TEACHERS AND AI: REVOLUTIONARY EDUCATIONAL TOOL OR LOOMING THREAT TO THE PROFESSION?

PROFESSORES E IA: FERRAMENTA EDUCACIONAL REVOLUCIONÁRIA OU AMEAÇA IMINENTE À PROFISSÃO?

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Resumo. A relação homem–máquina tem sido há muito tempo um tema controverso. Entre os defensores, alguns veem as máquinas como um meio de aliviar a carga de trabalho, simplificar a vida, aumentar a produtividade e proporcionar aos humanos mais tempo de lazer. Os pessimistas, por outro lado, enxergam as máquinas como concorrentes que continuam a ocupar seus lugares na força de trabalho. De fato, desde a invenção do computador, diversos setores passaram por mudanças profundas na gestão de muitas tarefas que foram automatizadas, resultando em perda de empregos nessas áreas. Nesse contexto, o Marrocos, que aspira tornar-se um ator emergente em tecnologias da informação e comunicação e um polo atraente para investimentos tecnológicos, tem feito esforços coordenados para modernizar seus setores públicos, notadamente por meio do projeto Maroc Digital. O país também lançou uma iniciativa nacional em inteligência artificial, colocando a IA no centro de sua estratégia de transformação digital. Sob essa perspectiva, o sistema educacional marroquino é considerado um alavanca fundamental para a implementação dessas políticas, promovendo a integração da tecnologia e desenvolvendo as competências digitais das futuras gerações. Além disso, o uso da IA na educação vem ganhando importância crescente em todo o mundo. Nesse contexto, o caso do Marrocos é particularmente relevante, pois reflete os desafios enfrentados pelos sistemas educacionais em países emergentes. Portanto, é crucial examinar as percepções e os pontos de vista dos professores em relação à IA no ensino. O objetivo deste artigo é oferecer uma visão sobre a relação professor–IA, com o intuito de melhor atender às necessidades de formação dos docentes e otimizar o uso da IA no ensino de ciências da vida e da terra.

Palavras-chave: Inteligência artificial; ensino; percepções; desafios.

Abstract. The man–machine relationship has long been a controversial topic. Among supporters, some see machines as a means to lighten workloads, simplify life, increase productivity, and provide humans with more leisure time. Pessimists, on the other hand, view machines as competitors that continue to take their place in the workforce. Indeed, since the invention of the computer, various sectors have undergone profound changes in the management of many tasks that have been automated, resulting in job losses in these fields. In this context, Morocco, aspiring to become an emerging player in information and communication technologies and a hub attractive to technological investments, has been making concerted efforts to modernize its public sectors, notably through the Maroc Digital project. The country has also launched a national initiative in artificial intelligence, placing AI at the heart of its digital transformation strategy. From this perspective, the Moroccan education system is considered a key lever for implementing these policies, promoting technology integration and developing the digital skills of future generations. Moreover, the use of AI in education is gaining increasing importance worldwide. In this context, the Moroccan case is particularly relevant, as it reflects the challenges faced by education systems in emerging countries. It is therefore crucial to examine teachers' perceptions and viewpoints regarding AI in teaching. The aim of this article is to

provide insight into the teacher–AI relationship, with the goal of better addressing teachers' training needs and optimizing the use of AI in teaching life and earth sciences.

Keywords: Artificial intelligence; teaching; perceptions; challenges.

1. INTRODUCTION

Could a computer ever think and act like a human being (Turing, 2009). This hypothesis opened the field for more than one research in the domain of artificial intelligence. In this sense, and thanks to the technological development in the field of microprocessors, in 1965, Dr. Gordon Moore formulated his famous law that bears his name (Moore's Law), where he predicted an exponential evolution of computer processing power and hardware complexity (Papon, 2017).

Nowadays, according to a report published in 2019 by the Organisation for Economic Co-operation and Development (OECD), information and communication technologies (ICT), and especially the field of AI, are the sectors that generates the most profit to companies. In 2011 investment in AI did not exceed 3% of global risk capital, while in 2018 AI attracted 12% of global investment capital just in the first half of 2018 (OCDE, 2019). This technological development has led to changes that have affected all aspects of society; quality of life, work, economy, education and the environment (Plante, 2015).

In the education field, with the great development of ICT, the development of the Internet and artificial intelligence, the integration of ICT in teaching has induced profound changes in teaching time and space (presential teaching/distance teaching, synchronous or asynchronous) and in the pedagogical relationship between teacher, learner and knowledge. Precisely, ICT constitutes both teaching content and learning environments in which learners can construct and produce knowledge, also collaborate, interact, etc. (Peraya, 2012). With this in mind, artificial intelligence (AI) is being given increasing importance and shadows other ICT, in view of its potential for teaching and learning. Indeed, conventional ICT that preceded AI, such as those that provide conventional machine learning, remain completely controlled by their program (Desmet, 2006). Indeed, they present to the user a predetermined fixed learning path without the possibility of adapting to his needs during his conventional automated learning experience. In contrast, AI can improve this experience by offering the learner a more adaptive automated learning tailored to their needs, expectations, and learning progress during this experience. For Lison (2023), artificial intelligence like ChatGPT, through its ability to analyse and generate text, has pushed the boundaries of traditional learning by opening doors for more individualised learning according to the needs of each learner (Lison, 2023). In the same vein, Psyché (2019) argues that AI can play an important role in the classroom by presenting new methods of learning such as personalised learning, adaptive learning and intelligent tutoring (Psyché, 2019). Indeed, AI, as "models making machines capable of solving problems, in the sense that the resolution of these problems is not completely coded and determined a priori, but where it is the result of an original construction by the machine" (Balacheff, 1994), has had an impact not only on the act of teaching and learning, but has revolutionised all aspects of the process leading to the development of knowledge. In this sense, Ganascia (2018) points out that the scientific approach, which focuses on experimentation to verify the hypothesis, is challenged by the AI, which has the faculty to conduct experiments directly on databases (experiments in silica) giving rise to new sciences so-called e-science (Ganascia, 2018).

