AI-Based Tools: Exploring the Perceptions and Knowledge of Moroccan Future Teachers Regarding AI in the Initial Training—A Case Study

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***Abstract*—The integration of Artificial Intelligence (AI) in education, particularly in the initial training of future teachers, is a crucial area of growing interest. This study explores the knowledge and perception AI-based tools in education among future Moroccan teachers. Employing a quantitative, descriptive, and exploratory design, a validated questionnaire was administered to a simple random sample of 767 future teachers at the Higher Normal School (ENS) of FEZ. Robust statistical methods were employed to analyze the data.**

The findings demonstrate that future teachers possess some knowledge of AI-based tools and hold a favorable perception of their potential. While, gender significantly influences the level of knowledge, with male teachers demonstrating slightly higher levels than woman, In contrast, it does not significantly affect future teachers' perceptions. Additionally, Academic level of the initial training affects both the degree of knowledge and perception of AI-based tools, with first-year future teachers exhibiting less knowledge and perception than those in their third year. Finally, the future teachers' specialty did not indicate any significant relationship with their level of knowledge or perception. This study contributes to the literature by investigating a topic with limited research in the Moroccan context.

***Keywords*—future teachers, AI-based tools, artificial intelligence, initial training, perception, knowledge, teaching**

I. Introduction

Artificial Intelligence (AI) has rapidly evolved, defying a single, universally accepted definition [1]. Characterized by its ability to solve complex problems using human-like reasoning [2, 3]. Its origins date back to 1943 when McCulloch and Pitts attempted to design an artificial neuron as a way to mimic the functioning of the human brain through electrical charges [4]. In 1956, John McCarthy coined the term Artificial Intelligence during a Dartmouth conference organized by Marvin Minsky and John McCarthy [5, 6]. AI has become an integral part of our lives, impacting various sectors like healthcare, finance, and education [7–9].

AI technologies are revolutionizing various application fields by leveraging Machine Learning (ML), Deep Learning (DL), and big data. ML algorithms enable systems to learn from data and improve their performance over time, making them ideal for applications like predictive analytics, recommendation systems, and fraud detection. DL, a subset of ML, utilizes neural networks with many layers to analyze complex patterns in large datasets, excelling in image and speech recognition, natural language processing, and autonomous vehicles. Big data provides the vast amount of information required to train these AI models, allowing for more accurate predictions and insights. Together, these approaches enable powerful AI applications that enhance efficiency, accuracy, and innovation across sectors [10–12].

The advanced growth of AI generates interest due to its potential and technical performance, not to mention ethical considerations. The use and integration of AI must be legitimate, in line with established laws, regulations, and values [13]. It should be robust, harmonious, and balanced from both technical and social perspectives [8]. Authors have identified key applications of AI in education, such as virtual personalized tutoring, automated assessment and feedback, adaptive learning and personalization, as well as prevention and detection of school dropout [14–16].

Therefore, AI has permeated and influencing pedagogical tools, learning methods, access to knowledge, and teacher training. The Director-General of UNESCO has highlighted the significant impact AI is expected to have on education [17, 18]. This perspective is supported by Gherheș and Obrad, who observed a broadly positive attitude towards AI and its potential benefits across various societal domains [18].

While a body of research indicates a generally positive perception of the potential of AI and its associated tools within educational settings [18–22]. However, a critical gap persists between these positive attitudes and the actual implementation of AI-based tools within classrooms. This ongoing discrepancy highlights the crucial need to equip educators with the necessary skills, knowledge and training to effectively integrate these tools into their teaching practices [23, 24].

In this regard, its use and integration can have impact on the initial training of future teachers, on learners' outcomes, on the improvement of success rates, and on the acceleration and optimization of teaching tasks for educators [7].

Thus, the initial training period holds a crucial place in enhancing the skills and development of future teachers, preparing them to play their required roles [6]. In this sense, Higuera announces, "*If we accept that AI is an important element of tomorrow's landscape, what skills and competencies should be included in the curriculum, and how should teachers be trained to play the required* *role*" [25–27].

Overall, a positive trend exists regarding the perceived value of AI in education. However, addressing the gap between positive attitudes and actual implementation requires strategies to empower educators with the skills needed to effectively leverage AI tools in the classroom. This includes not only professional development programs but also potentially revising curricula to address the evolving needs of educators in an AI-driven educational landscape.

Against this backdrop, the present study seeks to investigate the perceptions and knowledge of future Moroccan teachers regarding AI-based tools within their initial training program. Employing a case study approach focused on the Higher Normal School (ENS) of FEZ, the research utilizes a quantitative, descriptive, and exploratory methodology. Data collection primarily relies on a paper-based questionnaire administered to a simple random sample of future teachers enrolled at ENS of FES. These participants represent various specializations (primary, scientific, and literary) and academic level (1st, 2nd, and 3rd). To analyze the data, robust statistical methods were employed, including frequency analysis, the Mann-Whitney U test, and the non-parametric Kruskal-Wallis one-way ANOVA. These techniques were used to examine the relationships between key study variables.

II. Literature Review

A. Artificial Intelligence

Artificial Intelligence (AI) is a complex and rapidly evolving field, rendering a definitive definition elusive. Originating in the mid-20th (1930s) century with early attempts to simulate human brain function [4], AI has since become an integral part of contemporary society. Alan Turing's seminal work on machine intelligence, formalized through the Turing test, established a benchmark for evaluating AI systems' ability to exhibit human-like behavior [22, 28].

To achieve human-level intelligence, AI systems require capabilities such as natural language processing, knowledge representation, reasoning, and machine learning. The latter is crucial for enabling systems to learn from data and improve performance over time. Furthermore, computer vision and robotics are essential for AI's interaction with the physical world [4, 5, 11, 29, 30].

Coined by John McCarthy in 1956, the term "artificial intelligence" encapsulates the broader aspiration to create intelligent agents [30]. As Ganascia indicates "*AI as a new science was based on the conjecture that all cognitive faculties, especially reasoning, calculation, perception, memorization, even scientific discovery or artistic creativity, could be described with such precision that it should be possible to reproduce them using a computer*" [31, 32].

Today, AI is characterized by its reliance on high-performance algorithms capable of learning, reasoning, and executing tasks that traditionally required human intelligence.

B. AI Application Domains

AI's influence extends across numerous disciplines, drawing upon methodologies from computer science, mathematics, and statistics. Its foundations are rooted in the pioneering work of McCulloch and Pitts, who modeled artificial neurons in 1943. Turing's concept of machine intelligence, introduced in the Turing test, laid the groundwork for evaluating AI systems' capacity to exhibit human-like behavior [28–30].

