AI. Regarding the question about the challenges that face science teachers most of the teachers mentioned the lack of training and infrastructure in schools which is the same as in Chile in which the study found the need to provide additional support and specific training to overcome barriers to the successful adoption of these technologies in science education. (Silva Alé, 2024).

In response to these challenges, and for the importance of AI in education for sustainability, UNESCO, many universities like (Manchester metropolitan university, AUS, university of Edinburgh, and the open university) support the Codesigns ESD AI Coach. The Codesigns ESD AI Coach facilitates the implementation of Education for Sustainable Development (ESD) training across universities and educational institutions by Integrating SDGs and Sustainability Competencies in the Curriculum, Crafting ESD-Focused Teaching and Assessment Strategies, Invigorating the Classroom with ESD Games (*Key Features*, 2025).

And within the framework of the Beijing Consensus, UNESCO developed Artificial intelligence and education: Guidance for policy-makers to foster the readiness of education policy-makers in artificial intelligence, and It seeks to create a shared understanding of the opportunities and challenges that AI offers for education, as well as its impact on the core competencies required in the era of AI. UNESCO also released AI competency frameworks for teachers and students to guide countries in supporting students and teachers to understand the potential as well as risks of AI(*Artificial Intelligence in Education*, 2025).

5. Conclusion

The study revealed a positive attitude towards AI among science teachers in public and private schools in Lebanon, with the majority actively incorporating AI into their education for sustainable education. Participants reported receiving limited formal training, and they all expressed a strong belief that targeted investment and training in infrastructure are essential for their careers. Notably, most participants didn't receive training in AI and possess basic knowledge of AI. By addressing these challenges and opportunities, educational institutions and policymakers can better prepare the science teachers to deal with the complexities of an AI-driven world. Moreover, the urgent need to address global environmental issues like climate change and the rapid adoption of AI in education, places both at the heart of how we learn and teach. Therefore, it is crucial to implement measures that include preparing the necessary infrastructure and providing services that support this integration, while also building the capacity of educators, including teachers and supervisors, on how to effectively use AI in a way that adds value and attains educational goals.

In conclusion, AI and sustainability are central pillars in reshaping education worldwide. AI can enhance sustainable education by promoting the use of efficient resources, lifelong learning opportunities and personalized learning. To realize this potential, targeted investment and training in infrastructure are essential within educational institutions and schools to keep pace with the rapid development of AI tools and technologies.

References

- Alkhayyal, B., Labib, W., Alsulaiman, T., & Abdelhadi, A. (2019). Analyzing Sustainability Awareness among Higher Education Faculty Members: A Case Study in Saudi Arabia. *Sustainability*, 11(23), 6837. <https://doi.org/10.3390/su11236837>
- Ally, M., & Perris, K. (2022). Artificial intelligence in the Fourth Industrial Revolution to educate for sustainable development. *Canadian Journal of Learning and Technology*, 48(4). <https://doi.org/10.21432/cjlt28287>
- Al-Muqbil, N. S. M. (2024). The Impact of an Artificial Intelligence Application-Based Training Program on Developing Sustainable Thinking among High School Biology Teachers. *EBSCOhost*. <https://doi.org/10.12738/jestp.2024.1.016>
- Alneyadi, S. S., Almessabi, A. A., & Alshraifin, N. (2024). Exploring Science Teachers' Perceptions and Practices in Integrating STEM and AI Through Mind Mapping: A Case Study in the UAE. *Journal of Eco humanism*. <https://doi.org/10.62754/joe.v3i3.3434>
- AlSagri, H. S., & Sohail, S. S. (2024). Evaluating the role of Artificial Intelligence in sustainable development goals with an emphasis on "quality education." *Discover Sustainability*, 5(1). <https://doi.org/10.1007/s43621-024-00682-9>
- Andrade, C., Menon, V., Ameen, S., & Praharaj, S. K. (2020). Designing and conducting knowledge, attitude, and practice surveys in Psychiatry: Practical Guidance. *Indian Journal of Psychological Medicine*, 42(5), 478–481. <https://doi.org/10.1177/0253717620946111>
- Artificial intelligence in education*. (2025, April 15). UNESCO. <https://www.unesco.org/en/digital-education/artificial-intelligence>
- Bawaneh, A. K. (2025). AI Shaping the Future of Education: Science and Math Teachers' Satisfaction Level and Motivating Factors towards Integrating Artificial Intelligence in Teaching and Learning. *International Journal of Information and Education Technology*, 15(3), 496–509. <https://doi.org/10.18178/ijiet.2025.15.3.2261>
- Darayseh, A. A. (2023). Acceptance of artificial intelligence in teaching science: Science teachers' perspective. *Computers and Education Artificial Intelligence*, 4, 100132. <https://doi.org/10.1016/j.caeai.2023.100132>
- Elhajji, M., Alsayyari, A. S., & Alblawi, A. (2020, March). Towards an artificial intelligence strategy for higher education in Saudi Arabia. In *2020 3rd International Conference on Computer Applications & Information Security (ICCAIS)* (pp. 1-7). IEEE.
- Gerlich, M. (2023). Perceptions and acceptance of Artificial Intelligence: A multi-dimensional study. *Social Sciences*, 12(9), 502. <https://doi.org/10.3390/socsci12090502>
- Harish, V., Sharma, R., Rana, G., & Nayyar, A. (2023). Artificial intelligence in sustainable education. In Chapman and Hall/CRC eBooks (pp. 219–236). <https://doi.org/10.1201/9781003425779-1>