In this vision and with the advent of generative AI (GenAI) that has the ability to generate new content by analysing and repeating data patterns they integrate (database), the humain-machine relationship moves to another level where the learner (AI) can surpass the master (human) to generate text, images, videos and even music (Holmes, 2023). This state of affairs has given rise to new social expectations of AI as well as it has generated fears about the future

of the human-machine relationship. Certainly, towards technology in general and AI in particular, two points of view must be taken into account: the first postulates that technology determines the effects, positive or negative, it induces in society, thus its impacts on society will induce societal changes. The second argues that since technology is a social construct (socioconstructivism), and is therefore determined by social relations, it is only an instrument at the service of society, technological development will reflect societal evolution. While the two previous current view the technology-society relationship within a framework of causality, the relations between technology and society are more complex, as Valenduc says in his book Technology a Game of Society: "the relation between technology and society are more than cause and effect relationships, in one way or the other. The dilemma of technological determinism and social constructivism must be formulated in a more nuanced way: to what extent can technology shape society and to what extent can society shape technology? "(Valenduc, 2005)

In this perspective, the AI- society relationship is not limited to the duality of cause and effect but goes beyond to reflect a certain co-evolution of society and AI, thus society will influence the development of AI and in turn, the latter will induce societal changes that will lead to its evolution; thus, the loop will be closed like the image of the serpent biting its tail.

Certainly, the implications of AI in education will not have the same repercussions as those of its application in the health or the economy domain, and even if the challenge of AI in education is not to take the place of the teacher (Balacheff, 1994; Emprin, 2023), AI raises more than one question, especially in relation to ethics. Thus, giving AI access to a database, containing information on the learning of future generations, the potential of each learner, would be a double-edged sword, if poorly exploited, will have enormous repercussions on the future citizen's professional life, becoming a means of selection and control, thus exacerbating social inequalities. That said, it is important to clarify that the choice of Morocco as the research context is not based solely on institutional or logistical considerations. Rather, it is grounded in a specific national context characterized by a stated ambition to position the country as a technological hub at the African level, particularly through public policies that promote digital transformation and the integration of emerging technologies across various sectors, including education. Within this framework, the Moroccan school system represents a central institutional space for preparing future generations to face the social, economic, and technological transformations driven by artificial intelligence. Teachers occupy a strategic position as key actors in the implementation of pedagogical innovations. It therefore appears relevant to examine their perceptions and representations of artificial intelligence in order to better understand the factors that facilitate or hinder the effective mobilization of this technology in teaching and learning processes. Accordingly, the choice of the Moroccan context follows a dual rationale: on the one hand, to analyze educational dynamics in a country engaged in an ambitious digital transition; and on the other hand, to generate findings that may inform educational policies and pedagogical practices in comparable contexts, particularly within countries of the Global South.

2. MATERIALS AND METHODS

The perception of a person depends directly on the perceiver's perspective on their environment (Deonna, 2006). Thus, a teacher's perception of AI stems from his perspective on the role that AI can play in his teaching practices. Consequently, determines the success or failure of any reform aiming integrating AI into the teaching-learning process. With this in mind, we wanted to highlight the perceptions and perspectives of life and earth science teachers regarding AI. Therefore, we opted for an exploratory quantitative method, where we used an online questionnaire, which proved to be a suitable data collection instrument for quantitative studies (Marchat, 2008). Indeed, this instrument allowed us to collect information without

having to distribute the questionnaire on paper, while ensuring the anonymity of the participants and saving time.

Target population: life and earth science teachers in Morocco were our target population. In order to reflect their perceptions and perspectives of AI, we targeted a sample of 250 teachers from various regional education and training academies. Our sample consisted of 47.4 % women and 52.6 % men. Regarding their teaching experience, nearly half of our sample had more than 12 years of experience, while the remaining two categories each represented almost 23 % of the sample.

Table 1. Distribution of teachers by gender and length of teaching experience (years).

	Gender		Teaching experience (years)		
	♀	♂	[0 – 6]	] 6 – 12]	12<
Percentage %	47.4	52.6	23	23.9	53.1

Data collection: we developed an online questionnaire using the Google Forms tool. For the sampling, we relied on the inspectors of life and earth sciences in Morocco, who maintain a database containing the email addresses of life and earth sciences teachers. Participants were randomly selected from this database. A total of 250 teachers were randomly chosen, to whom we sent the link to the questionnaire. The teachers in our sample were informed of the purpose of the study and assured of the anonymity of their responses, they had the choice to respond or not to our request. We received 213 responses. For this study, we aimed to explore a field that has been little studied in the Moroccan context, which places our work within the scope of quantitative research, where the minimum sample size is set at 30 statistical units (Huot, 2003).

The questionnaire includes questions based on a Likert scale and other multiple-choice questions. The questionnaire consisted of Likert scale and multiple-choice questions and was divided into four main sections:

Section 1: Teachers' experiences with AI;

Section 2: Teachers' perceptions of AI;

Section 3: Teachers' perspectives on the envisaged role of AI in teaching;

Section 4: Teachers' appreciation towards AI.

To verify the validity of our questionnaire, it was subjected to two types of validation processes:

Validation of questionnaire content: we administered it to a small sample of 8 teachers to ensure the clarity and accuracy. Following feedback from this group, some questions were revised.

Validation of the questionnaire by statistical tests: To measure the reliability (internal consistency) of the questionnaire we turned to the Cronbach's alpha test,

According to the results obtained (Table 2 and Table 3), the homogeneity of our data collection instrument appears to be satisfactory and nearly good ($0.7 < \alpha < 0.8$), indicating that the different items in the questionnaire are correlated.

Table 2. Summary of processing observations

		N	**%**
Observations	Valid	213	100.0
	Excluded[a]	0	0
	Total	213	100.0

a. Deletion based on all variables in the procedure

Table 3. Reliability statistics

Alpha Cronbach	**Number of items**

.761	13

Data analysis: we conducted descriptive analyses according to the questionnaire sections, considering both response frequencies and specificity. We used Microsoft Excel software (Microsoft Office Professional 2021, Windows). Given the exploratory nature of the study and the sample size, the statistical analyses were descriptive. More advanced inferential analyses will be considered in future research involving the experimentation of an AI-based educational digital tool in classrooms. In this study, the inferential analysis was limited to three outcomes, aiming to determine whether teachers' perceptions of AI depend on their gender, teaching experience, and familiarity with AI tools.

3. RESULTS

The identification of teachers' perceptions of AI was based on four criteria: the personal teacher experience on using AI, the advantages and challenges of using AI in teaching, the potential role of AI in teaching, and teachers' overall appreciation of AI. Due to the complexity of studying perceptions and the subtlety of the responses obtained, we chose to focus on general trends in teachers' opinions in our analysis. This approach allows us to gain a global understanding of perceptions while preserving all the information collected. Note that to avoid unnecessary redundancy, we will use "teaching" and "teachers" throughout the following text specifically to refer to teaching life and earth sciences and teachers of life and earth sciences.

3.1.Appropriation of AI tools by teachers

3.1.1. Teachers' experience with AI tools

According to the graph in Figure 1, it appears that almost one third (31 %) of our sample did not have the opportunity to use AI either in their personal or professional lives.

