Investigating the Integration of Artificial Intelligence in Learning Assessment: Towards an Automated Remediation

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***Abstract*—In the context of educational innovation, Artificial Intelligence (AI) is transforming assessment and remediation, fostering greater personalization and efficiency. This study explores teachers' perceptions and practices in assessment and remediation, as well as their views on AI's potential to support adaptive interventions. A questionnaire was administered to 210 secondary school physics and chemistry teachers in the Fès-Meknès region. Findings show that diagnostic, formative and summative assessments are widely used, but challenges such as low student motivation, time constraints, and diverse learner needs limit assessment practices overall. Digital tools remain underused, with traditional methods still prevailing. While most teachers implement remediation, they struggle to adapt it to individual learners. Notably, 77.6% of respondents express a positive view of AI's potential, particularly for personalized learning, adaptive testing, and automated reporting. These results provide an overview of current practices and highlight the significant opportunities AI offers for improving the effectiveness and adaptability of assessment and remediation strategies.**

***Keywords*—artificial intelligence, assessment, remediation, adaptive learning, e-learning, physics/chemistry teachers**

I. Introduction

Recent studies have shown that AI is increasingly used to support adaptive learning, automated assessment, and personalized feedback in education [1, 2]. The educational field is experiencing rapid adoption of AI, with teaching and learning processes becoming increasingly data-driven and technology-enhanced [2]. However, traditional approaches to diagnosis and remediation face clear limitations as class sizes grow and students' learning profiles become more diverse [3]. These challenges make it increasingly difficult for teachers to provide timely and individualized support [4]. AI therefore emerges as a promising tool to complement teachers' work, offering intelligent systems that can analyze student performance data, generate rapid feedback, and recommend targeted remediation strategies [4].

The objective of this study is to examine teachers' perceptions and practices related to assessment and remediation, and to explore their views on the potential role of Artificial Intelligence in Education (AIED) to support these processes. The study also seeks to identify the main barriers to AI adoption in schools and to discuss possible solutions that could improve the efficiency and adaptability of assessment and remediation. In doing so, the study aims to highlight how AI could potentially complement teachers' work and support the integration of innovative, data-driven approaches to education. This development is crucial if we want to ensure that every student benefits from more personalized and equitable learning opportunities.

For teachers, checking in on the learning of children is still an important responsibility. Assessment is about more than measuring progress—it illuminates students' challenges and enables teachers to refine how they help each student [5]. So, as important as diagnosis is remediation—the way forward after the diagnosis which makes students capable of overcoming their difficulties and learning gaps [5].

The fact that AI can handle massive amounts of data and implement sophisticated algorithms leads to a new form of efficiency [6]. It could swiftly process the assessment results and recommend a more personalized remediation paths based on individual pupils' requirements [7]. Prior studies report that such personalization improves the continuity and effectiveness of learning [7].

Despite the growing literature on AI in education, few studies have explored teachers' perceptions of AI-supported assessment and remediation in underrepresented contexts such as Morocco. This lack of empirical evidence limits our understanding of how AI can be effectively integrated into diverse educational systems.

This study addresses this gap by providing data from 210 secondary school physics and chemistry teachers, offering one of the first comprehensive investigations of assessment and remediation practices in this region. Beyond documenting current practices, the study highlights teachers' views on the potential of AI to enhance personalization, efficiency, and adaptivity in education. By linking these findings to global discussions, it contributes new insights and practical recommendations that can inform both local and international efforts to integrate AI into educational assessment and remediation.

To examine this integration more closely, we propose the following research questions, directly addressing the identified gap in the literature. They focus on the practices and views of physics and chemistry teachers regarding AI in learning assessment and remediation:

1) What are the attitudes and levels of trust of Moroccan secondary school physics and chemistry teachers toward AI specifically in the context of learning assessment and automated remediation, and how do these perceptions compare to findings from digitally advanced contexts?
2) How do these teachers currently integrate, or intend to integrate, AI tools into their assessment and remediation practices under resource-constrained conditions?
3) What specific benefits (personalization, workload

reduction) and challenges (infrastructure, training, ethical concerns) do they identify regarding AI adoption in these processes?

II. Literature Review

A. AI-Based Tools vs Digital Tools

Digital tools in education generally refer to software or platforms that facilitate teaching tasks, such as online quizzes, grading systems, or plagiarism detectors, without relying on advanced computation [8]. By contrast, AI tools integrate machine learning, natural language processing, and intelligent tutoring systems to provide adaptive feedback, predict student performance, and personalize learning pathways [9, 10]. However, this distinction is sometimes blurred in empirical studies, where tools labeled as 'AI-based' often rely on basic automation rather than true intelligent systems [11].

B. Evaluation and Remediation in the Age of AI-Based Tools

Artificial Intelligence is no longer confined to theoretical debates; it is already taking shape through concrete tools that are gradually transforming evaluation and remediation practices. In classrooms and digital platforms alike, Generative AI is now able to provide personalized feedback and adaptive testing [8]. Natural Language Processing (NLP) technologies can analyze students' written responses, detect errors, and suggest tailored corrections [10]. Other tools, such as Reason Checkers (RC) and Plagiarism Detectors (PD), help strengthen academic quality and integrity [12]. Machine Learning (ML) algorithms are also being used to identify at-risk students and anticipate their performance [13]. Finally, Intelligent Tutoring Systems (ITS)—such as those described by Gomes [9] and Rizvi [14]—show how AI can guide learners step by step, adapting content in real time to their needs. These examples, already operational in various contexts, show that AI is not a distant promise but an emerging reality transforming how teachers assess and support learners.

