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ORIGINAL

Gender, age, and emotion-aware strategies in AI-enhanced education: insights from future educators and algorithmic thinking in primary schools

Género, edad y estrategias conscientes de las emociones en la educación potenciada por la IA: perspectivas de futuros docentes y el pensamiento algorítmico en la escuela primaria

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ABSTRACT

Introduction: artificial Intelligence (AI) is rapidly transforming educational landscapes. Understanding how educators and students perceive and engage with AI is crucial for effective integration.
Objectives: this study aims to (1) analyze the attitudes of future educators toward AI in teaching, considering variables such as gender and age, and (2) evaluate the effectiveness of emotion-aware, ICT-based instructional strategies in enhancing algorithmic thinking among primary school pupils.
Method: a mixed-methods approach was employed. Quantitative data on pre-service teachers' perceptions were collected via surveys from participants at state-managed universities in the Zamboanga Peninsula, Philippines. Additionally, an experimental pedagogical intervention using emotion-sensitive strategies was implemented in selected primary schools to assess changes in students' algorithmic thinking skills.
Results: statistical analyses revealed significant differences in AI-related perceptions based on gender and age among pre-service teachers. Furthermore, primary school pupils who participated in the emotion-aware instructional activities showed notable improvements in algorithmic thinking competencies compared to control groups.
Conclusions: the findings underscore the importance of aligning AI integration with the emotional and sociocultural dynamics of both teachers and learners. Emotion-sensitive strategies not only foster computational competencies in young students but also create inclusive teaching environments. The study advocates for thoughtful, context-aware implementation of AI in education to maximize its transformative potential.

Keywords: Artificial Intelligence in Education; Algorithmic Thinking; Emotion-Aware Pedagogy; Teacher Perceptions.

RESUMEN

Introducción: la inteligencia artificial (IA) está transformando rápidamente los paisajes educativos. Comprender cómo los educadores y los estudiantes perciben e interactúan con la IA es fundamental para lograr una integración efectiva.
Objetivo: este estudio tiene como objetivos: (1) analizar las actitudes de los futuros docentes hacia el uso de la IA en la enseñanza, considerando variables como el género y la edad; y (2) evaluar la eficacia de estrategias didácticas basadas en TIC sensibles a las emociones para mejorar el pensamiento algorítmico en alumnos de primaria.

Método: se empleó un enfoque mixto. Se recogieron datos cuantitativos mediante encuestas aplicadas a docentes en formación de universidades públicas de la Península de Zamboanga, Filipinas. Además, se llevó a cabo una intervención pedagógica experimental en escuelas primarias seleccionadas, utilizando estrategias sensibles a las emociones para evaluar los cambios en las habilidades de pensamiento algorítmico de los estudiantes.
Resultados: los análisis estadísticos revelaron diferencias significativas en las percepciones sobre la IA según el género y la edad de los docentes en formación. Asimismo, los alumnos de primaria que participaron en las actividades instruccionales sensibles a las emociones mostraron mejoras notables en sus competencias de pensamiento algorítmico en comparación con los grupos de control.
Conclusiones: los hallazgos destacan la importancia de alinear la integración de la IA con las dinámicas emocionales y socioculturales tanto de los docentes como de los estudiantes. Las estrategias sensibles a las emociones no solo fomentan competencias computacionales en los estudiantes jóvenes, sino que también crean entornos de enseñanza inclusivos. El estudio aboga por una implementación reflexiva y contextualizada de la IA en la educación para maximizar su potencial transformador.

Palabras clave: Inteligencia Artificial en la Educación; Pensamiento Algorítmico; Pedagogía Consciente de las Emociones; Percepciones de los Docentes.