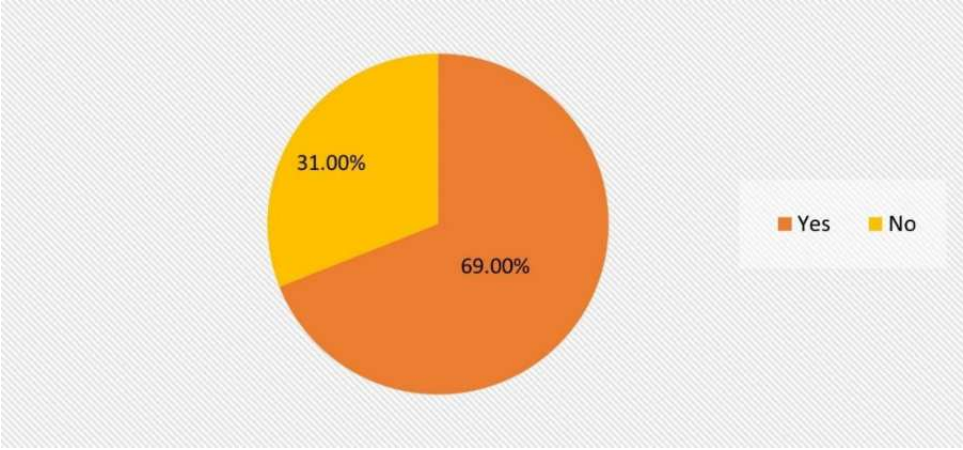


Figure 1. Use of AI technologies by teachers

3.1.2. Teachers' level of knowledge in AI

Referring to the results displayed in Figure 2, it appears that 24.4% of the surveyed teachers claim to be not at all familiar with AI. For 66.70% of teachers, they consider themselves to be slightly familiar or familiar with some basic concepts. Only a minority of 8.90% feel familiar with AI applications in different domains.

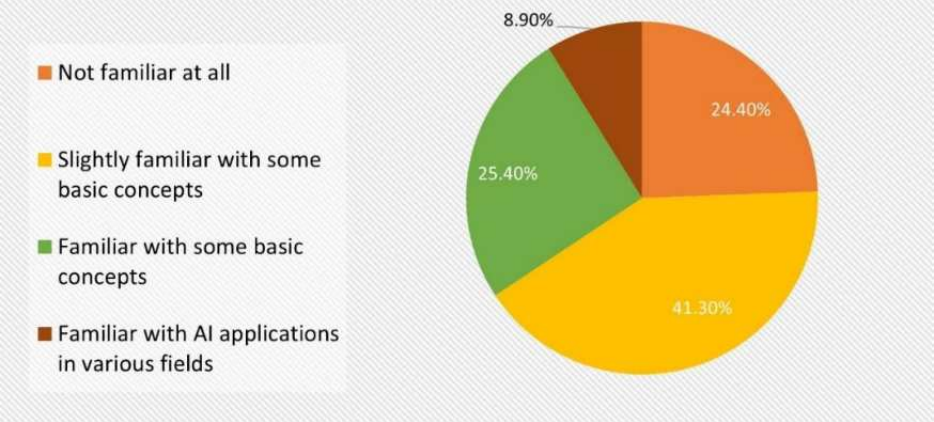


Figure 2. Teachers' familiarity with AI technologies

3.1.3. How Gender Shapes Views on the Importance of AI Technology

The data on Figure 3, demonstrates that gender does not significantly influence perceptions of this technology's importance. Both women and men show nearly identical distribution patterns across all perception levels, with statistical tests confirming no significant difference between the groups. This suggests that factors other than gender are more influential in shaping perceptions of technology importance.

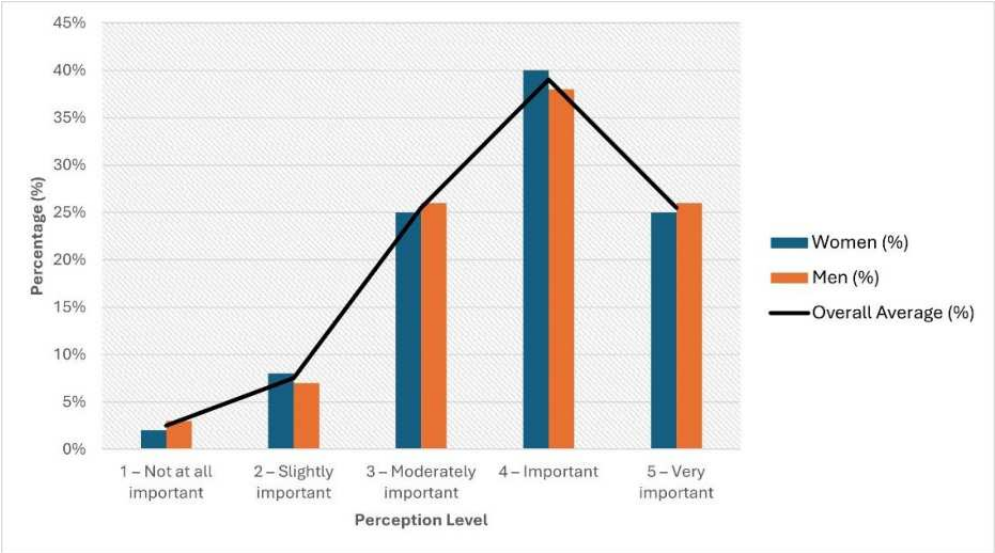


Figure 3. The Influence of gender on perceptions of AI Importance

3.1.4. Familiarity vs. Future Importance of AI

The visualization in Figure 4, provides a clear and compelling depiction of how perceptions of a technology's future importance evolve as familiarity with it increases. Among experts, who possess extensive knowledge and experience, an overwhelming 90% consider the technology to be highly important, highlighting their strong confidence in its potential impact. In contrast, beginners display a more varied perspective: 45% of them perceive the technology as having low importance, reflecting uncertainty or limited understanding of its future relevance.