Contemporary AI encompasses a broad spectrum of applications, including robotics, autonomous systems, and natural language processing. Machine learning, a subset of AI, has become instrumental in driving advancements across industries. Moreover, AI has shown significant potential in the realm of education, with applications ranging from intelligent tutoring systems to automated assessment tools [20].

1) AI and education: Use of AI in teaching

The integration of AI within educational environments holds transformative potential for teaching and learning practices. AI-based tools present numerous opportunities to enhance educational outcomes, as evidenced by recent studies [6, 15, 16, 22, 33–36]. These opportunities include:

- Virtual Personalized Tutoring: AI systems provide individualized support by tailoring content and teaching methodologies to the specific needs and levels of learners, thereby facilitating personalized learning experiences.
- Automated Assessment and Feedback: AI can automate assessment processes and deliver prompt feedback, quickly identifying learning gaps and enabling targeted interventions and corrective measures.
- Adaptation and Personalization of Learning: AI facilitates the development of adaptive learning systems that customize educational experiences based on detailed analyses of learner performance and preferences.
- AI-Powered Tools in Classroom Monitoring and Visual Analysis: Leveraging sensors and AI technologies enables the monitoring of classroom dynamics and the analysis of teaching methodologies and student interactions. These tools offer precise data on student engagement, such as attention levels and participation, allowing educators to adjust instructional strategies and improve teaching effectiveness. Additionally, AI can provide recommendations for corrective actions and enhancements to the learning process, thereby elevating educational quality.
- Prevention and Detection of School Dropout: AI systems can identify early warning signs of potential school dropout by analyzing patterns in student behavior, interactions, and attendance.
- Digital Games-Based Learning ("Educational Simulations" or "Adaptive Learning Games"): AI-enhanced educational games and simulations offer significant advantages by dynamically adjusting game difficulty and challenges based on real-time analysis of student interactions. This approach maintains an optimal level of challenge that is motivating and conducive to effective learning.

Furthermore, AI tools such as chatbots, Virtual Reality

(VR), Augmented Reality (AR), Mixed Reality (MR), validity and adaptive testing, plagiarism checkers, automatic essay writing, and others, provide numerous opportunities to enhance training, learning, and teaching. They contribute to creating more personalized, engaging, and effective educational experiences [22, 33].

In a study titled "An Exploratory Study of Pre-service Teacher Perception of Virtual Reality and Artificial Intelligence for Classroom Management Instruction", participants recognized AI and VR as pivotal tools for future educational settings. Moreover, these innovations are used to improve the quality and efficiency of teachers and teaching as a whole. As well, AI and VR can help teacher trainees in overcoming pedagogical challenges [37].

2) AI and education: Impact of AI on education

While the Brookfield Institute and Entrepreneurship report identifies teaching as a relatively stable profession in the face of automation, it emphasizes that AI enhancing the capabilities of educators rather than replacing them [17]. Nevertheless, AI is poised to significantly transform educational practices [38] making the profession more attractive while retaining traditional aspects that have enriched it for centuries [8].

The integration and use of AI can have a direct impact on the teaching and learning process. AI contributes to increasing the efficiency of both teaching and learning through innovative, learner-centered methods and techniques. By automating routine tasks, AI frees up teachers' time, allowing them to focus more on individualized instruction. According to Microsoft research, AI can free up to 30% of teachers' time. Furthermore, personalized teaching facilitated by AI has been shown to improve success rates, with learners in AI-assisted learning environments outperforming 98% of those in traditional settings [39]. AI can also act as a supervisor through intelligent tutoring agents, fostering learner autonomy in self-directed learning [7, 8, 40, 41].

Slimi and Carballido [14] reveals that AI has a transformative effect on the quality of teaching and learning. The key findings include:

- AI facilitates learners' communication and interaction with the world.
- AI advances the personalization of teaching.
- AI promotes creative problem-solving, effective time management, and collective communication.
- AI enhance cognitive abilities, adaptability to learning, and decision-making speed.
- AI increases the efficiency of strategic planning and the instructional process.
- AI augments the accuracy of predicting students at risk and accelerates data mining processes.

3) AI-based tools and initial teacher training

AI-based tools have increasingly become a global phenomenon and a prominent fixture within educational systems. These tools are now ubiquitous across various platforms, including smartphones, applications, web browsers, desktop publishing software, and search engines. Concurrently, future teachers of the 21st century, who are inherently engaged with digital technologies, utilize these tools extensively in both their personal and professional lives, including for self-directed learning and skill development.

Given this context, initial teacher training programs must prioritize the integration of digital technologies, particularly AI-based tools. This approach will ensure that future educators remain aligned with global advancements and can effectively navigate the era of intelligent education and Education 4.0. Incorporating AI into training programs can significantly impact the quality of initial education, enhance learning outcomes, and streamline pedagogical tasks [7], For instance, prospective teachers might use AI-powered simulations to refine classroom management techniques or receive tailored feedback on lesson planning.

To fully capitalize on these advantages, it is imperative that future teachers develop a thorough understanding of AI-based tools and acquire the requisite skills to meet contemporary educational demands [26, 42]. Essential competencies include:

- A clear comprehension of how AI systems facilitate learning.
- Proficiency in using AI applications, software, and tools.
- Research and data analysis skills.
- Practical experience with AI-based tools in educational settings.
- Integration of AI in pedagogical practices and content preparation.
- The ability to guide learners and impart knowledge about AI within an ethical framework.

According to the Beijing Consensus, AI should serve education, teachers, learning, evaluation, values, and skills [43]. UNESCO Director-General states that "*educational tools, learning methods, access to knowledge, and teacher training will undergo a revolution*" [44].

Yang and Chen [45] indicates a growing interest among teacher trainees in utilizing AI tools for instructional purposes and content organization. Conversely, Zhang *et al.* [42] reveals that media representations often shape teachers' perceptions of AI, leading to concerns about AI replacing educators and highlighting knowledge gaps regarding AI's contributions to teaching and learning. This suggests a need for enhanced AI-related knowledge and skills among future teachers. Consequently, initial teacher training programs should be reassessed to better support the integration of AI and intelligent tools, addressing the gap between the potential interest in AI and its perceived ease of use among future educators.

C. Recent Studies on the Perception of AI-Based Tools

AI is poised to revolutionize education by transforming pedagogical tools, learning methods, knowledge accessibility, and teacher training, as emphasized by UNESCO's Director-General. This sentiment is widely shared among experts and stakeholders. However, to fully harness AI's potential, it is imperative to address challenges such as digital inequality and algorithmic bias. A thoughtful approach is essential to ensure that AI integration benefits all learners without exacerbating existing educational disparities [17, 44]. This perspective aligns with the findings of research by Gherheș and Obrad [18], which indicate a positive attitude towards the emergence of AI and its potential benefits across various societal domains, primarily the field of education.