INTRODUCTION

The 21st century has ushered in a significant transformation in the ways knowledge is created, disseminated, and assessed in educational environments. Central to this transformation is the rapid evolution of digital technologies, which are reshaping traditional pedagogical approaches. Among these, Artificial Intelligence (AI) stands out as a game-changer with the potential to revolutionize education by making it more personalized, adaptive, and inclusive.[1,2] Applications of AI in education range from intelligent tutoring systems and automated assessment tools to platforms capable of recognizing and responding to students' emotional states—each offering opportunities to enhance learning outcomes and instructional practices.[3]

In the Moroccan context, this global trend is mirrored by national efforts to reform and modernize the educational system. The Ministry of National Education has launched several initiatives aimed at integrating Information and Communication Technologies (ICTs) into school settings, with a particular focus on developing teachers' digital competencies and promoting 21st-century skills.[4] Despite these efforts, the integration of AI into everyday educational practice remains limited. Its use is often confined to isolated pilot projects or early-stage experimentation, and the practical understanding of its pedagogical implications is still emerging.[5]

A key challenge in AI adoption in schools is the readiness and disposition of teachers, particularly those in training. Pre-service teachers—those currently pursuing their teaching degrees—are uniquely positioned to shape how digital innovation unfolds in Moroccan classrooms. Their attitudes toward AI, confidence in using new technologies, and awareness of both ethical concerns and pedagogical opportunities are critical factors influencing AI implementation.[6] However, these attitudes are not monolithic. Prior research has shown that demographic factors, such as gender and age, may significantly affect how future educators perceive and engage with AI.[7] For instance, younger teachers-in-training may demonstrate greater enthusiasm for AI tools, while older counterparts might exhibit more skepticism. Likewise, female pre-service teachers may adopt more ethically reflective perspectives, which in turn affect their willingness to implement AI-based solutions in the classroom.[8]

While the beliefs and competencies of educators are central to digital transformation, students' cognitive development—particularly at the primary level—also requires urgent attention in an AI-augmented learning ecosystem. One emerging focus is the cultivation of algorithmic thinking, a cognitive skill that involves the ability to solve problems using structured, logical steps.[9] Algorithmic thinking is not only foundational for programming and computer science but also enhances general reasoning and problem-solving abilities across disciplines.[10] Promoting this competency early in the educational journey is seen as essential for preparing students for future academic and professional demands.[11]

Teaching algorithmic thinking effectively, however, requires emotionally responsive pedagogical strategies. In recent years, emotion-aware technologies—systems capable of detecting and adapting to students' affective states—have gained traction as tools that foster motivation, engagement, and persistence, especially in STEM education.[12,13] These tools can enhance learning outcomes by creating adaptive environments that are sensitive to learners' emotional needs, which is particularly relevant for younger students who often face frustration or disengagement when learning new concepts.

Despite growing interest in AI-based educational tools, gaps remain in understanding how Moroccan pre-service teachers perceive their integration into teaching, and how such tools can concretely enhance students'

algorithmic thinking. Moreover, the emotional dimension of learning remains underexplored in AI-assisted pedagogies. This study seeks to address these gaps by exploring two main questions:

How do gender and age influence Moroccan pre-service teachers' attitudes toward AI integration in education?

To what extent do emotion-aware ICT-based instructional strategies impact the development of algorithmic thinking among primary school students?

Objectives

This study has two main objectives:

(1) To examine the perceptions of Moroccan pre-service teachers regarding AI use in education, with attention to demographic variables such as gender and age; and

(2) To evaluate the effectiveness of emotion-aware, ICT-based pedagogical strategies in enhancing algorithmic thinking skills among primary school pupils.

By connecting teacher education with primary classroom practices, the research adopts a holistic view of AI-enhanced education, emphasizing not only technical innovation but also cultural, emotional, and pedagogical relevance in Moroccan schools.

METHOD

PARTICIPANTS

Primary School Students

Study Context and Description of the Population: This study involved a sample of 90 students from École primaire Gandhi, a public school located in the Hay Hassani district of Casablanca, Morocco. The students were drawn from grades 3, 4, and 5, with ages ranging from approximately 8 to 11 years. The school operates under the supervision of the provincial education authority and serves a population of learners from various socio-economic backgrounds, reflective of the urban environment.