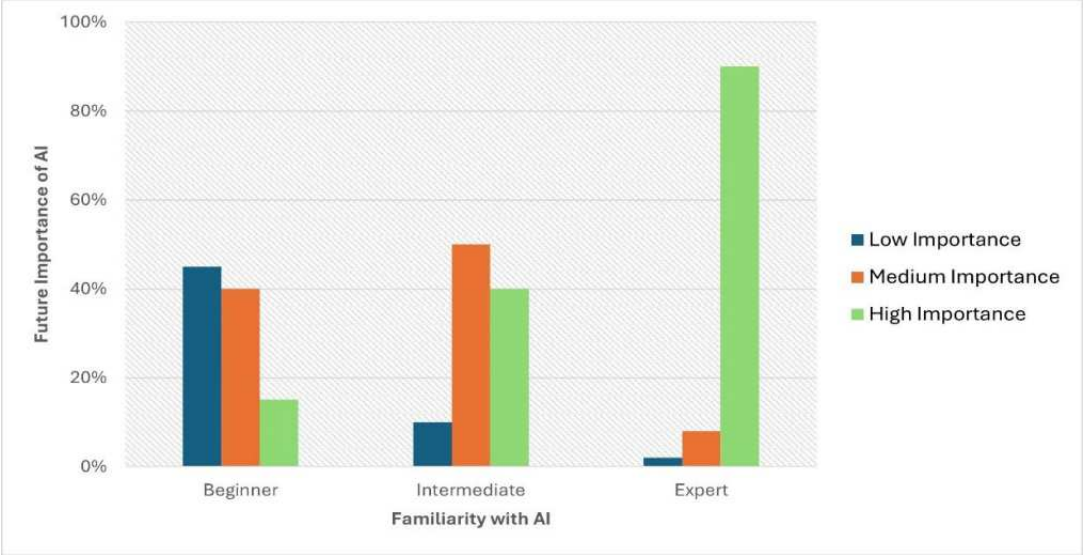


Figure 4. How familiarity shapes perceptions of AI technologies

3.2.Life and earth sciences teachers' perceptions of AI

3.2.1. Advantages of AI for improved teaching

In relation to the benefits of using AI in teaching, Figure 5 shows that the three advantages that received the most votes are: AI can provide access to a greater amount of data and resources (61.5 %), can enhance learners' motivation and engagement (59.20 %), and can create interactive and immersive learning experiences (58.70 %). However, the fact that AI can personalise learning for each learner or can provide real-time assessments and feedback are the advantages that received the least votes, with 38.50 % and 38 % of the sample respectively.

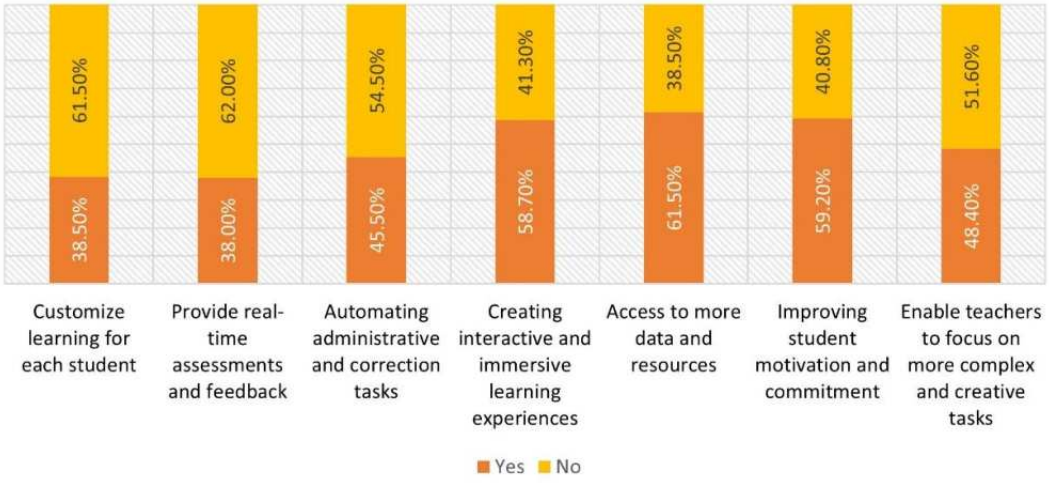


Figure 5. Benefits of AI in teaching

3.2.2. Obstacles to integrating AI in teaching

The data from Figure 6 indicates that the lack of training and support for teachers tops the list of challenges that may hinder the use of AI in teaching for (75.1 %) of our sample. This is followed by the inability of AI to replace human interaction and feedback (54.40 %) and the difficulty of integrating AI into existing curriculum plans. On the other hand, factors such as the high cost of AI technologies, AI's inability to meet the needs of learners, or data privacy and security issues are seen as potential challenges by less than 41.3 % of the sample.

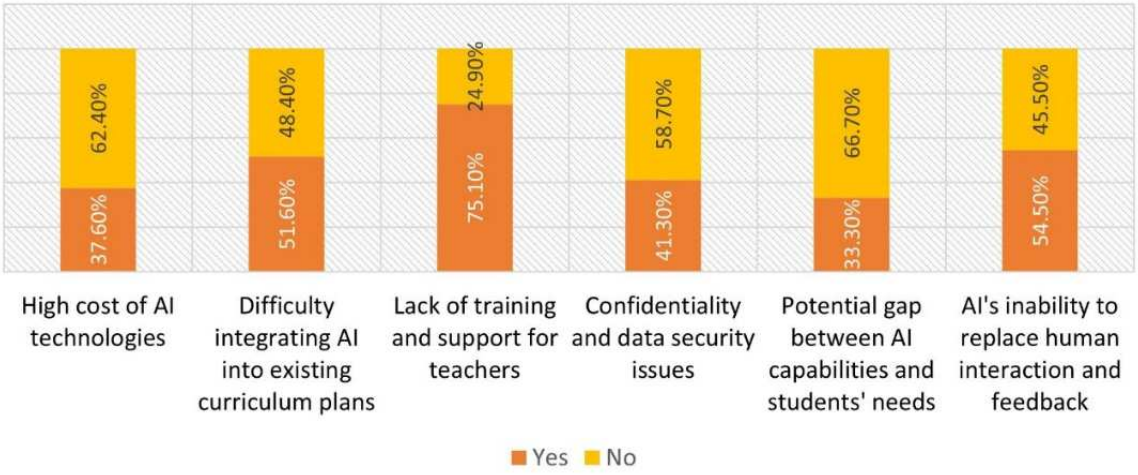


Figure 6. challenges related to the use of AI in teaching

3.3.Teachers' perspectives on the envisaged role of AI in teaching

3.3.1. Projections on the future effect of AI on teaching

The results from Figure 7 indicate that the majority of surveyed teachers are optimistic about the role AI can play in teaching. Thus, for 9.4 % of the sample, AI will be indispensable, for 52.6 % it will play a very important role, and for 34.3 % it will have a moderately important role. However, for 3.8 % of teachers, the role of AI will not be important at all.