While Jeffrey [19] and Sangapu [20] indicate a generally positive perception of AI among educators, a discrepancy exists between this positive outlook and its practical implementation in classrooms. This gap is exacerbated by the public's complex understanding of AI, characterized by both optimism and apprehension about its impact. Increased knowledge about AI intensifies these contrasting perceptions, contributing to a societal tension surrounding the technology's rapid advancement and uncertain consequences.

Galindo-Domínguez [23] investigating AI use in Spanish classrooms, primary, secondary, and higher education, found that despite a positive outlook on AI in education, only 25% of teachers integrated AI tools. The most commonly used tools were ChatGPT, Dall-E, and Midjourney. Primary and secondary school teachers mainly use AI for content creation, such as presentations, texts, or videos, without emphasizing student engagement with AI tools. In contrast, higher education teachers use AI for academic-technical purposes, such as explaining AI functioning, obtaining information, enabling students to experiment with AI tools, and research-related tasks like text translation and data analysis. These findings suggest that AI training programs for educators should be tailored to each educational stage and incorporate a wider variety of AI-based tools beyond the commonly used ones like ChatGPT. Similarly, another study focusing on Korean teachers' perceptions of AI showed favorable attitudes towards AI education for teaching and its future use but emphasized the need for effective professional development programs to bridge the gap between perception and practical application [24]. This highlights the importance of not only fostering positive perceptions but also equipping educators with the skills and knowledge to integrate AI effectively.

Subsequent research indicates a favorable trend in the perception of AI and its utility in educational settings. The findings of the study conducted by Idroes *et al.* [21] revealed a generally positive perception of the utility of AI in education.

While international perceptions of AI-based tools are generally positive, a limited research base exists on this topic in the Moroccan educational context. Several factors contribute to this gap. The integration of AI in education is a relatively new phenomenon in Morocco, and many Moroccan educational institutions have limited access to AI technologies and resources, hindering the practical implementation and study of these tools. Additionally, the curriculum for teacher training programs in Morocco has not yet fully incorporated AI-related content or AI-based tools, leading to a lack of exposure and awareness among future teachers.

To address these issues, this study seeks to bridge the gap by exploring the knowledge and perceptions of future Moroccan teachers enrolled in initial training programs regarding AI-based tools in education. Understanding these perspectives is essential for aligning teacher training with the requirements of Education 4.0 and the digital and intelligent era, particularly within the specific context of Morocco, as exemplified by a case study at ENS of FES.

Drawing upon the identified research gap and a comprehensive review of the existing literature, this study posits four research questions.

Research questions:
1) To what extent do future teachers possess knowledge of AI-based intelligent teaching tools?
2) How do future teachers perceive AI-based intelligent teaching tools, in terms of positive or negative trends?
3) What is the level of motivating among future teachers to utilize and integrate AI-based teaching tools into their pedagogical practices during initial training?
4) How do gender, specialization, and academic level of the initial training actively influence future teachers' knowledge and perceptions of AI-based tools?

III. Materials and Methods

A. Procedure

Quantitative data collection for this exploratory descriptive study was conducted during the winter semester of the academic year 2023–2024. A paper-based questionnaire was administered to a sample of future teachers enrolled in initial training programs at the ENS of FEZ, Morocco. Participants represented various specializations (primary, scientific, and literary education) across all three academic levels of initial training (1st, 2nd, and 3rd years). To ensure anonymity, voluntary participation and informed consent were obtained from all respondents.

B. The Simple

A sample of 767 participants was selected from the Higher Normal School (ENS) of FEZ, representing a response rate of 92.96% (n = 767/825). This sample comprised prospective teachers enrolled in various teacher-training programs. To ensure a representative sample, a simple random sampling method was employed, granting all eligible participants an equal probability of selection. This approach aimed to minimize sampling bias and enhance the study's reliability by capturing the diverse characteristics of the target population.

C. Participants

Participants in this study were future teachers in initial training, including 181 (23.6%) male and 586 (76.4%) women, from various teacher training programs and academic levels of the initial training. They comprised future primary education teachers (n = 172), future science education teachers (n = 355), and future literature education teachers (n = 240). Among the participants, 269 were 1st year future teachers, 256 were in the 2nd year, and 242 were in the 3rd year. The majority of participants are in the age group of 18 to 24, with an average age of 21. Most possess only a high school diploma (BAC), and less than 10% hold a university general studies diploma (BAC+2). They volunteered, all consented to this study, and willingly participated. The table below (Table 1) and (Fig. 1) presents the relevant data:

Table 1. Demographic characteristics of participants (future teachers)

Variable	Demographic	Frequency	Percent	Valid Percent
Gender	Man	181	23.6	23.6
	Woman	586	76.4	76.4
Academic Level	1st year	269	35.1	35.1
	2nd year	256	33.4	33.4
	3rd year	242	31.6	31.6

Specialty	Primary	172	22.4	22.4
	Scientist	355	46.3	46.3
	Literary	240	31.3	31.3
Diploma	BAC	700	91	91,26
	BAC+2	67	9	8,74
Age range	18–24	767	100	100

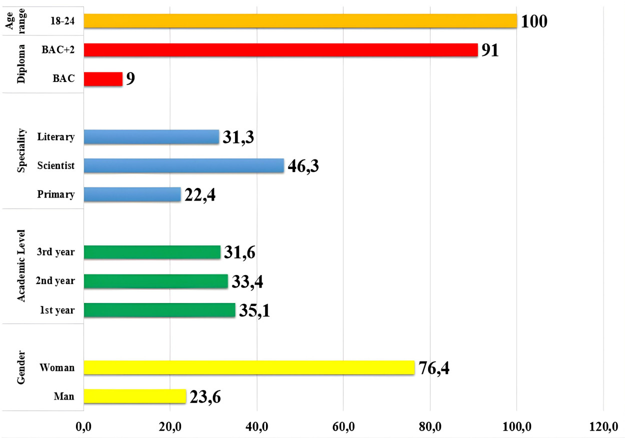

Fig. 1. Demographic characteristics graphic representation.

D. The Instrument

For this research, we adopted a quantitative approach utilizing a questionnaire designed to collect measurable and statistically analyzable data. The survey was conducted at the ENS of FEZ and comprised three sections, totaling16 items.

The first section gathered demographic information, including gender, specialization, and academic level of the initial training. The second section contained five questions related to the knowledge of AI and intelligent tools in education. The third section included items assessing the perception of AI and intelligent tools in education.

We utilized a three-point Likert scale for the items in the second and third sections. This choice is justified by its:

- Simplicity and ease of use for participants.
- Adequate discrimination between response options.
- Alignment with our research objectives of measuring knowledge and perception.
- Consistency with common practices in educational research.
- Ease of interpreting the results.