- Huang, S. (2018). Effects of using artificial intelligence teaching systems for environmental Education on environmental knowledge and attitude. *Eurasia Journal of Mathematics Science and Technology Education*, 14(7). <https://doi.org/10.29333/ejmste/91248>
- Isidori, M. V., Muccini, H., Santelli, A., & Evangelista, C. (2024). Education and training for sustainability. Towards Artificial Intelligence: an exploratory investigation on teachers. *From re-Open Journal per la formazione in rete*, 24(1), 294-300.
- Javkhedkar, S. R., Shrugarkar, A., & Kulkarni, A. P. (2024). The impact of artificial intelligence on current education System: a case study. *International Journal of Research Publication and Reviews*, 4742–4746. <https://doi.org/10.55248/gengpi.5.0624.1573>
- Key features. (2025, April 3). CoDesignS ESD AI COACH. <https://esd-ai.coach/key-features/>
- Kharroubi, S. A., Tannir, I., Abu El Hassan, R., & Ballout, R. (2024). Knowledge, Attitude, and Practices toward Artificial Intelligence among University Students in Lebanon. *Education Sciences*, 14(8), 863.
- Mangubat, J. P. L., & Paglinawan, J. L. (2025). Teachers' perceptions on the use of artificial intelligence tools in teaching science research. *International Journal of Research and Innovation in Applied Science*, X(V), 169–174. <https://doi.org/10.51584/ijrias.2025.100500016>
- Manning, C. (2020). Artificial intelligence definitions. *HAI Stanford Univ*, (September), 1.
- Minsky, M. L. (1969). *Semantic information processing*. The MIT Press.
- Mulà, I., & Tilbury, D. (2023). *Teacher education for the green transition and sustainable development*. Publications Office of the European Union.
- Pokrivcakova, S. (2023). Pre-service teachers' attitudes towards artificial intelligence and its integration into EFL teaching and learning. *Journal of Language and Cultural Education*, 11(3), 100-114.
- Russell, S. J., & Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Hoboken: Pearson.
- Savec, V. F., & Jedrinović, S. (2024). The Role of AI Implementation in Higher Education in Achieving the Sustainable Development Goals: A Case Study from Slovenia. *Sustainability*, 17(1), 183. <https://doi.org/10.3390/su17010183>
- Silva Alé, J. A. (2024). Integrating Machine Learning for the Continuing Education of Science Teachers. *Journal of Information and Systems Management*, 14(2), 82–89. <https://doi.org/10.6025/jism/2024/14/2/82-89>
- Su, J., & Yang, W. (2023). Unlocking the Power of ChatGPT: A Framework for Applying Generative AI in Education. *ECNU Review of Education*, 6(3)
- Sulthan, N., & Navas, S. (2022). Knowledge and attitude of Artificial Intelligence (AI) technology among clinical researchers in the Kingdom of Saudi Arabia. *International Journal of Health Sciences*, 5937–5947. <https://doi.org/10.53730/ijhs.v6ns4.9513>

- The Kap survey model - knowledge attitude and practices - Médecins du Monde.* (2023, October 10). Médecins Du Monde. <https://www.medecinsdumonde.org/en/publication/the-kap-survey-model-knowledge-attitude-and-practices/>
- Tonegawa, Y. (2022). Education in SDGs: What is Inclusive and Equitable Quality Education? In *Sustainable development goals series* (pp. 55–70). https://doi.org/10.1007/978-981-19-4859-6_4
- Toosi, A., Bottino, A. G., Saboury, B., Siegel, E., & Rahmim, A. (2021). A brief history of AI: how to prevent another winter (a critical review). *PET clinics*, 16(4), 449-469.
- UnescoPhysicalDocument.* (n.d.). UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000366994>
- United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. <https://sustainabledevelopment.un.org/post2015/transformingourworld>.
- View of Education and training for sustainability. Towards Artificial Intelligence: an exploratory investigation on teachers.* | *Form@re - Open Journal per la formazione in rete.* (n.d.). <https://oaj.fupress.net/index.php/formare/article/view/15452/12931>
- Vinkóczy, T., Koltai, J. P., Nagy, N. G., Szabó-Szentgróti, E., & Szabó-Szentgróti, G. (2023). The Sustainable contribution of Artificial intelligence to higher Education - results of a pilot study. *www.cetjournal.it*. <https://doi.org/10.3303/CET23107082>
- Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., ... & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature communications*, 11(1), 233.
- Zawiah, M., Al-Ashwal, F., Gharaibeh, L., Farha, R. A., Alzoubi, K., Hammour, K. A., Qasim, Q. A., & Abrah, F. (2023). ChatGPT and Clinical Training: Perception, concerns, and practice of Pharm-D students. *Journal of Multidisciplinary Healthcare, Volume 16*, 4099–4110. <https://doi.org/10.2147/jmdh.s439223>