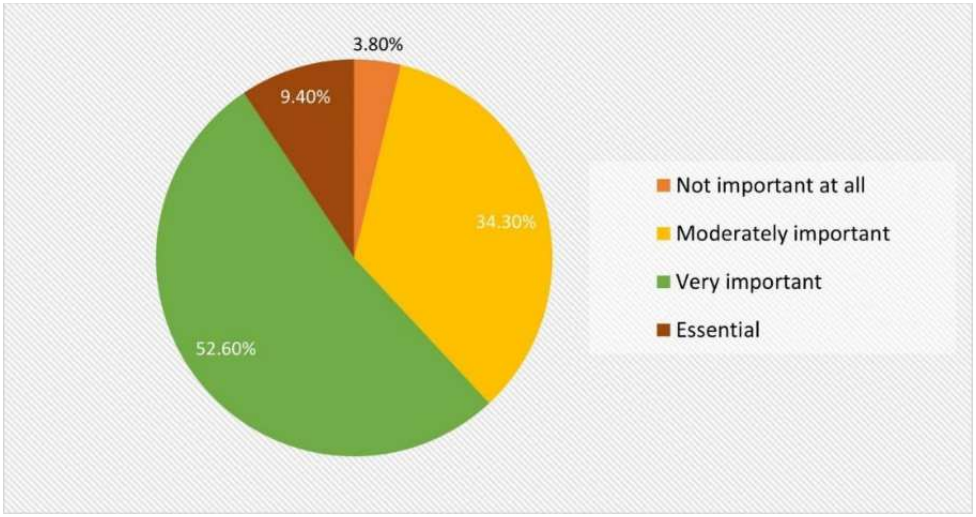


Figure 7. Importance of AI in teaching

3.3.2. Exploration of teaching functions that could be optimised by AI

According to Figure 8, one of two teachers believes that data analysis, correction and assessment of learners' work and exams, generation of personalised pedagogical content, or lesson planning are teaching tasks that can be performed by AI-based systems. However, only 30 % of teachers think that AI can assist in classroom management and communication with learners and parents, and only 15.50 % of our sample believe that AI can teach a school curriculum.

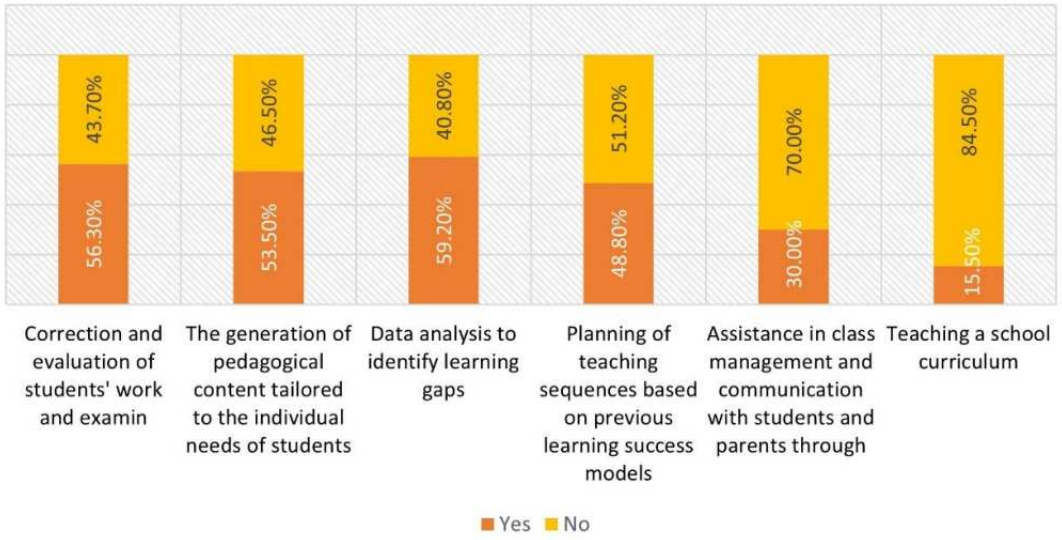


Figure 8. Potential automation of teaching tasks through AI

3.4. Overall appreciation of teachers towards AI

3.4.1. AI: a threat or an opportunity for the future of the teaching profession

The figure 9 indicates that 44.70 %) of teachers believe that AI poses a threat to the future of the teaching profession (26.30 % slightly threatened, 11.30 % moderately threatened, and 6.10 % strongly threatened. However, 55.30 % of our sample believe that AI does not pose a threat to the teaching function.

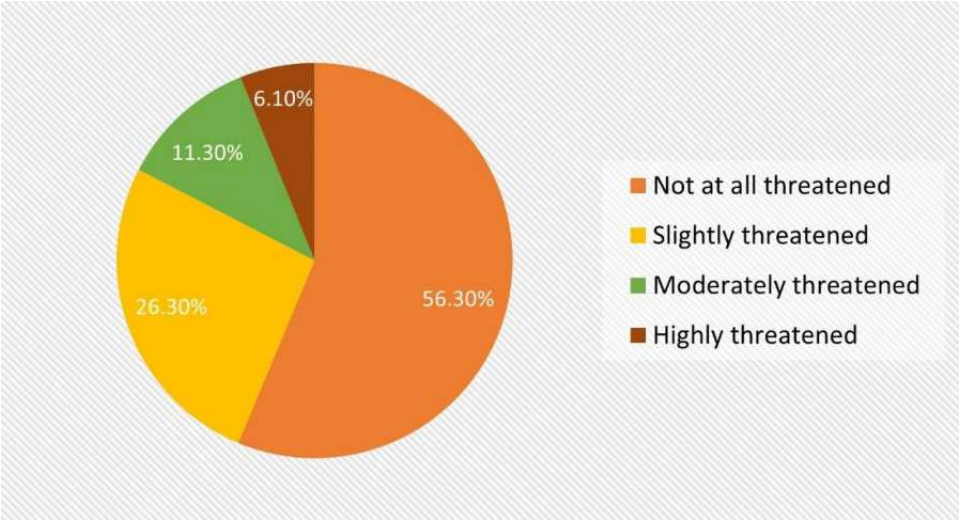


Figure 9. AI as a threat to teacher employment

3.4.2. Distribution of Threat Level According to Seniority

Figure 10 clearly shows that perceived threat levels change with seniority: “Not at all threatened” decreases slightly from 65% to 60% as experience grows. “Slightly threatened” rises from 20% to 25%, showing greater awareness of potential challenges among more experienced employees. Moderate threat perception peaks mid-career (12% for 5–15 years), reflecting added responsibilities and pressures. High threat perception remains rare (4–5%) across all seniority levels. Overall, 85–90% feel minimal threat, indicating a generally safe and

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secure work environment. These trends suggest experience increases nuanced threat awareness while maintaining overall workplace confidence.