C. Ethical Considerations for AI Adoption

Beyond technical and pedagogical dimensions, ethical and regulatory issues remain central to the adoption of Artificial Intelligence (AI) in education. Key concerns include algorithmic transparency, fairness in automated grading, and the protection of students' personal data, all of which strongly influence teachers' trust in AI-based tools [15–17]. In contexts such as Morocco, where digital literacy and regulatory frameworks are still developing, these concerns become even more critical [10, 18]. Without clear institutional guidelines, the risks of bias, privacy breaches, and reduced accountability may hinder large-scale implementation. Therefore, several studies call for stronger ethical governance policies and targeted professional-development programs to enhance educators' critical understanding of AI [19–21].

D. International Educational Context

Artificial Intelligence (AI) has become a significant driver of innovation across sectors, and education is no exception [7, 22]. Recent reviews highlight its applications in adaptive learning, automated assessment, and data-driven feedback loops that improve personalization and instructional efficiency [8, 12]. Empirical evidence further suggests that AI can reduce teachers' workloads by automating routine grading and analytics, freeing time for higher-value teaching and individualized student support [23, 24]. Beyond efficiency, AI can tailor learning materials to individual needs, identify knowledge gaps, and recommend targeted resources [25].

A major body of research has focused on Intelligent Tutoring Systems (ITS), which personalize learning trajectories through machine-learning algorithms and support autonomy and differentiated instruction [9, 13, 26–29].

In parallel, learning assessment remains a cornerstone of schooling: it measures attainment and actively guides pedagogical improvement [4, 13, 14, 30] helping teachers celebrate successes, diagnose difficulties, and adjust their strategies [31]. Yet assessment is time-consuming and, in qualitative or oral formats, vulnerable to subjectivity that can limit reliability and impact [32, 33] with context-specific challenges reported in under-resourced or rural settings [34]. Against this backdrop, AI is increasingly proposed as a means to automate grading, analyze response patterns, and provide timely feedback [35, 36]. Tools such as Intelligent Tutoring Systems (ITS), conversational agents, and learning-analytics platforms can deliver adaptive support, detect learning gaps in real time, and calibrate task difficulty to match learners' abilities [9, 37–40].

However, much of the current evidence originates from digitally advanced systems in Europe, North America, and East Asia, where robust infrastructure, supportive policy frameworks, and structured teacher-training initiatives facilitate AI integration [41]. Adoption depends strongly on educators' digital literacy and critical digital literacies, which remain uneven [19, 20], while upskilling and reskilling needs persist at the institutional level [21]. Trust is also pivotal: teachers must view AI outputs as accurate, fair, and pedagogically meaningful [42–44]. Sustained professional development is therefore essential for informed integration [44]. Ethical concerns—privacy, transparency, and fairness—are frequently noted but insufficiently addressed empirically [15, 16]. Teachers' perspectives and broader work documents technology's effects on student emotions and behaviours in classrooms [45]. Preparing future educators for AI-enhanced practice, including measuring trust with validated instruments, is becoming a priority [17, 46, 47] yet theory-practice gaps in AIED remain [10].

Consequently, the literature converges on a pragmatic stance: AI should complement—not replace—teachers, who remain central to interpretation, adaptation, and the human dimension of learning [48, 49], with AI serving as a pedagogical partner whose outputs require expert mediation [50, 51]and a balanced, human-centered approach to adoption [52, 53].

However, findings remain inconsistent across contexts: while studies from technologically advanced regions highlight efficiency and personalization, research conducted in developing settings often reports a limited impact due to infrastructural, pedagogical, and ethical constraints [20, 41, 42]. Moreover, most of the reviewed

studies rely on self-reported data, small or non-representative samples, and rarely include validated instruments for measuring teachers' trust and competence in AI, which limits the generalizability of their conclusions [8, 10, 17, 20, 53].

Building on this foundation, our study makes an international contribution by providing empirical evidence from Moroccan secondary education—specifically in physics and chemistry—on how teachers perceive and implement AI for learning assessment and automatic remediation. By examining both perceived value and classroom practices within a resource-constrained context, we identify where AI offers clear benefits (personalization, timely feedback, workload reduction) and where persistent barriers remain (infrastructure, training, trust, and ethics). These findings provide valuable insights to inform local educational reforms and contribute to global discussions.

E. Moroccan Educational Context

The integration of Artificial Intelligence (AI) into the Moroccan educational system has attracted growing attention from educators and institutions due to its potential to transform pedagogical practices and promote more personalized and responsive forms of assessment [52]. Recent studies highlight AI's significant contributions, particularly in adapting learning pathways to students' individual needs, automating repetitive tasks, and facilitating the early identification of academic difficulties [53]. Ejjami [52] demonstrates that AI technologies—especially machine learning and large language models (LLMs)—have the potential to revolutionize education in Morocco by enabling customized learning experiences while promoting student inclusion and autonomy. In the context of science education, Chaibi [54] reports positive outcomes associated with the use of AI tools in virtual simulations, automated grading, and the modulation of instruction according to each learner's pace.