The scale ranges from 1 (weaker response) to 3 (stronger response) to measure the degree of knowledge and perception of future teachers regarding AI-based tools in education. The items in the first section were presented as follows: gender in a dichotomous nominal style (Man/Woman) and academic level and specialization in a nominal style.

Several steps were followed in developing the questionnaire:

- Define the main objective of the questionnaire to clearly identify what is being measured.
- Develop relevant, clear, and precise questions.
- Structure the questionnaire into three main sections.
- Test the questionnaire with a small, randomly selected sample of the target population (45 future teachers), before the final data collection.
- Distribute the questionnaire to six university professors for feedback and make adjustments based on their remarks, evaluating clarity, comprehension, question formulation, relevance, linguistic correctness, and word choice.
- Test the reliability and validity of the questionnaire.
- Collect data and distribute the questionnaire in paper format, adhering to ethical and confidentiality protocols.

E. Reliability, Factor Analysis, and Confirmatory Analysis

Initially, content validation of the questionnaire was sought from six expert teachers in scientific research, resulting in minor modifications. Subsequently, based on the feedback and instructions received, certain questions were paraphrased. Following this, a pilot test of the questionnaire was conducted with a small, randomly selected sample of the target audience (45 future teachers in initial training from various specialties and academic levels at ENS of FEZ). The questionnaire was deemed [46] reliable, with a determined reliability coefficient of 0.761 using Cronbach's alpha and 0.761 for McDonald's Omega. As we observe in Table 2 our coefficient indicates acceptable internal consistency. According to the empirical rule for assessing the value of Cronbach's alpha provided by George and Mallery [47].

Table 2. Reliability statistics

Mean	SD	Cronbach's α	McDonald's ω
2.27	0.313	0.761	0.761

Subsequently, we examined the inter-item correlation to identify linear relationships between variables and obtain insights into the presence of groups of correlated variables. This analysis aimed to determine whether these variables share a common cause represented by a latent factor. With a *p*-value of less than 0.05, it suggests that Exploratory Factor Analysis (EFA) might be a useful tool for further analysis.

The inter items correlation, illustrated in the correlations heatmap (Fig. 2) show that the Pearson correlation coefficient (r) tends to approximate 0.500, with p-value generally less than 0.001. Most questions exhibit a moderate positive correlation with one another and no negative correlations were identified among the items.

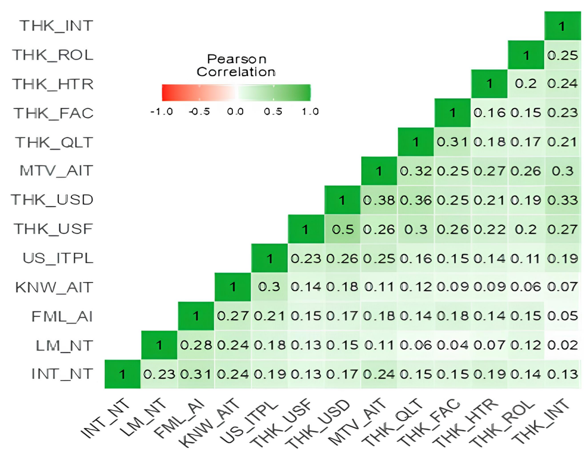

Fig. 2. Correlations heatmap.

Given the utility of EFA and based on descriptive statistics, we observe that the Shapiro-Wilk *p*-value is <0.001 (Table 3), indicating that the distribution does not follow the normal distribution, and a lack of normality persists.

Table 3. Statistiques descriptives

Items	Shapiro-Wilk *p*-value
INT_NT	< 0.001
LM_NT	< 0.001
FML_AI	< 0.001
KNW_AIT	< 0.001
US_ITPL	< 0.001
THK_USF	< 0.001
THK_USD	< 0.001
MTV_AIT	< 0.001
THK_QLT	< 0.001
THK_FAC	< 0.001
THK_HTR	< 0.001
THK_ROL	< 0.001
THK_INT	< 0.001

The significant result from the Bartlett's test of Sphericity (Table 4), with a p-value less than 0.001 confirm the aforementioned deductions. This test suggests that the null hypothesis (H0) of an identity correlation matrix can be rejected, indicating a significant structure in the correlation matrix of the observed variables. This demonstrates that the variables are sufficiently correlated, sharing some underlying relationship, which provides a reasonable basis for EFA.

Table 4. Bartlett's test of sphericity

χ^2	Df	P
1497	78	<0.001

The Kaiser-Mayer-Olkin (KMO) measure was determined to be 0.835, as shown in Table 5, indicating that there are enough elements to produce a factor and consequently excellent "factorability" of the data.

Table 5. KMO Measure of sampling adequacy

Items	MSA
INT_NT	0.830
LM_NT	0.783
FML_AI	0.805
KNW_AIT	0.788
US_ITPL	0.856
THK_USF	0.818
THK_USD	0.812
MTV_AI	0.859
THK_QLT	0.864
THK_FAC	0.859
THK_HTR	0.883
THK_ROL	0.859
THK_INT	0.845
Overall	0.835

In conclusion, an EFA was performed using the "Principal Axis" factor extraction method with a "Promax" rotation to reduce the dimensionality of the data and identify underlying structures.

Based on the "total variance explained" presented in Tables 6 and 7, two components had an eigenvalue greater than 1 (Factor_1 = 2.22 and Factor_2 = 1.23). indicating that these factors should be extracted.

- Latent Factor_1 represents "PERCEPTION": the factor loading of the item THK_USD with the highest contribution value (0.658) among all contributing elements indicates its strong association with Latent Factor_1. Additionally, THK_ROL has the lowest contribution value (0.348), although it still indicates an association with the component. The other elements (5 items) also show moderate contributions based on their factor loadings.
- Latent Factor_2 represents "KNIOWLEDGE": the factor loading of the item FML_AI with the highest contribution value (0.573) among all contributing elements indicates its strong association with Latent Factor_2. Next, US_ITPL has the lowest contribution value (0.330), although it still indicates an association with the component. The other elements (3 items) also show moderate contributions based on their factor loadings.

The cumulative percentage shows that the two factors explain 26.5% of the total cumulative variance (Latent Factor_1 % 17.08 and Latent Factor_2 %9.46).

Table 6. Factor loadings

Items	PERCEPTION	KNOWLEDGE	Uniqueness
THK_USD	0.658		0.562
THK_USF	0.587		0.662
THK_INT	0.581		0.724
MTV_AI	0.557		0.662
THK_QLT	0.538		0.727
THK_FAC	0.444		0.802
THK_HTR	0.377		0.840
THK_ROL	0.348		0.860
FML_AI		0.573	0.679
KNW_AIT		0.539	0.734
LM_NT		0.525	0.765
INT_NT		0.460	0.747
US_ITPL		0.330	0.784

Table 7. Factor summary

Factor	SS Loadings	% of Variance	Cumulative %
PERCEPTION	2.22	17.08	17.1
KNOWLEDGE	1.23	9.46	26.5

According to Table 8, the correlation between Factor_1 and Factor_2 (0.513) indicates a moderate positive relationship. This positive association suggests that individuals with stronger knowledge tend to have a more favorable perception of AI-based tools. This relationship could be explained in two ways: either improved knowledge fosters a more positive perception of these tools, or a positive perception might motivate individuals to acquire more knowledge about them.