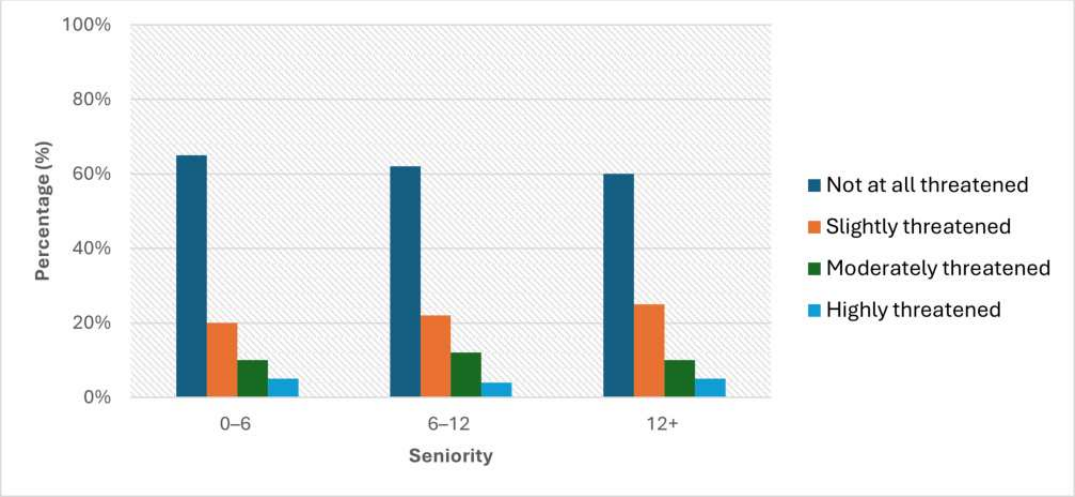


Figure 10. Variation of Threat Perception with Seniority

3.4.3. Teacher and AI: meeting the challenge of successful complementarity

The data from Figure 11 reveals that for a minority of 6.6 % of our sample, only banning the use of AI in teaching-learning is a means to ensure the sustainability of the teaching profession. For the majority of the sample (73.80 %), they recommend measures that promote the coexistence of with AI. Thus, promoting a hybrid learning environment, collaboration between teachteachers ers and AI systems, or continuous training in the field of AI are all measures that can ensure the non-disappearance of the teaching profession.

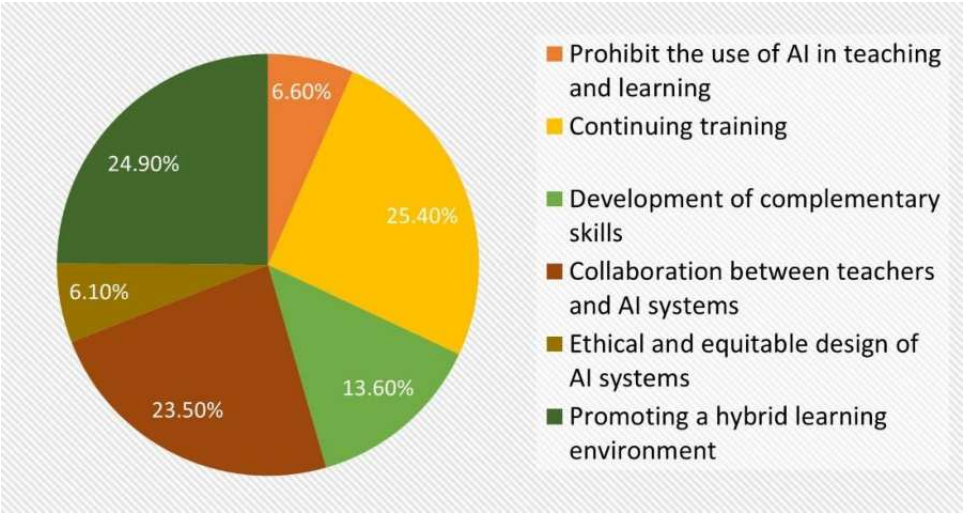


Figure 11. Measures for successful teaching in the era of AI

3.4.4. AI and teachers: A complex spectrum of opinions

According to Figure 12, 14.10 % of teachers have a pessimistic view (very negative 2.80 % or negative 11.30 %) of the potential impact of AI on the teaching profession. However, the majority (85.90 %) of our sample are optimistic (positive 70.40 % or very positive 15.50 %) about AI's impact on the teaching profession.

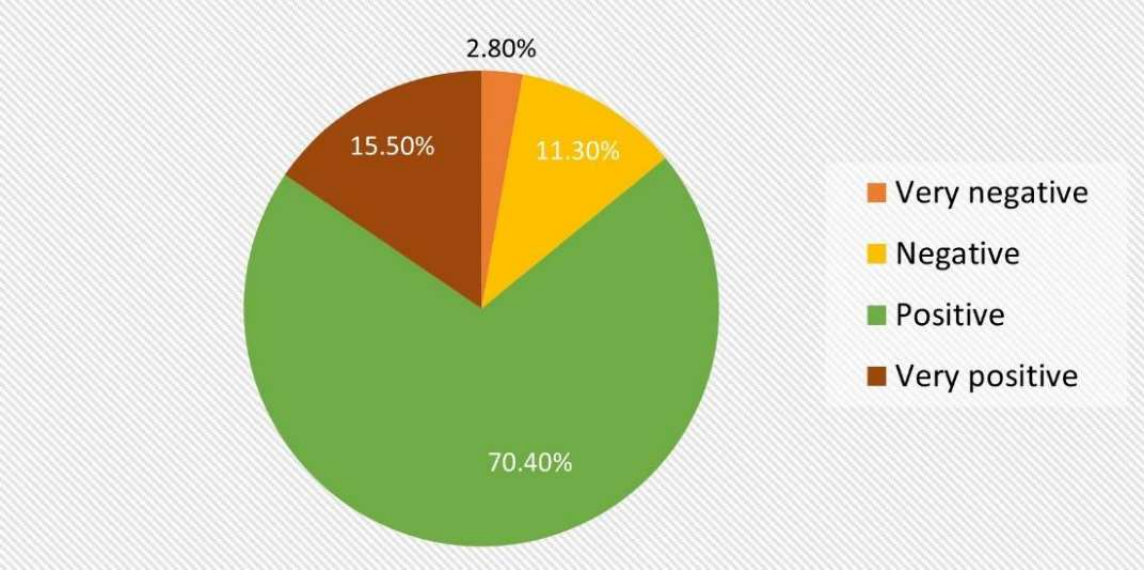


Figure 12. Teachers' attitudes towards AI

4. DISCUSSION

With the advent of information and communication technologies (ICT) and AI in particular in the classroom, teachers are now faced with the obligation to acquire digital (technological) skills in order to integrate these tools effectively into their teaching practices. These skills are now considered to be a fundamental element of schooling, vocational integration and civic life in a society where the technological environment is changing rapidly (MASTAFI, 2018). From this perspective, Morocco, like most developing countries, has not yet established an AI competency framework to guide teachers in the judicious or problematic use of artificial intelligence (AI) in education. However, an AI competency framework has been developed by UNESCO to address the urgent need to prepare teachers for artificial intelligence in education (Miao, F., & Cukurova, 2024). Indeed, UNESCO offers here a guiding, non-prescriptive framework to inform national policies, teacher training, and competency assessment. It places the teacher at the heart of an ethical and human-centered digital transition, positioning them as an informed and responsible actor in the integration of AI in education. The UNESCO framework identifies 15 AI competencies for teachers, structured across three levels: Acquire, to master the basics and literacy in AI; Deepen, to integrate AI in advanced ways while preserving human agency; and Create, to develop expertise enabling innovation, the co-creation of tools, and the definition of ethical standards.