Nevertheless, the literature consistently points to significant challenges that hinder large-scale deployment. National studies report both structural and human barriers, including insufficient teacher training (25%), high infrastructure costs (35%), ethical concerns regarding data protection (20%), and resistance to change (19%) [55]. Bouziane and Bouziane [56] confirm that, although teachers express strong interest in AI, they lack the necessary digital and pedagogical skills for effective adoption. Furthermore, while experimental work such as that of Elbouknify *et al.* [57] demonstrates AI's potential by predicting at-risk students with 88% accuracy, most studies remain descriptive, lack robust inferential or experimental analyses, and fail to explore systematic integration of AI across the entire assessment–remediation cycle [9, 18, 58, 59].

Compared with studies from digitally advanced systems such as those in East Asia or Europe, Moroccan research remains in its early stages, focusing more on feasibility and teachers' perceptions than on large-scale or experimental validation [20, 41, 42].

These findings reveal a persistent gap between the theoretical potential of AI and its practical implementation in classrooms. Accordingly, this study aims to provide empirical evidence from Moroccan secondary education—specifically in physics and chemistry—by exploring teachers' perceptions, practices, and the conditions enabling meaningful AI-supported assessment and remediation.

Building on this gap, the present study offers new empirical insights from Moroccan secondary education by examining how teachers' perceive and apply AI in assessment and remediation processes, and by identifying the conditions under which AI can be effectively integrated. These findings aim to inform educational policy, guide teacher training initiatives, and contribute to the global discussion on equitable and effective AI adoption in education.

III. Materials and Methods

A. General Background

Understanding teachers' perceptions and practices regarding AI in assessment and remediation requires taking into account their professional context. In Morocco, the integration of AI into education is still at an early stage, with uneven access to infrastructure and limited opportunities for teacher training. These factors can influence teachers' readiness to adopt AI tools and shape how they use them in daily classroom practice. By focusing on physics and chemistry teachers in the Fès-Meknès region, this study provides valuable insights into how AI adoption is experienced in a real-world, resource-constrained setting. This contextual understanding is essential for interpreting the findings and for designing methodological choices that reflect authentic teaching conditions.

This study adopts a quantitative method to capture a comprehensive understanding of teachers' practices and perceptions regarding AI in learning assessment and automated remediation. The focus is on physics and chemistry teachers in the Fès-Meknès region, as their perspective provides valuable insights into local implementation conditions.

A structured questionnaire was developed to ensure scientific rigor and reflect authentic classroom conditions. Its content validity was evaluated by a panel of professors and experts in education and educational technology, who reviewed each item for clarity, relevance, and alignment with the study's objectives. Based on their feedback, minor wording adjustments were made to enhance comprehensibility and precision.

The questionnaire was then piloted with a small group of teachers whose feedback helped refine items and ensure that response options were clear, non-overlapping, and representative of daily teaching practice. This process strengthened the face validity of the instrument and minimized potential response bias.

Data analysis was conducted using descriptive statistics for the quantitative items, with results presented through frequencies, percentages, and graphs. Open-ended responses were examined qualitatively through careful reading and descriptive interpretation, identifying recurrent ideas and summarizing them narratively to enrich the understanding of teachers' perspectives.

This rigorous design ensured that the data collected are reliable and meaningful, capturing teachers' attitudes, practices, and expectations regarding AI integration in assessment and remediation.

B. The Sample

The questionnaire was administered to 210 physics and chemistry teachers in the Fès-Meknès region. The sample included teachers from three levels: lower secondary (middle school), upper secondary (high school), and higher education. This selection ensured diversity in professional profiles and teaching contexts. It also provided a comprehensive overview of practices and perceptions across different levels of the education system.

Details on participants—including gender, subject area, age, education, teaching experience, and level taught—are shown in Table 1.

Table 1. Demographic information of the participants

Variable	Characteristics	Frequency	Percentage (%)
Gender	Male	125	59.4%
	Female	85	40.6%
Age	≤30 years	144	68.6%
	31–40 years	45	21.4%
	41–50 years	18	8.6%
	>50 years	3	1.6%
Level of education	Baccalaureate	1	0.4%
	BAC+2	2	0.97%
	BAC +3	102	48.6%
	BAC+5	72	34.33%
	Doctorate	33	15.7%
Teaching Cycle	Primary	18	8.7%
	Middle School	40	18.9%
	High School	137	65.2%
	Higher Education	15	7.2%
Subject	Physics/Chemistry	210	100%
Teaching experiences	≤5 years	155	73.9%
	6–10 years	27	13%
	11–20 years	16	7.5%
	>20 years	12	5.6%

C. The Sampling

A snowball sampling method was used to engage participants. Initial physics and chemistry teachers were contacted through professional networks linked to our research laboratory. These teachers then shared the survey with colleagues, allowing the target sample of 210 participants to be reached. Although the study focused on physics and chemistry teachers to align with the expertise and research interests of our laboratory, the proposed solutions and recommendations are designed to be applicable across disciplines, ensuring their relevance for educators in other subject areas as well. Participation in this study was entirely voluntary. All participants were informed about the objectives of the research and consented to participate anonymously. Participation in this study was entirely voluntary. All participants were informed about the objectives of the research and consented to participate anonymously.

D. Questionnaire and Procedure

This quantitative study aims to examine how physics and chemistry teachers perceive and apply Artificial Intelligence (AI) in learning assessment and automated remediation. To achieve this goal, a detailed questionnaire was developed. It consists several sections to collect demographic information, describe current assessment practices, highlight related challenges, and capture teachers' opinions on the potential of AI in education (Fig. 1). The study complied with general ethical principles for educational research, ensuring confidentiality and data protection throughout the data collection process. Since the questionnaire included mostly descriptive and multiple-choice questions, internal consistency measures such as Cronbach's alpha were not applicable. However, the instrument's reliability was ensured through expert validation, pilot testing, and refinement of items to guarantee clarity, relevance, and consistency with the study objectives.