Table 8. Inter-factor correlations

Factor	PERCEPTION	KNOWLEDGE
PERCEPTION	------	0.513
KNOWLEDGE		------

As observed in Table 9, the reliability statistics, including Cronbach's Alpha and McDonald's Omega, for the two extracted latent factors (PERCEPTION and KNOWLEDGE) indicate moderate and acceptable internal consistency. The observed variables of each component are consistent and reliably measure the two concepts.

Table 9. Scale reliability statistics "Factor"

Factor	Mean	SD	Cronbach's α	McDonald's ω
PERCEPTION	2.09	0.379	0.618	0.621
KNOWLEDGE	2.38	0.370	0.737	0.739

In summary, the results from the EFA allowed the extraction of two latent factors, labeled "KNOWLEDGE" and "PERCEPTION," each with a total variance explained greater than 1. The factor loadings for the items contributing to these components range from moderate to high, indicating a substantial association. The internal consistency of the variables within each factor is considered acceptable. To further validate and confirm the factor structure identified through EFA and to assess the model's overall fit, Confirmatory Factor Analysis (CFA) will be conducted.

The positive factor loadings presented in Table 10 indicate that the two extracted latent factors exhibit a positive association with their respective observed variables. Furthermore, the positive covariance between the two factors, as shown in Table 11 (0.543), indicates a concordance, meaning they tend to vary together in the same direction. This implies that higher levels of knowledge are often associated with a more favorable perception of AI-based tools, and vice versa.

Table 10. Factor loadings

Factor	Indicator	Estimate	SE	Z	p	Stand. Estimate
PERCEPTION	THK_USF	0.375	0.0237	15.83	< 0.001	0.598
	THK_USD	0.452	0.0246	18.41	< 0.001	0.679
	MTV_AIT	0.346	0.0231	15.00	< 0.001	0.571
	THK_QLT	0.332	0.0243	13.66	< 0.001	0.524
	THK_FAC	0.270	0.0241	11.19	< 0.001	0.439
	THK_HTR	0.230	0.0234	9.86	< 0.001	0.391
	THK_ROL	0.227	0.0246	9.23	< 0.001	0.369
	THK_INT	0.309	0.0245	12.58	< 0.001	0.487
KNOWLEDGE	INT_NT	0.311	0.0263	11.81	< 0.001	0.508
	LM_NT	0.227	0.0223	10.18	< 0.001	0.440
	FML_AI	0.323	0.0256	12.62	< 0.001	0.543
	KNW_AIT	0.321	0.0273	11.77	< 0.001	0.506
	US_ITPL	0.313	0.0283	11.05	< 0.001	0.483

Table 11. Factor Covariances

Covariance	Estimate	SE	Z	p	Stand. Estimate
PERCEPTION—KNOWLEDGE	0.543	0.0439	12.4	< 0.001	0.543

Table 12 presents the fits indices for the adjusted measures model, indicating the following values:

- Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI): both indices exceed 0.90, indicating a good fit.
- Standardized Root Mean Square Residual (SRMR): The value is below 0.08, indicating a good fit.
- Root Mean Square Error of Approximation (RMSE): The value is below 0.05, reflecting a good fit.
- Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC): lower values are typically preferred.

These results collectively support a good fit for our model, suggesting that the hypothesized structure, comprising the two latent factors "Knowledge" and "Perception," effectively represents the relationships between the observed variables.

Table 12. Fit measures

CFI	TLI	SRMR	RMSEA	RMSEA 90% CI		AIC	BIC
				Lower	Upper		
0.926	0.910	0.0389	0.0464	0.0380	0.0549	17,292	17,478

F. Data Analysis

The data analysis was conducted using the open-source statistical software JAMOVI 2.3.28 [48]. For this purpose, we opted for a qualitative descriptive approach based on the non-parametric Mann-Whitney U Test and the non-parametric Kruskal-Wallis test (ANOVA).

Our study considers three independent quantitative variables:

- The GENDER of the participants, a dichotomous nominal variable (Male, Woman).
- The Academic Level of the initial training, a nominal variable (1st, 2nd, and 3rd year).
- The SPECIALIZATION of training, a nominal variable (Primary, Scientific, and Literary).

Informed by the identified research questions and drawing upon a comprehensive literature review, this study endeavors to formulate and empirically test seven hypotheses.

H1: Future teachers have satisfactory knowledge of AI-based intelligent teaching tools.

H2: Future teachers tend to perceive AI-based intelligent teaching tools positively.

H3: The level of knowledge of AI-based tools positively influences the perception of future teachers.

H4: Future teachers are motivated to use AI-based intelligent teaching tools in their tasks during initial training.

H5: Future teachers are motivated to integrate AI-based intelligent teaching tools into initial training.

H6: The perception of future teachers toward AI-based tools is influenced by demographic variables: Gender, Specialization, and Academic Level of initial training.

H7: The level of knowledge of future teachers toward AI-based tools is influenced by demographic variables: Gender, Specialization, and Academic Level of initial training.

IV. Result and Discussion

A. Result

1) Frequency analysis

According to the results obtained (Table 13 and Fig. 3), we observe that most future teachers are interested in new technologies (+57.6%), which explains the recorded level of mastery of these technologies (13.6% have an advanced level and 73.4% have an intermediate level). As for familiarity with the concept of AI, a strong majority of future teachers (80%) report familiarity with this concept. Regarding knowledge of AI-based tools in teaching, 56.3% of future teachers reported having average knowledge of these tools, while 31.2% have perfect knowledge. Additionally, 58% of future teachers frequently use some AI-based tools in their personal lives, 22.6% use them every day, and 19.4% use them only rarely.