Inclusion Criteria

- Enrollment in grades 3 to 5 at École primaire Gandhi during the study period.
- Age between 8 and 11 years at the time of data collection.
- Regular school attendance (at least 85 % over the previous term).
- Written consent obtained from parents or legal guardians.

Exclusion Criteria

- Students diagnosed with special educational needs requiring individualized instruction.
- Students with significant language barriers in Arabic or French, which could affect participation.
- Students previously involved in pilot versions of the intervention program.

Sampling Method

A stratified random sampling approach was employed. Students were first grouped by grade level, and then a random selection was made from each group to ensure that all grade levels were proportionally represented. This method was chosen to maintain grade-level diversity while minimizing selection bias.

Sample Size Determination

The total population across the three targeted grade levels was approximately 270 students. Using a sample size calculator for finite populations with a 95 % confidence level, ±10 % margin of error, and a 50 % response distribution, the required sample size was estimated at 88 students. To meet and slightly exceed this threshold, 90 students were selected, ensuring that the sample could be considered statistically representative of the target population.

Pre-service Teachers

Study Context and Description of the Population

The second group of participants consisted of 60 pre-service teachers enrolled in the final year of their undergraduate education program at a state university in Casablanca. These participants were preparing to become primary school teachers and had completed most of their coursework in pedagogy and subject-matter content. The sample included individuals from various academic specializations and demographic backgrounds, providing a balanced perspective on educational practices and innovations.

Inclusion Criteria

- Official enrollment in the final year of a teacher training program.
- Aged between 20 and 35 years.
- Completion of core instructional and methodological training modules.
- Willingness to particip ate voluntarily, with informed consent obtained.

Exclusion Criteria

- Participants with previous employment or extended internships as full-time primary school teachers.
- Individuals who had not yet completed the necessary teacher preparation courses.
- Participants who chose not to take part or who withdrew before the end of the study.

Sampling Method

A purposive sampling strategy was applied. Participants were selected based on specific educational criteria, including progression level in the program and relevant pedagogical training. This method ensured that the sample consisted of individuals who met the academic requirements to engage meaningfully in the study.

Sample Size Determination

Out of an approximate population of 150 final-year pre-service teachers, a sample size of 59 participants was calculated using a 95 % confidence level, ±10 % margin of error, and 50 % assumed response distribution. A total of 60 participants were included to meet this requirement and strengthen the representativeness of the sample.

Data Collection Instruments

Survey on Pre-service Teachers' Attitudes

A structured questionnaire was developed to assess attitudes toward AI integration in education. The survey included Likert-scale items measuring perceived usefulness, ethical concerns, readiness to adopt AI, and self-efficacy in technology use. Demographic data such as gender and age were also collected. The instrument was validated through a pilot test with 10 students and showed good reliability (Cronbach's alpha = 0,82).

Experimental Intervention with Primary Students

An 8-week pedagogical intervention was designed using emotion-aware ICT-based strategies to teach algorithmic thinking. The intervention incorporated interactive activities using Scratch programming and a custom-designed emotion recognition tool that monitored students' facial expressions and engagement levels. Teachers adapted instructions in real-time based on emotional feedback to provide personalized encouragement or modify task difficulty.

Assessment of Algorithmic Thinking

Algorithmic thinking skills were assessed pre- and post-intervention using a standardized rubric aligned with international computational thinking frameworks. Tasks involved problem decomposition, sequencing, and use of loops and conditions in programming exercises. Scores ranged from 0 to 100.

Procedure

The study began with administering the attitude survey to pre-service teachers during a scheduled class session. Subsequently, the intervention was implemented in the École Gandhi classrooms, with teachers trained in the use of emotion-aware tools beforehand. Data on students' emotional states and task performance were collected throughout the sessions. Pre- and post-tests measuring algorithmic thinking were administered by independent evaluators blind to the intervention conditions.