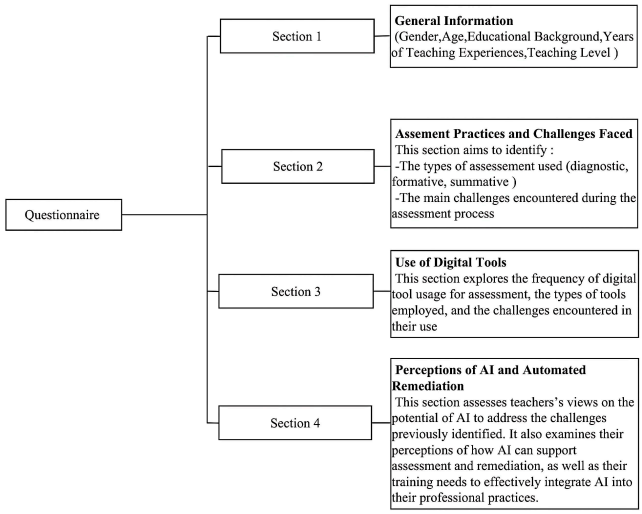

Fig. 1. Sections of the questionnaire.

E. Data Collection

For this study, the questionnaire was primarily distributed through Google Forms. This platform provided a simple and organized way to collect data. It facilitated response management and helped reach the targeted group of teachers. Google Forms was chosen because it is both accessible and easy to use. Teachers could complete the questionnaire at their convenience, a flexibility that increased participation and contributed to obtaining more a representative sample.

A paper version was also provided. This alternative allowed teachers without digital access to chosen because it is both accessible and easy to use. Teachers could complete the questionnaire at their participate, ensuring broader coverage and inclusivity.

F. Data Cleaning

One of the main risks was non-response bias if certain teacher profiles decided not to participate. To reduce this risk, follow-up reminders were sent. Clear explanations were also given to encourage participation from all targeted teachers, regardless of their school or years of experience.

A rigorous data-cleaning and validation procedure was carried out to ensure the quality and reliability of the dataset. The responses collected through Google Forms were first exported to Excel, while data from the paper-based questionnaires were manually entered into the same file. All responses were carefully reviewed for completeness and consistency. Duplicate entries were systematically identified and removed to eliminate redundancy, ensuring that each participant was represented only once. This process resulted in a verified and ready-to-analyze dataset, providing a solid foundation for subsequent statistical examination.

G. Data Analysis

To analyze the data, a quantitative approach was adopted. The questionnaire responses were compiled and organized in

Microsoft Excel, which enabled the calculation of frequencies, identification of general trends, and determination of proportions for each response category. This statistical analysis helped to highlight the main practices, common perceptions, and recurring challenges related to the use of artificial intelligence in assessment and remediation.

IV. Results

This section presents the results of our study on how Moroccan physics and chemistry teachers view and use Artificial Intelligence (AI). It focuses on their perceptions of AI in learning assessment and automated remediation. The section shows how teachers see AI's role, how they currently use it or plan to use it, and how they assess its benefits and challenges. The analysis highlights key trends and dominant opinions about how AI can improve pedagogical monitoring. These findings open a broader discussion on the impact of AI on the Moroccan education system. They shed light on its influence on assessment practices and remediation strategies.

A. Assessment and Challenges Faced

The question "Do you conduct diagnostic assessment?" was a closed-ended item. It asked physics and chemistry teachers whether they carry out diagnostic assessment, offering only two response options: Yes or No, as shown in Table 2:

Table 2. Diagnostic assessment practices among Moroccan physics and chemistry teachers

Response	Frequency	Percentage (%)
Yes	198	94.3 %
No	12	5.7 %

As shown in Table 2, the vast majority of physics and chemistry teachers regularly conduct diagnostic assessments, indicating that this practice is almost universal among the respondents.

The question "What difficulties do you encounter during diagnostic assessment?" was a multiple-choice item. Teachers could choose several answers from eight available options. Its purpose was to identify the main challenges teachers face when carrying out diagnostic assessments. The results are summarized in the following Table 3.

Table 3. Difficulties encountered by teachers during diagnostic assessment

Response	Frequency	Percentage (%)
Lack of time	45	21.7%
Lack of student motivation	115	55.1%
Challenges in designing diagnostic assessment tests	33	15.9%
Marking papers is time-consuming	57	27.5%
Categorizing learners into groups according to their difficulties	97	46.4%
Learners' lack of knowledge	6	2.8%
Student absenteeism	6	2.8%
No difficulties	3	1.4%

Note: The total percentage exceeds 100% *due to multiple responses.*

The results presented in Tables 2 and 3 show that diagnostic assessment is widely practiced by the surveyed teachers 94.3% as part of their teaching. Conversely, only 5.7% of teachers reported not using this type of assessment.

Among the reported challenges, lack of student motivation was the most significant 55.1%. Additionally, 46.4% of teachers reported difficulties in categorizing students based on their needs.

More operational constraints were also identified: time required for grading papers 27.5%, lack of time 21.7%, and difficulties in designing assessment tasks 15.9%. Occasional barriers such as student absenteeism and heterogeneity of learners' levels were also reported.