Table 13. Frequency of KNOWLEDGE factor results

Statements		Indicator	Frequency	Percent (%)
Interested in new technologies	Not at all interested	INT_NT	77	10.04
	interested		442	57.63
	Very interested		248	32.33
Level of mastery of new technologies	Weak	LM_NT	100	13.04
	Moderately		563	73.40
	Alright		104	13.56
Familiarity with the concept of AI	Not at all familiar	FML_AI	143	18.64
	Familiar		495	64.54
	Yes, Very familiar		129	16.82
Knowledge AI-based tools	No way	KNW_AIT	96	12.52
	Moderately		432	56.32
	Yes perfectly		239	31.16
Use of AI-based tools (Personal life)	Rarely	US_ITPL	149	19.43
	From time to time		445	58.02
	Every day		173	22,56

Table 14. Frequency of PERCEPTION factor results

Statements		Indicator	Frequency	Percent (%)
Do you think AI is useful in the field of education?	No not at all	THK_USF	57	7.4
	Yes maybe		330	43.0
	Yes, Absolutely		380	49.5
Do you think AI should be used in the field of education?	Not really	THK_USD	78	10.2
	Yes maybe		303	39.5
	Yes, Absolutely		386	50.3
Motivation regarding the use of AI-based tools (future teaching practices)?	Unmotivated	MTV_AIT	49	6.39
	Yes, motivated		362	47.20
	Yes, Absolutely motivated		356	46.41
Do you think AI can improve the quality of teaching and learning performance?	Slightly	THK_QLT	62	8.1
	Probably		339	44.2
	Certainly		366	47.7
Do you think AI-based tools can facilitate tasks during initial training?	Slightly	THK_FAC	49	6.4
	Probably		268	34.9
	Certainly		450	58.7
Do you think AI can help manage the cognitive heterogeneity of future teachers during initial training?	Not really	THK_HTR	60	7.8
	Maybe		451	58.8
	Yes, Absolutely		256	33.4
How do you perceive the role of the teacher in a learning environment supported by AI?	Not beneficial	THK_ROL	62	8.1
	Quite beneficial		396	51.6
	Very beneficial		309	40.3
Do you think AI should be integrated into the initial training of future teachers?	Not at all necessary	THK_INT	71	9.3
	Quite necessary		383	49.9
	Very necessary		313	40.8

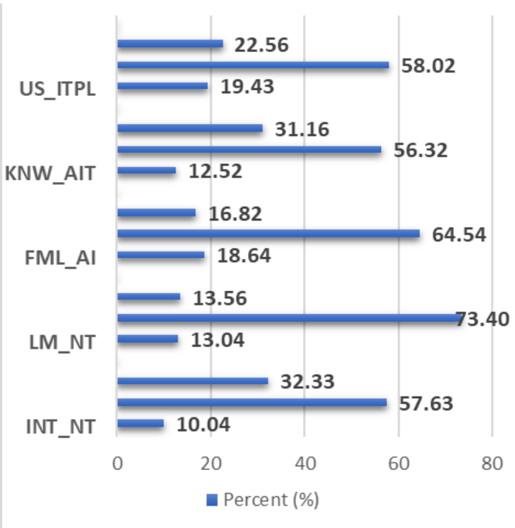

Fig. 3. Knowledge factor graphic representation.

According to the collected responses (Table 14 and Fig. 4), the perception of AI-based tools in teaching shows that 43% of future teachers believe that AI can be useful in the field of education, while 50% consider it absolutely useful, and 7.4% see it as not useful at all. Regarding the necessity of using AI in education, 50.3% of surveyed future teachers believe it is entirely necessary, while only 10.2% think otherwise. Analyzing the responses regarding the motivation of future teachers toward the use of AI-based tools, we note that the rate of responses between those who are motivated and those who are entirely motivated is very close: 47.2% for the former and 46.4% for the latter. Concerning the impact of AI on improving the quality of teaching and learning performance, 47.7% of future teachers believe that this impact is certain, and 44.2% believe it is probable. Regarding the ease of tasks, 58.7% believe that AI will facilitate their tasks, while 34.9% are unsure. Regarding the question of cognitive heterogeneity and the personalization of learning for future teachers during initial training, 58.8% think that AI might help manage this issue, 33.4% see it as entirely useful in this situation, and 7.8% think it cannot help solve this problem. Regarding the interest in the role of the teacher in an AI-supported learning environment, most future teachers believe that the teacher remains important, and only 8.1% believe that the teacher will lose importance. For the question of the necessity of integrating AI into the programs of initial training for future teachers, the majority of respondents believe it is necessary, while 9.3% believe it is not necessary at all.

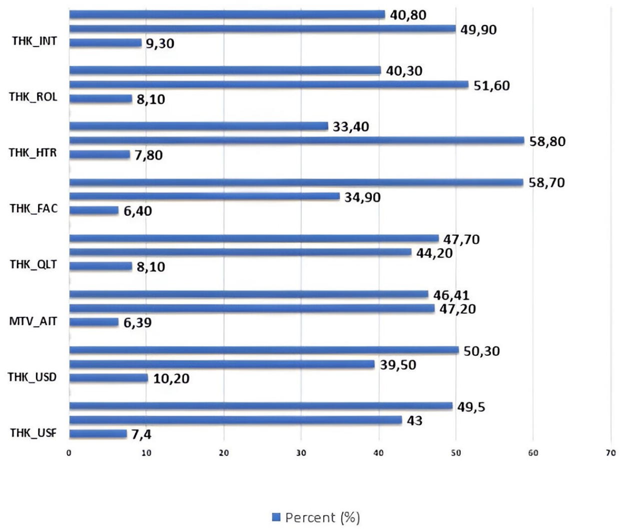

Fig. 4. Perception factor graphic representation.

2) Mann-Whitney U test and Kruskal-Wallis ANOVA analysis

The relationship between "Knowledge", "Perception", and the demographic independent variables "Gender, Specialty and Academic Level of initial training" will be investigated through statistical analysis. The Mann-Whitney U Test and an analysis of variance (ANOVA) will be employed to examine this relationship, contributing to a comprehensive understanding of how individual characteristics influence future teachers' perceptions and comprehension of AI-based tools.

Prior to conducting the Mann-Whitney U test and ANOVA to assess group differences in means, several preliminary analyses were undertaken. The normality of data distribution was evaluated using the Shapiro-Wilk test, while Levene's test was employed to verify the homogeneity of variances. These assessments were crucial to ensure the appropriateness of the selected statistical tests.

To examine potential differences in knowledge and perception of AI-based tools among participant groups, the following null hypotheses were established:

- H0 (Knowledge): There is no statistically significant difference ("equality") between the means of groups (Gender, Academic Level and Specialty) and the degree of knowledge of AI-based tools among future teachers in initial training.
- H0 (Perception): There is no statistically significant difference between the means of groups (Gender, Academic Level and Specialty) and the perception of AI-based tools among future teachers in initial training.

Following normality testing with the Shapiro-Wilk statistic (Table 15), the p-value (< 0.001) indicates a non-normal distribution of the data. Conversely, Levene's test for homogeneity of variances (Table 16) reveals no significant differences between groups (high F-value, $p > 0.05$). Consequently, we fail to reject either null hypothesis (H0).