However, in current teaching practices, classroom observations show that the use of ICTs remains limited. Many life and Earth science teachers use ICTs primarily to replace non-digital tools, performing the same tasks as before, without questioning or reinventing their teaching methods (Maouni et al., 2014; Mastafi, 2020). In this context, it is essential to look at teachers' perceptions of AI as an educational tool. As adults, teachers, who are generally selective and pragmatic, will only change their teaching practices if they are convinced of the usefulness of these tools for their teaching (MAOUNI, 2014; MASTAFI, 2020).

It should be recalled that the main objective of this study was to clarify the perceptions and perspectives of life and Earth science teachers regarding artificial intelligence, which is one of the novelties of ICT in the 21st century. Indeed, these perceptions will guide perspectives and influence teachers' choices about teaching methods and whether or not to use this technology in the classroom. Thus, understanding how teachers perceive AI is a crucial step in any educational reform aimed at integrating AI into the teaching-learning process of life and Earth sciences. Life and Earth science teachers are often at the initial stage of use, integrating it

primarily as a replacement of traditional tools, without fully exploring their potential to transform their teaching practices. This reflects a first step towards the adoption of digital technologies, but without any real change in teaching methods.

4.1.State of play: One third of teachers lag behind in AI

The education of future generations has always been and will remain the primary concern of any society. In this regard, Herbert Spencer believed that a well-educated society has a better chance of meeting challenges in a changing environment (Holmes, 1994). Indeed, in a context marked by the arrival of AI, it is essential to prepare teachers to better leverage this technology to improve their pedagogical practices. In this sense, Karsenti (2018) suggests that training teachers in AI will contribute to the success of learners in their social integration by preparing them for the reality that AI (intelligent robots) will bring about radical changes in their way of life and work (Karsenti, 2018).

In relation to our study sample, it turns out that our teachers have a long way to go to catch up with the delay they have in AI. Indeed, the AI sector is evolving rapidly. AI technologies such as ChatGPT, Gemini, facial recognition, automatic translation, weather forecasting, etc., are readily available and only require a technological interface (mobile, tablet, or computer) to be utilised. However, only 8.90 % of teachers claim to be familiar with AI applications in different domains, and nearly one-third of the sample states that they have never used AI before.

Knowing that Morocco has been committed to digital transformation since the 2000s, starting in the telecommunications sector and subsequently spreading to other sectors, is important. In fact, to strengthen and accelerate its digital transformation, Morocco launched the "Digital Morocco 2020" Strategy in 2016, aiming at the digital transformation of the national economy, reinforcing Morocco's position as a regional digital hub, and creating an agency dedicated to the development of digital services (UNESCO, 2020). In the same period, Morocco implemented the strategic vision 2015-2030 reform, which emphasised equipping all classrooms in educational establishments with audiovisual means, ICT, and diversifying training modes, support, and extracurricular assistance through the use of educational television, new technologies, and, in the long term, integrating distance learning methods (The Higher Council of Education, 2015).

Furthermore, according to the Artificial Intelligence Index 2023 report, Morocco has begun developing a strategy aimed at AI to stimulate innovation and economic transformation (Maslej, 2023). Moreover, Morocco wants to make schools a driving force that will contribute to achieving these objectives. However, the results obtained from our sample lead us to question whether our teachers are truly prepared to teach Life and Earth Sciences in an environment where technology in general, and AI in particular, continues to occupy an increasingly significant role. In this context, it is clear that action must be taken to strengthen both the initial and continuing training of teachers. The UNESCO AI Competency Framework for Teachers constitutes an essential reference tool to guide this process. As an international benchmark, this framework can guide the development of national training curricula, provide strategies for teachers' professional development, and support the effective integration of AI in the teaching of life and Earth sciences.

4.2.Life and earth sciences teachers' perceptions of AI

The potential of artificial intelligence to improve the quality of teaching and learning has been well documented internationally (Karsenti, 2018). Among its potentialities, AI in education can offer several advantages, including personalised learning, automatic assessment and grading of learners' work, and assisting teachers in course planning, among others (Tyson,

2021). Tyson (2021) suggests that AI, by performing tasks related to the teaching profession that can be automated, will allow teachers to focus more on tasks that require their human skills and social intelligence (Tyson, 2021).

In relation to our study, the advantages of AI most praised by the teachers in our sample lie in its potential to provide access to a greater amount of data and resources and to motivate learners by providing immersive learning experiences. However, the potential of AI, particularly its interactive potential in terms of personalising learning for each learner or providing real-time assessments, are mentioned less frequently as advantages. Regarding the challenges that the use of AI in the classroom may pose, the majority of our teachers indicated the lack of AI training as the primary major challenge, while the use of AI raises more significant issues, especially in terms of ethics and confidentiality. In this regard, Collin (2022) points out that AI's ability to profile and predict, especially if associated with decision-making regarding which students will be selected for a given training program, raises ethical issues if AI uses other available data such as students' socio-cultural or ethnic data (Collin, 2022). In terms of confidentiality, giving AI access to a learner's personal data related to their academic background and learning potential, if not properly utilised, will make AI a tool that exacerbates social inequalities in the field of education. In this regard, the OECD Council Recommendation on Artificial Intelligence (OECD, 2019), often referred to as the OECD AI Principles, provides a practical and ethical framework to guide the responsible development, deployment, and use of human-centred AI that respects fundamental rights. Its core objective is to maximize the benefits of AI while mitigating its risks, such as disinformation, privacy violations, or misuse (Yeung, 2020).

In short, it appears that the teachers in our study have a rather simplistic perception of AI, considering it as just another ICT and assigning it almost the same roles as traditional ICT, such as the role of an information medium. However, AI, even though it is part of ICT, has a broader scope of action, and the repercussions of its use in education go beyond simply being a support for information to becoming an active participant in the teaching-learning process by interacting with and adapting to the learner's momentary needs during automated learning.