The question "Do you use formative assessment?" is a single-choice, closed-ended question aimed at determining whether teachers implement formative assessment in their practice. Respondents were asked to select between two options: Yes or No. As illustrated in Table 4, a large majority confirmed that they conduct formative assessment as part of their teaching.

Table 4. Formative assessment practices among Moroccan physics and chemistry teachers

Response	Frequency	Percentage (%)
Yes	186	88.4%
No	24	11.6%

The question *"What difficulties do you face when conducting formative assessment?"* is a multiple-choice question in which teachers could select several responses from six available options. This question aims to identify the main challenges encountered in the implementation of formative assessment. The results are summarized in the following Table 5.

Table 5. Difficulties encountered by teachers during formative assessment

Response	Frequency	Percentage (%)
The diversity of learners' difficulties	110	52.5%
Time constraints	61	29.4%
The pressure to complete the full curriculum	105	50%
Difficulty in identifying learners' diverse needs	71	33.8%
Requires more effort	49	23.5%
No difficulty	12	6%

Note: The *total percentage exceeds 100% due to multiple responses.*

The results presented in Tables 4 and 5 show that 88.4% of teachers report using formative assessment, while 11.6% do not implement it. The main reasons cited include the wide range of students' learning gaps 52.5% and the pressure to complete the curriculum 50%. Other reported barriers include the lack of tools to identify learners' specific needs 33.8%, increased workload 23.5%, and insufficient time 29.4%.

The question *"What challenges do you face in summative assessment?"* is a multiple-choice question in which teachers could select several responses from four available options. This question aims to identify the main difficulties encountered in the practice of summative assessment. The results are summarized in the following Table 6.

Table 6. Challenges faced by teachers in summative assessment

Response	Frequency	Percentage (%)
Difficulty in rigorously analyzing students' results	97	46.4%
Grading papers is time-consuming	100	47.8%
Lack of time to conduct objective assessments	91	43.5%
No difficulties	6	2.8%

Note: The total *percentage exceeds 100% due to multiple responses*

The results displayed in Table 6 show that 47.8% of teachers identify grading assessments as a major challenge and 46.4% report difficulty analyzing student results.

Additionally, 43.5% indicate a lack of time to conduct objective assessments, often linked to workload or large class sizes.

The question *"When conducting diagnostic assessment, do you use traditional methods or digital tools?"* is a single-choice question where teachers select one option from two available choices. The objective is to determine the type of diagnostic assessment used by physics and chemistry teachers. The results are presented in the following Table 7.

Table 7. Type of approach used by teachers during diagnostic assessment

Response	Frequency	Percentage (%)
Traditional (without using digital tools)	158	75.4%
Digital	52	24.6%

The results show that 75.4% of teachers prefer traditional assessment methods, while 24.6% use digital tools for diagnostic assessment.

The question *"When conducting formative assessment, do you use traditional methods or digital tools?"* is a single-choice question where teachers were asked to select one option from two possible responses. The objective is to determine the type of formative assessment implemented by physics and chemistry teachers. The results are presented in the following Table 8.

Table 8. Type of approach used by teachers during formative assessment

Response	Frequency	Percentage (%)
Traditional (without using digital tools)	150	71.6%
Digital	60	28.4%

The results show that 71.6% of physics and chemistry teachers use traditional, non-digital methods for formative assessment, while 28.4% report using digital tools.

The question *"When conducting summative* assessment*, do you use traditional methods or digital tools?"* is a single-choice question in which teachers select one option from two possible responses. The purpose is to determine the type of summative assessment used by teachers. The results are presented in the following Table 9.

Table 9. Type of approach used by teachers during summative assessment

Response	Frequency	Percentage (%)
Traditional (without using digital tools)	160	76.5%
Digital	50	23.5%

The results indicate that most teachers continue to favor traditional methods for summative assessments 76.5%, whereas only 23.5% have adopted digital tools. This trend may shift with the enhanced integration of digital and the provision of targeted training.

The question "Do you implement remediation strategies for students facing learning difficulties?" is a closed-ended question with a single choice. It asks physical sciences and chemistry teachers whether they apply remediation strategies for students with learning difficulties. Respondents were required to choose between two options: Yes or No. The results are presented in the following Table 10.

The results show that 88.2% of teachers answered "Yes", indicating that the vast majority of respondents implement remediation strategies to support students with learning difficulties. In contrast, a small minority 11.8% reported not using such strategies. Overall, the respondents exhibit a high level of commitment to adopting remediation strategies aimed at supporting students with learning difficulties.

Table 10. Application of remediation strategies to support students with learning difficulties

Response	Frequency	Percentage (%)
Yes	**185**	**88.2%**
No	**25**	**11.8%**

The question "What challenges are encountered during the remediation process?" is a closed-ended multiple-choice item allowing teachers to select more than one response from five possible options. Its objective is to better understand the obstacles faced in implementing remediation. The results are summarized in Table 11. It should be noted that the total percentage exceeds 100% as respondents were allowed to select multiple answers.

Table 11. Challenges encountered by teachers during the remediation process

Response	Frequency	Percentage (%)
Difficulty choosing remediation activities	75	35.8%
The diversity of students' learning difficulties	97	46.3%
The diversity of remediation pathways adapted to the specific needs of each learner	81	38.8%
Limited time available for remediation	88	41.8%
No difficulties	6	3%

According to the results, 46.3% of teachers view the diversity of students' learning difficulties as one of the main obstacles to effective remediation. Time limitations are another significant concern, mentioned by 41.8% of teachers as a barrier to developing truly personalized support plans.