Table 15. Normality test (Shapiro-Wilk)

Factor	W	p
KNOWLEDGE	0.986	< 0.001
PERCEPTION	0.972	< 0.001

Table 16. Homogeneity of variance test (Levene test)

Factor	F	df	df2	p
KNOWLEDGE	0.783	1	765	0.376
PERCEPTION	0.205	1	765	0.651

Given the non-normality of the data and the absence of significant differences in variances, the non-parametric Mann-Whitney U Test will be employed to examine the relationship between the two factors and the Gender variable (Male, Woman) of prospective teachers. Concurrently, the non-parametric Kruskal-Wallis test will be utilized to analyze the relationship between the two factors and the two independent variables (Academic Levels and Specialty of initial training).

This analysis will be based on the mean scores of the items corresponding to each factor, as per the following formulas:

Factor (Knowledge) = Mean (INT_NT, LM_NT, FML_AI, KNW_AIT, US_ITPL)

Factor (Perception) = Mean (THK_USF, THK_USD, MTV_AIT, THK_QLT, THK_FAC, THK_HTR, THK_ROL, THK_INT)

This approach ensures a robust analysis of the data, accommodating the specific characteristics and distributions of the variables under study.

- **Non-parametric Mann-Whitney U Test:** Impact of Gender differences on Knowledge and Perception

The results for the knowledge factor revealed a statistically significant difference between Male and Woman participants ($U = 42709$, $p < 0.001$, Table 17). As shown in Table 18, Male participants demonstrated significantly higher mean knowledge scores ($M = 2.19$) compared to Woman participants ($M = 2.05$).

Table 17. Independent samples T-Test Mann-Whitney U

Factor		Statistic	p	Mean Difference
KNOWLEDGE	Mann-Whitney U	42709	< 0.001	0.200
PERCEPTION	Mann-Whitney U	52232	0.757	1.71e-5

Table 18. Descriptive statistics of groups

Factor	Group	N	Mean	Median	SD	SE
KNOWLEDGE	Male	181	2.19	2.20	0.364	0.0271
	Woman	586	2.05	2.00	0.378	0.0156
PERCEPTION	Male	181	2.39	2.38	0.369	0.0274
	Woman	586	2.38	2.38	0.371	0.0153

Conversely, the Mann-Whitney U test did not indicate significant differences in perception based on Gender ($U = 52232$, $p = 0.757$, Table 17), suggesting that Gender (for both male and woman participants) does not influence perceptions of AI-based tools among future teachers ((as shown the Mean

(2.38) in Table 18).

- **Non-parametric Kruskal-Wallis test:**

a) Impact of Academic Levels on Knowledge and Perception

Results from the Kruskal-Wallis test indicate statistically significant differences in both knowledge ($p < 0.005$) and perception ($p < 0.005$) of AI-based tools across academic levels (Table 19). These findings suggest a positive relationship between the academic levels of the initial training and the degree of AI-based tools related knowledge and perception.

Table 19. One-way ANOVA (non-parametric Kruskal-Wallis)/LEVEL

Factor	χ^2	df	p	ε^2
KNOWLEDGE	13.3	2	0.001	0.0174
PERCEPTION	11.1	2	0.004	0.0144

Post-hoc pairwise comparisons (Table 20) revealed that first-year prospective teachers exhibited significantly lower levels of AI-based tools related knowledge compared to their third-year counterparts ($p = 0.001$). However, no significant differences were found between first- and second-year ($p = 0.699$) or second- and third-year ($p = 0.020$). These results suggest a progressive increase in AI-based tools knowledge as future teachers advance through their training programs.

Table 20. Dwass-Steel-Critchlow-Fligner pairwise comparisons KNOWLEDGE-LEVEL

Academic Levels		W	p
1st year	2nd year	1.14	0.699
1st year	3rd year	4.96	0.001
2nd year	3rd year	3.80	0.020

Post-hoc comparisons revealed significant differences in perceptions of AI-based tools across academic levels (Table 21). First-year prospective teachers demonstrated significantly lower perceptions compared to third-year counterparts ($p = 0.004$). However, no significant differences were found between first- and second-year ($p = 0.073$) or second- and third-year ($p = 0.511$). These findings suggest a progressive increase in positive perceptions of AI-based tools as future teachers advance through their training programs.

Table 21. Dwass-Steel-Critchlow-Fligner pairwise comparisons PERCEPTION-LEVEL

Academic Levels		W	p
1st year	2nd year	3.10	0.073
1st year	3rd year	4.57	0.004
2nd year	3rd year	1.56	0.511

b) Impact of specialty on Knowledge and Perception

Kruskal-Wallis tests revealed no statistically significant differences in either knowledge ($p > 0.05$) or perception ($p > 0.05$) of AI-based tools among future teachers specializing in primary, scientific, or literary education (Table 22). These findings suggest that the field of specialization does not significantly influence future teachers' understanding or attitudes towards AI-based tools.

Table 22. One-Way ANOVA (Non-parametric)/SPECIALTY

Factor	χ^2	df	p	ε^2
KNOWLEDGE	1.91	2	0.385	0.00249
PERCEPTION	2.05	2	0.360	0.00267

Comparative analysis of knowledge level regarding AI-based tools across the three fields of initial training yielded no statistically significant differences (all $p > 0.05$, Table 23). These findings suggest that the field of specialization does not influence knowledge of AI-based tools among future teachers.

Table 23. Dwass-Steel-Critchlow-Fligner pairwise comparisons KNOWLEDGE-SPECIALTY

Specialty		W	P
Primary	Scientific	−0.784	0.844
Primary	Literary	−1.881	0.379
Scientific	Literary	−1.389	0.588

Table 24. Dwass-Steel-Critchlow-Fligner pairwise comparisons PERCEPTION-SPECIALTY

Specialty		W	p
Primary	Scientific	−1.392	0.587
Primary	Literary	−2.018	0.327
Scientific	Literary	−0.856	0.817

Post-hoc comparisons of perception scores between primary, secondary, and literary fields revealed no statistically significant differences (Table 24). These findings indicate that the area of specialization does not have a discernible influence on future teachers' attitudes towards AI-based tools.

Table 25. Results recap of the relationship between factors and demographic variables

Factor	Gender	Academic Level	Specialty
KNOWLEDGE	YES	YES	NO
PERCEPTION	NO	YES	NO

B. *Discussion*

The present study aimed to explore the knowledge and perception of future teachers regarding AI-based tools in education. To achieve this objective, a survey instrument was administered to collect quantitative data. Correlation analysis and frequency distributions were employed to confirm the hypotheses established (H1–H5). Notably, the results revealed a strong positive correlation between teachers' knowledge and perception of AI, and a significant interest in incorporating these tools into their teaching practices.

- **Relationship between Knowledge and Perception**

A strong positive correlation ($r = 0.513$) was observed between future teachers' knowledge and perception of AI-based tools, indicating that a deeper understanding of these technologies is associated with more favorable attitudes and vice versa [13, 19–22, 24]. This finding aligns with previous research highlighting the importance of comprehensive training in fostering positive perceptions and increased engagement with these educational technologies [49].