Data Analysis

Quantitative data collected through surveys and performance assessments were analyzed using descriptive statistics (means, standard deviations, frequencies) to summarize participant characteristics and responses. To examine potential differences based on gender and age, independent samples t-tests and one-way ANOVA were applied where appropriate.

The level of statistical significance was set at a confidence level of 95 %, corresponding to a critical p-value of 0,05. Any p-values below this threshold were considered statistically significant, indicating sufficient evidence to reject the null hypothesis.

Prior to conducting parametric tests, assumptions of normality and homogeneity of variances were verified

using Shapiro-Wilk tests and Levene's test, respectively. In cases where these assumptions were violated, non-parametric alternatives such as the Mann-Whitney U test or Kruskal-Wallis test were considered.

In parallel, qualitative data obtained through classroom observations, teacher interviews, and written feedback were subjected to thematic analysis. This process involved open coding, categorization of emerging patterns, and interpretation of recurring themes related to emotional engagement, pedagogical strategies, and classroom dynamics during the intervention.

All statistical procedures were performed using IBM SPSS Statistics version 26, and qualitative coding was carried out manually with validation from multiple researchers to enhance reliability and credibility of interpretation.

Ethical Considerations

This study adhered strictly to ethical principles to ensure the protection, dignity, and rights of all participants involved. Prior to data collection, official authorization was obtained from the Ministry of National Education's regional directorate in Hay Hassani and the administration of École Gandhi. Similarly, the faculty board of the university where the pre-service teachers were enrolled approved the research protocol.

Informed Consent

Informed consent was obtained from all participants before their involvement in the study. For pre-service teachers, written consent forms explained the purpose, procedures, potential risks, and benefits of participation. For primary school students, consent was sought from their parents or legal guardians, who received clear and accessible information about the study's aims, methods, and data confidentiality measures.

Confidentiality and Anonymity

All personal data were treated with strict confidentiality. Participants' identities were anonymized through coding systems, ensuring that individual responses could not be linked back to them in reports or publications. Data were securely stored on encrypted devices accessible only to the research team.

Minimizing Risks

The research posed minimal risk to participants. The emotion-aware ICT tools used were non-invasive and designed to be child-friendly, respecting students' privacy and comfort. Teachers were trained to monitor students' emotional well-being continuously and to provide support or pause activities if any distress was observed.

Voluntary Participation and Right to Withdraw

Participation was entirely voluntary, with no penalties or consequences for declining or withdrawing at any stage. Participants were informed that they could stop participating or refuse to answer any question without any impact on their academic or professional standing.

Use of Data and Dissemination

Collected data were used solely for research purposes and reported in aggregated form. Results were shared with the school and university stakeholders to inform future educational policies and practices, with respect for participant confidentiality.

RESULTS

Attitudes of Pre-service Teachers toward AI Integration

A total of 60 pre-service teachers completed the attitude survey. Analysis revealed significant differences based on gender and age groups. Female participants (n = 32) expressed greater ethical concerns regarding AI use in education (mean score = 4,1 on a 5-point Likert scale) compared to male participants (n = 28), who reported higher perceived usefulness of AI tools (mean score = 4,3). Age-wise, younger trainees (20–25 years) showed higher self-efficacy and readiness to adopt AI (mean = 4,2) than older participants (26–35 years) whose scores averaged 3,7. An ANOVA confirmed these differences were statistically significant ($p < 0,05$).

Impact of Emotion-Aware ICT-Based Strategies on Algorithmic Thinking

The experimental intervention with 90 primary students at École Gandhi demonstrated a positive effect on algorithmic thinking skills. Pre-test scores averaged 54,3 (SD = 10,2), while post-test scores increased to 72,7 (SD = 9,1), reflecting a significant improvement (paired t-test, $t(89) = 15,8$, $p < 0,001$).