Similarly, 38.8% report that adapting multiple remediation pathways to match individual learner profiles is a continuing challenge. Finally, 35.8% of respondents struggle with selecting the most appropriate activities to meet their students' specific needs.

B. Assessment and Digital Tools

The question "What difficulties prevent you from using digital tools (software, educational applications, etc.) in assessment?" is a multiple-choice closed question, where teachers could select several responses from seven proposed options. This question aims to identify the obstacles that hinder teachers from using digital tools in the assessment process. The results are presented in the following Table 12. It should be noted that the total percentage exceeds 100% due to multiple responses.

The results reveal that the lack of adequate training digital tools 40.9%. Technical limitations are also mentioned, including tools' inability to interpret diverse student responses 24.2% and to adapt activities to learners' specific needs 27.3%. In addition, 24.2% of teachers report difficulties handling open-ended questions.

The question "How often do you use digital tools during assessment?" is a single-choice closed-ended question offering four response options. Its purpose is to determine the frequency with which teachers use digital tools in their assessment practices. The results are presented in the following Table 13.

The results show that 38.8% of teachers rarely use digital tools during assessment. In contrast, 23.9% report always using them, indicating a moderate but not predominant level of adoption. Additionally, 22.4% report using them very rarely and 14.9% never use them. Overall, the majority of

teachers either rarely or never integrate digital tools into their assessment practice.

Table 12. Difficulties preventing teachers from using digital tools in assessment

Response	Frequency	Percentage (%)
Insufficient training to use digital tools effectively.	85	40.9%
Digital tools' inability to interpret diverse student responses.	51	24.2%
Nability of digital tools to deliver activities tailored to learners' needs.	57	27.3%
Digital tools' inability to perform text correction.	32	15.2%
Digital tools' inability to process and automate student responses.	38	18.2%
Digital tools' inability to interpret open-ended questions.	51	24.2%
Time constraints	3	1.5%
Lack of digital tools from the start	9	4.5%

Table 13. Frequency of digital tool usage during assessment

Response	Frequency	Percentage (%)
Always	50	23.9%
Rarely	81	38.8%
Very rarely	47	22.4%
Never	31	14.9%

The question "Which tools do you use during assessment?" is a multiple-choice closed-ended question, allowing teachers to select more than one option among the following: Moodle, Google Classroom, Hot Potatoes, and Other. The objective is to identify the digital tools used for assessment purposes. The results are presented in the following Table 14.

Table 14. Types of tools used by teachers during assessment

Response	Frequency	Percentage (%)
Moodle	68	32.7%
Google Classroom	130	61.8%
Hot Potatoes	38	18.2%
NetQuiZ	4	1.8%
Kahoot	4	1.8%
Power point, Word (pdf)	4	1.8%
Nothing	4	1.8%

Note: The total percentage *exceeds 100% due to multiple responses.*

The results show that Google Classroom is the most frequently used assessment tool, selected by 61.8% of respondents. Moodle is second with 32.7%, followed by Hot Potatoes with 18.2%. In contrast, NetQuiz, Kahoot, and PowerPoint/Word (PDF) are rarely used, each selected by only 1.8% of participants.

C. Perceptions of AI and Automated Remediation

The question "Do you think AI could help overcome the difficulties you mentioned?" is a single-choice closed-ended question asking teachers whether they believe that Artificial Intelligence (AI) could assist in addressing the challenges they previously identified. Respondents were required to choose between two options*: Yes* or *No*. The results are presented in the following Table 15.

The results show that more than three-quarters of teachers view AI as a potential aid in education, indicating a broadly favorable attitude toward this technology. In contrast, 22.4% of teachers do not believe in the usefulness of AI.

The question "If yes, why?" is a multiple-choice closed-ended question allowing teachers to select several reasons from four proposed options. The aim is to identify the motivations behind teachers' belief that AI could help overcome challenges related to assessment and automatic remediation. The results are presented in the following Table 16.

Table 15. Teachers' perceptions of AI's potential to overcome identified difficulties

Response	Frequency	Percentage (%)
Yes	163	77.6%
No	47	22.4%

Table 16. Reasons why teachers believe AI could help overcome the mentioned difficulties

Response	Frequency	Percentage (%)
AI can assist in automating the grading of tests and assignments.	109	51.8%
AI enables the generation of assessment reports	105	50%
AI makes it possible to create assessments that are adaptive to learners' needs.	112	53.6%
AI enables personalized learning by identifying students' strengths, weaknesses, and learning gaps	120	57.1%

Note: The total *percentage exceeds* 100*% due to multiple responses.*

The results indicate that personalized learning 57.1% and the creation of adaptive assessments 53.6% are the two most frequently cited benefits of AI. Automated grading was also identified by 51.8% of teachers, while 50% mentioned the generation of assessment reports.

The Question "If not, why?" is a multiple-choice closed-ended question in which teachers could select several reasons from five proposed options. The purpose is to identify why some teachers do not believe that AI can help overcome challenges related to assessment and automatic remediation. The results are presented in the following Table 17.

Table 17. Reasons why teachers believe AI cannot help overcome the mentioned difficulties

Response	Frequency	Percentage (%)
Cost-related issues	52	25%
Accessibility issues	68	32.5%
Challenges in evaluating higher-order skills, including critical thinking and creativity	142	67.5%
Lack of training	79	37.5%
Problem with the text captured by your camera. It inherits incapacity, lack of diligence, and laziness.	5	2.5%

Note: The total percentage exceeds 100% due to multiple responses.