- **Future teachers' and knowledge regarding AI-based tools.**

Overall, a favorable interest in new technologies can be observed among most future teachers, explaining their declaration of a moderately proficient level with these innovative tools.

Regarding the familiarity of future teachers in initial training with the concept of AI, the majority of them report a high level of familiarity [50]. This is attributed to the young age of the target audience and their belonging to the millennial generation. They are passionate, even captivated, by everything digital and technological, using these tools daily in their personal and professional lives, for self-learning and training [7].

In light of the obtained statistical results, we observe an above-average knowledge of AI-based tools used in the education sector. These results positively affect the use of tools such as ChatGPT, Gemini, ChatBot, facial recognition, intelligent tutoring, etc., in the personal lives of future teachers [45, 51].

- **Future teachers' and perception regarding AI-based tools**

The majority of future teachers expressed a generally positive outlook on the role of AI and its associated tools in education [19–21]. This explains the inclination towards its integration, especially in initial training programs.

Moreover, future teachers express that AI-based tools facilitate the accomplishment of pedagogical tasks, which explains their motivation to use it in their future teaching practices. Additionally, it is highly likely that these innovative tools can contribute to solving problems related to personalizing learning in a context of cognitive heterogeneity based on AI [50, 52, 53].

However, it is crucial to retain certain traditional aspects that have enriched the teaching profession for centuries, despite all the changes that AI will bring to the way the profession is practiced, making it more attractive [8]. This is precisely what future teachers have expressed regarding the role of the teacher in an environment supported by intelligent tools and AI.

- **Impact of independent variables on the level of Knowledge and Perception of AI-based Tools**

Based on the applied statistical tests, including the Mann-Whitney U and Kruskal-Wallis tests, we examined hypotheses (H6) and (H7) using data from Tables 17 to 25. The statistical analyses revealed significant impacts of independent variables on the levels of knowledge and perception of AI-based tools among future teachers.

Regarding the relationship between the Gender variable and the Knowledge factor of AI-based tools, the results indicate that future teachers of different genders exhibit significant differences in their levels of knowledge of these innovative tools. Notably, male futures teachers demonstrating a slightly higher level of knowledge compared to woman (Table 17) [18, 22, 54]. However, the dependence between the Gender variable and the Perception factor of AI-based tools states that future teachers of different genders no longer differ in terms of the degree of perception of these intelligent tools. In other words, whether male or woman, it has no influence on the perception of these intelligent tools.

Conversely, the academic years of initial training significantly affects both knowledge and perception of AI-based tools. Intra-group comparisons results highlight a discernible trend, revealing that first-year prospective teachers exhibit a lower level of knowledge and perception of intelligent tools compared to their third-year counterparts. This is perfectly logical and understandable, given that first-year future teachers are newly enrolled students with only a bachelor's degree, whereas third-year students are in their final year of training to become practicing teachers. Furthermore, the ICT module spread over 3 years of training, provides third-year future teachers with more experience and a higher conceptual understanding in the digital and technological era. This enables them to acquire skills and knowledge using AI-based tools to carry out pedagogical tasks during initial training, compared to those in the first year. Moreover, the pedagogical progression throughout the initial training course will help final-year future teachers accumulate more knowledge and perception regarding innovative concepts and tools (AI, VR, Robotics, ChatGPT, Gemini, ChatBot, facial recognition, intelligent tutoring, etc.).

Additionally, the sound judgment of future teachers in initial training plays a fundamental role, as it allows them to address current topics in a more in-depth and critical manner and to have considerable knowledge and perception of things.

In contrast, the specialty of future teachers, whether in primary education, scientific fields, or literary disciplines, did not significantly influence their level of knowledge and perception of AI-based tools.

V. Conclusion

The global trend towards integrating (AI) and AI-based tools in education necessitates a strategic response from the Moroccan educational system. To capitalize on this transformative potential, the Moroccan educational system, particularly leaders of initial teacher training programs within ENS, should develop a comprehensive strategy for integrating AI-based tools into the curriculum. This integration can help keep pace with global educational movements like Education 4.0.

Our study explored the knowledge and perception of these tools among future teachers. The results revealed a positive attitude, significant interest, and motivation towards AI-based tools, with future teachers expressing a willingness to learn more about their potential benefits. These encouraging findings suggest a growing openness to AI-based tool integration in the educational system.

However, the results also highlight the need for targeted professional development programs to enhance future teachers' knowledge and facilitate the effective integration of AI tools across all levels and specializations within the initial training program. By providing targeted training and resources, training schools like ENS-FEZ can ensure that future teachers are equipped to harness the power of AI and its tools, creating a more innovative and effective learning environment for their students.

These encouraging results suggest potential avenues for further research. Future research can explore the positive impact of AI-based tools in the context of teacher training and establish their necessity as intelligent assistants. This approach could involve utilizing AI tools to demonstrate their potential benefits and advantages in education, thereby motivating educators to adopt and integrate these technologies into their practices.

VI. Limitations

This study offers valuable insights into the perceptions and knowledge of Moroccan future teachers regarding AI-based tools in their initial training program. However, several limitations warrant consideration.

Primarily, the Higher Normal School (ENS) of FEZ was chosen as the sole institution for this study due to practical considerations, including financial constraints, logistical demands, and time pressures. Consequently, the generalizability of the findings to other institutions or regions within Morocco, as well as to different educational systems globally, may be restricted. Future research that incorporates a broader sample of institutions and geographic locations could serve to validate and extend the present findings to more diverse educational contexts.

Subsequently, quantitative data obtained from questionnaires utilizing a three-point Likert scale formed the sole basis for this study. This methodological choice prioritized participant simplicity and ease of use, ensuring both the reliability and validity of the findings. Additionally, it facilitated adequate discrimination between response options and aligned with the research objectives of measuring knowledge and perception. The ease of analysis and interpretation of the results also played a significant role in the selection of this approach. While this method enabled efficient data collection and analysis, it may have limited the depth of responses and failed to capture more nuanced views and experiences of the participants. Future research could address these limitations by incorporating qualitative data collection techniques, such as interviews or open-ended survey questions. This would provide a richer and more comprehensive understanding of teachers' attitudes and perceptions towards AI-based tools. Furthermore, employing a more detailed Likert scale, such as a five-point or seven-point scale, could offer greater granularity in the responses, thereby enhancing the potential for insightful data analysis.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

M.L is the main author of this scientific contribution, who analyzed, interpreted the data and wrote the paper; H.F and N.E revised the draft and contributed to the final manuscript on conception and design; K.E.K is the co-supervisor of this research article; L.A is the supervisor of this research article. All authors had approved the final version.

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