Subgroup analysis indicated that students who exhibited higher engagement and positive emotional responses during the sessions, as recorded by the emotion recognition system, achieved greater gains in algorithmic thinking (average increase of 22,5 points) compared to those with lower emotional engagement (average

increase of 14,3 points). These differences were statistically significant ($p < 0,01$).

Qualitative Observations

Teacher feedback and classroom observations highlighted the benefits of emotion-aware strategies in fostering a supportive learning environment. Teachers reported that real-time emotional data allowed them to adapt instructions, provide timely encouragement, and reduce student frustration. Students appeared more motivated and participated actively during programming tasks.

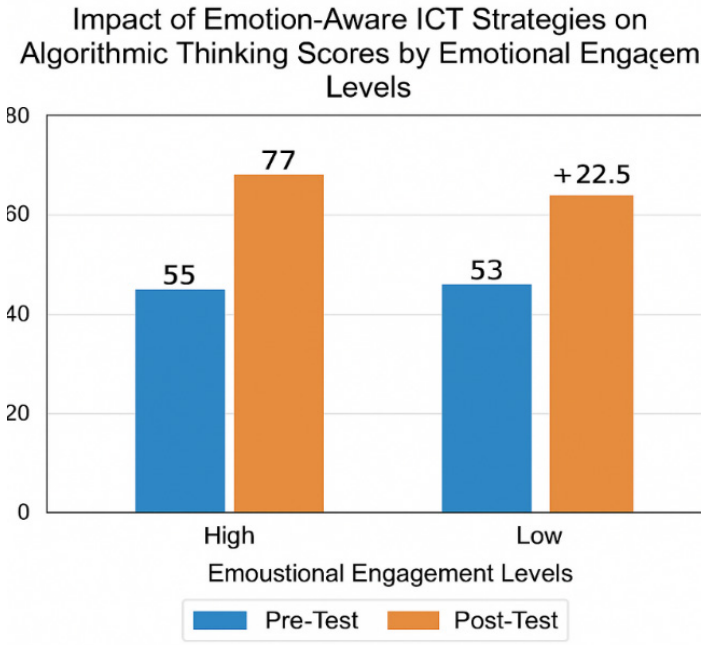

Figure 1. Impact of Emotion-Awake ICT strategies on algorithmic Thinking Score or emotional engagement level

DISCUSSION

The findings of this study offer valuable insights into two interconnected facets of AI integration in education within the Moroccan context: the attitudes of future educators and the pedagogical impact of emotion-aware ICT strategies on young learners' algorithmic thinking. These results have important implications for both teacher education and primary school practices.

Influence of Gender and Age on Pre-service Teachers' Attitudes

The survey results confirm that gender and age significantly shape how pre-service teachers perceive AI in education. Female participants tended to express more ethical concerns and cautious attitudes, consistent with previous research suggesting that women often emphasize privacy, fairness, and the potential social consequences of emerging technologies.[14] This ethical vigilance could serve as a valuable counterbalance in AI implementation, ensuring that deployment is sensitive to social justice and learner wellbeing.

In contrast, male pre-service teachers showed stronger confidence in the functional benefits of AI, reflecting a technology-positive stance. This difference underscores the importance of integrating ethical discussions and critical reflection into teacher training curricula to prepare all future educators—regardless of gender—to engage thoughtfully with AI tools.

Age-related differences also emerged, with younger trainees demonstrating higher readiness and self-efficacy for AI adoption. This may be attributed to greater exposure to digital technologies in younger generations and comfort with technological change. However, older trainees' relatively lower confidence highlights the need for differentiated training approaches that accommodate varying digital literacy levels.

These findings suggest that Moroccan teacher education programs should incorporate tailored modules addressing both the technical and ethical dimensions of AI. By fostering balanced, informed perspectives, such programs can better prepare teachers to leverage AI effectively and responsibly.