The results show that teachers who are skeptical about AI often point to several barriers: 67.5% mention its inability to assess complex competencies, 32.5% cite limited accessibility, 25% highlight financial constraints, and many also report a lack of adequate training 37.5%.

The question "In your opinion, what are the contributions of AI to assessment and automatic remediation?" is a multiple-choice closed-ended question, allowing teachers to select several responses from five proposed options. The aim is to identify the perceived contributions of artificial intelligence in the context of educational assessment and automated remediation. The results are presented in the following Table 18.

The results identify four main ways teachers see AI contributing to assessment and automatic remediation. The most frequently cited is classifying learners according to their difficulties 53%, which helps group students based on their specific challenges. Designing personalized teaching systems

and adapting instruction to individual needs were both selected by 40.9% of teachers, showing that AI is valued for tailoring learning experiences. Finally, 34.8% highlighted AI's role in creating inclusive and interactive learning environments.

Table 18. Teachers' perceptions of AI contributions to assessment and automatic remediation

Response	Frequency	Percentage (%)
Identifying and categorizing learners according to their specific learning difficulties	111	53%
Developing effective systems for personalized instruction	86	40.9%
Providing adaptive instruction based on individual learner needs	86	40.9%
Learner support through interactive and inclusive environments	73	34.8%
There is a strong need for training among both teachers and learners	3	1.5%

"Are you in favor of or against the use of AI in the assessment and automatic remediation process?" is a single-choice closed-ended question asking teachers whether they consider AI useful in addressing the previously identified challenges. Respondents were required to choose one of the following five options: *Strongly disagree, Disagree, Neutral, Agree*, or *Strongly agree.* The results are presented in the following Table 19.

Table 19. Teachers' opinions on the use of AI in assessment and automatic remediation

Response	Frequency	Percentage (%)
Strongly disagree	25	12.1%
Disagree	25	12.1%
Neutral	51	24.2%
Agree	70	33.3%
Strongly agree	32	15.2%

The results show that a majority of respondents support the use of AI in assessment and automatic remediation, with 33.3% selecting "Agree" and 15.2% "Strongly Agree." About 24.2% expressed a neutral opinion, while 27.3% in total reported disagreement ("Disagree" or "Strongly Disagree").

Table 20. Teachers' training needs for integrating AI into assessment and remediation practices

Response	Frequency	Percentage (%)
Need for pedagogical and technical support	60	28.8%
Training needs related to programming languages	86	40.9%
Enhancing teachers' digital competencies	73	34.8%
Professional training on how to use artificial intelligence tools	130	62.1%
Engaging with AI professional communities for meaningful career development	63	30.3%
AI tools training	3	1.5%
Joining AI communities for career development	3	1.5%
Providing free software	3	1.5%
Adaptive training in planning and managing time and task types	3	1.5%

Note: The total percentage exceeds 100% due to multiple responses.

Question "What types of training do you need to integrate AI into your assessment and remediation practices?" is a multiple-choice closed-ended question allowing teachers to select several options from six proposed modalities. The aim is to identify the types of training teachers consider necessary for effectively incorporating AI into their assessment and remediation practices. The results are presented in Table 20.

The results show that 62.1% of teachers express a need for specific training on artificial intelligence, while 40.9% seek training on new technologies more broadly. Additionally, 34.8% wish to strengthen their technical skills, 28.8% request guidance and practical support, and 30.3% express interest in joining communities of practice for peer-based learning.

V. Discussion

The results of this study confirm that diagnostic and formative assessments are deeply embedded in the teaching practices of Moroccan physics and chemistry teachers, showing a strong commitment to understanding students' starting points and adapting instruction accordingly. Yet, the reported challenges—such as low student motivation, difficulties in grouping learners, and the constant pressure of time—reveal that applying these assessments in everyday practice is far from easy. These findings make it clear that teachers need greater institutional support and practical, user-friendly tools to make assessment more efficient and allow them to focus on what matters most: meaningful feedback and learning progress.

An important insight from this study is the contrast between teachers' generally positive view of AI and their continued dependence on traditional, paper-based approaches. This paradox can be explained by several factors specific to the Moroccan context: limited and uneven digital infrastructure, particularly in rural areas; large class sizes that make innovation harder to implement; and the pressure of completing a demanding curriculum that leaves little time for experimentation. Financial barriers and the absence of sustained technical support further explain why many teachers hesitate to adopt AI-based solutions.

These barriers can be interpreted through the lens of the Technology Acceptance Model (TAM), which explains that users' adoption of technology depends primarily on two factors: perceived usefulness and perceived ease of use. In our case, while Moroccan teachers recognize the usefulness of AI tools for improving assessment and remediation, the lack of training, technical support, and digital infrastructure significantly lowers their perceived ease of use. This theoretical interpretation helps explain why teachers' generally positive attitudes toward AI do not necessarily translate into effective classroom implementation.

When placed in an international perspective, these results highlight that Morocco's digital transition in education is advancing more slowly and unevenly than in many other regions. While teachers elsewhere increasingly use adaptive platforms and automated feedback systems, Moroccan educators still face structural hurdles that prevent full integration. This suggests the need for a context-specific national strategy that invests in infrastructure, ensures equitable access, and provides affordable and practical tools for teachers.