4.2.1. Teachers' perspectives on the role of AI in teaching life and earth sciences

It goes without saying that ICT in general (Karsenti, 2013; Vescio, 2008) and AI in particular (Terwiesch, 2023) have a positive impact on improving teaching and learning. However, the role that AI will play in a teaching-learning process will mainly depend on teachers' perceptions of AI and will thus determine their perspective on this technology. In this regard, it is noted that the majority of teachers in our study are aware of the role that AI can play in the future of teaching life sciences. However, when it comes to aspects of work as a life and earth science teacher that could be automated or replaced by AI-based systems, the results show that teachers show some reluctance to delegate certain tasks to AI, especially those that require direct interaction with the learner. For example, only 30 % of teachers believe that AI cannot assist them in class by communicating with learners or their parents, and only 15.50 % of teachers believe that AI can teach a class. This observation indicates that AI is perceived as a means of information (access to data, immersive experiences) rather than as a means of adaptive learning for the learner (personalisation of learning, interactivity).

4.2.2. Overall appreciation of teachers towards AI

Every innovation is a double-edged sword, often praised and criticised at the same time. It is synonymous with progress, development, uncertainty, and concern. Indeed, according to Barthes, "since the Middle Ages, innovation has been considered a dangerous, harmful,

transgressive, disruptive, and even satanic action. Innovation was seen as a kind of rebellion that would crush everything that could be considered institutional and established" (Barthes, 2019). The history of printing summarises this dualism characterising innovation well. At the end of the 16th century, the Ottoman Sultan Mehmed Beyazıd II, under the pretext of contributing to the preservation of the Quran, issued a decree prohibiting printing for his Muslim subjects. This decree was not the last, as about ten years later, during the reign of Sultan Murad III, faithful to the spirit of prohibition, he allowed Europeans to distribute their goods within the Ottoman Empire, provided that it was limited to scientific books, excluding others, particularly religious books (Schwartz, 2017). This ban hindered the dissemination of ideas and knowledge within the Ottoman Empire, thus limiting the intellectual and cultural development of Ottoman society. Nowadays, AI is both a major human invention and innovation that will mark the beginning of the 21st century by far. Regarding AI, the majority of our teachers are optimistic about its impact on improving teaching life and earth sciences and recommend collaboration, continuous training, and the development of hybrid learning environments. However, 43.70 % of our sample consider AI a potential threat to the teaching profession, with a minority (6.10 %) going so far as to propose banning AI in teaching-learning. This appreciation of AI, in our opinion, indicates a misunderstanding of the role that AI can play in teaching and learning. Especially with the negative image of AI conveyed by the media, cult films such as "2001: A Space Odyssey" (1968), "Terminator" (1984), "The Matrix" (1999), "I, Robot" (2004), an image where AI will compete with humans and eventually reach a singularity point where it will become smarter than humans, leading to the decline of humanity. This portrayal of AI will fuel people's fears of AI. However, artificial intelligence represents, as De Ganay points out (2017), an opportunity to seize provided that irrational fears of AI are addressed and the relationship between humans and AI is seen in a perspective of complementarity that will lead to augment human intelligence (De Ganay, 2017).

5. CONCLUSION

Artificial intelligence (AI) currently represents a structural transformation of educational environments, going far beyond its status as a technological tool for information support. Through its capacities for adaptation, data analysis, and interaction, AI is profoundly reshaping teaching and learning processes, redefining teachers' professional roles, and raising new ethical frameworks in education. The purpose of this study was to analyze the perceptions and perspectives of life and earth sciences teachers regarding AI, in order to identify both the levers and the barriers to its pedagogical integration.

The findings reveal a significant gap between, on the one hand, the widely recognized potential of AI to enhance teaching and learning, and on the other hand, the still largely simplistic conceptions held by teachers. AI is predominantly perceived as an extension of traditional information and communication technologies (ICT), mainly used for access to information, and only rarely as an adaptive, interactive, and transformative learning system. The data also indicate an insufficient appropriation of the ethical, social, and pedagogical issues associated with AI, despite their central role in international normative frameworks. This situation highlights the urgent need to move beyond a technocentric approach to teacher training and to situate AI within a framework of integrated professional competencies that combine technical knowledge, pedagogical practices, human responsibility, and ethical principles.

In this regard, UNESCO's AI Competency Framework for Teachers provides a particularly relevant structuring reference. By organizing competencies across three progressive levels—Acquire, Deepen, and Create—the framework conceptualizes teacher training not as a one-time technological initiation, but as a process of continuous professional development grounded in human-centered and responsible innovation. Recommendations for Successful AI Integration:

In light of the findings and in alignment with existing international standards, the following recommendations are proposed:

- Align teacher training with international AI competency frameworks: Initial and in-service teacher training should be embedded within UNESCO's AI Competency Framework for Teachers, structuring professional development pathways around the Acquire, Deepen, and Create levels. This approach would enable a shift from basic technological familiarization to a pedagogically informed and critical mastery of AI.
- Move beyond an instrumental view of AI toward a transformational pedagogical approach: Training programs should explicitly aim to develop competencies related to the use of AI as an adaptive learning tool—such as personalization, formative feedback, and analysis of learners' difficulties—rather than treating AI as a mere substitute for traditional instructional resources.
- Systematically integrate ethical principles and responsible AI governance: The adoption of the OECD Principles on Artificial Intelligence should serve as a normative foundation for regulating AI use in education. Teacher training should include competencies related to data protection, equity, algorithmic transparency, and human accountability in pedagogical decision-making.
- Develop hybrid learning environments aligned with international standards: It is recommended to design hybrid pedagogical environments that combine face-to-face instruction, digital resources, and AI tools, in accordance with UNESCO's recommendations on the digital transformation of education. Such environments can promote inclusion, pedagogical differentiation, and learner engagement.
- Promote research–action and pedagogical innovation grounded in shared standards: Encouraging research to develop AI-based pedagogical applications adapted to local contexts should be accompanied by strict alignment with UNESCO's competency framework and the ethical safeguards established by the OECD principles. This alignment will ensure that innovations are both locally relevant and consistent with international standards of quality and responsibility.

In sum, the successful integration of artificial intelligence in education cannot be reduced to a superficial technological adoption; it requires a genuine and sustainable transformation of pedagogical practices. Such a transformation demands a rigorous calibration of teacher training and support programs, grounded in international competency and ethical frameworks related to AI use. This anchoring is a necessary condition for enabling Morocco—as well as any country seeking to leverage AI as a driver of educational improvement—to prepare teachers for an informed, critical, and responsible integration of AI, ultimately moving beyond the reductive view of AI as a mere tool for information support.

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