This divergence from studies conducted in technologically advanced contexts refines the current understanding of teachers' readiness for AI, suggesting that motivation alone is insufficient when systemic barriers persist. Our findings therefore contribute to a more nuanced view of AI adoption

in education, emphasizing the importance of context-sensitive strategies that align technological innovation with local teaching conditions

This study makes a unique contribution by exploring not only teachers' perceptions of AI, but also their actual classroom practices and training needs. Few studies have addressed these three dimensions together, especially in the Moroccan context. What makes this study distinctive is its comprehensive approach that integrates three key dimensions—teachers' perceptions, classroom practices, and professional training needs—within a single analytical framework. While many previous studies have focused on specific aspects of artificial intelligence in education, such as adaptive learning environments [4, 5, 12], or intelligent tutoring systems [12, 30], our research provides a more holistic and context-sensitive understanding of AI adoption among Moroccan physics and chemistry teachers. By combining quantitative data with teachers' reported experiences, this study reveals how pedagogical, institutional, and motivational factors interact to shape teachers' readiness for AI integration. This multidimensional perspective complements more technical and model-based research [8, 10, 23, 24] by emphasizing the human and contextual dimensions of AI use in education. It also extends recent Moroccan studies [50–55] by addressing the gap between theoretical awareness and practical implementation, offering new insights into how AI integration can be adapted to local educational realities.

By combining quantitative data with teachers' reported challenges, this research helps fill a gap in the literature and offers evidence-based guidance for decision-makers.

Looking ahead, several paths can be explored. Pilot projects could test how AI-based diagnostic and formative tools affect student engagement and learning outcomes. Long-term studies could show whether training and institutional support truly change classroom practice over time. At the policy level, creating hands-on professional development opportunities and fostering communities of practice would give teachers the confidence and skills they need to integrate AI into their teaching in a meaningful way.

To translate these findings into practical actions, several recommendations can be proposed. For teachers, continuous professional development programs should focus on AI literacy, the use of adaptive assessment platforms, and strategies for interpreting data-driven feedback. For policymakers, institutional support mechanisms are essential, including investment in digital infrastructure, equitable access policies, and incentives that encourage AI experimentation in schools. For educational institutions, collaborative initiatives between teachers, researchers, and IT specialists can facilitate the contextual adaptation of AI-based assessment tools and ensure sustainable implementation.

Collectively, these recommendations aim to transform teachers' positive attitudes toward AI into concrete pedagogical practices, fostering a more equitable, data-informed, and innovative educational ecosystem.

The results of this study reveal a clear and growing interest among Moroccan physics and chemistry teachers in the integration of artificial intelligence, particularly in assessment and remediation processes. These findings echo prior research emphasizing the potential of AI to enhance teaching efficiency through adaptive learning pathways, real-time performance analysis, and personalized feedback mechanisms [12, 22, 38] However, they extend this body of work by showing that, despite positive perceptions, effective classroom integration remains limited in the Moroccan context due to structural constraints such as insufficient infrastructure and lack of institutional support. In our context, teachers expressed confidence in AI's ability to support diagnostic, formative, and summative assessments—especially by helping to identify student difficulties and adjust instruction accordingly—thus confirming the value of intelligent tutoring systems discussed in the literature [4, 9, 29].

Nonetheless, while teachers show enthusiasm toward AI's potential, they also reported a number of limitations, notably the lack of training, limited access to digital tools, and uncertainty about how to implement AI effectively in daily classroom practice. These challenges are consistent with structural barriers documented in previous Moroccan studies [50, 53, 59] which highlight the gap between theoretical awareness and practical integration.

What makes this study distinctive is its simultaneous examination of attitudes, classroom practices, and specific training needs. The results suggest that for AI to be meaningfully integrated into science education, efforts must focus not only on raising awareness but also on providing sustained pedagogical support and technical capacity building. This aligns with recent calls for tailored professional development and collaborative learning environments that empower teachers to use AI tools as complements to their instructional methods [48, 50, 52].

VI. Conclusion

In conclusion, this study demonstrates that teachers actively engage in diagnostic, formative, and summative assessment, yet continue to face significant obstacles such as time constraints, heterogeneous learner needs, and insufficient training. Despite these challenges, there is a strong belief that AI has the potential to enhance assessment and remediation by enabling personalized learning, automating reporting, and supporting adaptive evaluation practices. In practical terms, AI can support teachers through tools such as automated grading or adaptive grouping of students, helping to ease workload and address classroom diversity. These concrete applications illustrate how AI could directly respond to the challenges reported by teachers in this study. This work makes a valuable contribution by documenting teachers' perceptions of AI within the Moroccan educational context—an area that remains underrepresented in the existing literature. The findings underscore the importance of targeted professional development and the design of digital tools that are context-sensitive and responsive to classroom realities.

However, this study has certain limitations. The data are based on teachers' self-reported practices, which reflect their perceptions and may not fully capture actual classroom behaviors. Moreover, the focus on physics and chemistry teachers provides specific but limited insight, as many of the challenges identified—such as training needs, access to digital tools, and institutional support—extend across

disciplines. Additionally, because the research design was cross-sectional, it could not capture the evolution of teachers' practices over time.

Future research should therefore consider longitudinal designs that examine how teachers' integration of AI evolves, as well as larger and more diverse samples to enhance representativeness. Combining quantitative surveys with qualitative methods such as interviews and classroom observations could provide deeper insights into teachers' experiences, beliefs, and the long-term impact of AI-based tools on teaching and learning outcomes.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

S.G., H.F analyzed and interpreted the data. K.E.K. and F.O supervised the work. Also, S.G wrote the paper. All authors had approved the final version.

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