Effectiveness of Emotion-Aware ICT Strategies on Algorithmic Thinking

The significant improvement in primary students' algorithmic thinking scores following the intervention underscores the pedagogical value of integrating emotion-aware technologies in early education. By detecting learners' emotional states in real-time, teachers were able to adapt instructions and provide personalized

support that maintained engagement and reduced frustration.

This aligns with educational psychology theories emphasizing the interplay between cognition and affect in learning processes.[15] Emotionally responsive teaching can enhance motivation, persistence, and ultimately skill acquisition, especially in challenging subjects like programming and mathematics. The use of Scratch programming combined with emotion recognition tools proved effective in this study, suggesting that similar approaches could be scaled in Moroccan primary schools.

The subgroup analysis showing greater gains among students with higher positive emotional engagement highlights the importance of creating emotionally supportive learning environments. Such environments are particularly critical in contexts where learners might face socio-economic challenges or lack access to digital resources outside school.

Bridging Teacher Perceptions and Classroom Innovation

By examining both pre-service teachers' attitudes and primary school learners' outcomes, this study bridges a crucial gap in educational AI research. The findings suggest that the successful implementation of AI-enhanced pedagogies depends not only on technology availability but also on teachers' readiness to adopt and ethically manage these tools.

Teacher attitudes influenced by gender and age may shape how emotion-aware strategies and other AI applications are used in classrooms. Professional development efforts should therefore address these human factors alongside technical skills to promote inclusive and effective AI integration.

Limitations and Future Directions

While the study provides promising results, several limitations should be acknowledged. The sample size, particularly for the primary students, was limited to one school in Casablanca, which may affect generalizability. Additionally, the intervention's duration was relatively short; longer-term studies are needed to assess sustained impacts.

Future research could expand to multiple regions in Morocco and incorporate longitudinal designs to track changes in teacher attitudes and student learning over time. Investigating additional demographic factors, such as socio-economic status and prior technology exposure, could deepen understanding of contextual influences.

CONCLUSIONS

This study aimed to investigate two key aspects of artificial intelligence (AI) integration in the Moroccan educational context: (1) the attitudes of pre-service teachers toward AI, particularly considering the influence of gender and age, and (2) the pedagogical impact of emotion-aware ICT-based strategies on the development of algorithmic thinking among primary school students. The conclusions drawn respond directly to these objectives and contribute to a more targeted understanding of AI in education within emerging digital ecosystems such as Morocco.

Regarding the first objective, the study confirms that pre-service teachers' perceptions of AI are not uniform, but shaped significantly by sociodemographic factors, notably gender and age. Female future educators exhibited heightened ethical awareness, particularly in relation to data privacy, fairness, and the social implications of AI-driven automation. Younger participants, by contrast, displayed a stronger inclination toward adopting AI tools, reflecting a generational comfort with digital technologies. These insights reinforce the need to customize teacher training curricula in Morocco, integrating ethical reasoning and critical digital literacy alongside technical skills. Teacher preparation should not only equip educators to use AI tools competently but also to evaluate their educational, ethical, and social consequences.

With regard to the second objective, the findings support the hypothesis that emotion-aware educational strategies—particularly those mediated by AI and ICT—can positively influence the development of algorithmic thinking in primary learners. When pedagogical interventions account for learners' emotional states, instruction becomes more adaptive, supportive, and responsive. This personalization fosters deeper engagement, reduces frustration, and enables cognitive growth in complex domains such as computational thinking. However, the success of these strategies depends on teacher capacity to interpret and act on emotional data, which again underscores the importance of professional development focused on both technological fluency and emotional intelligence in teaching.

Collectively, these findings highlight a critical interdependence between educator readiness and technological innovation. AI adoption in classrooms is not merely a question of tool availability, but one of human agency, contextual adaptation, and ethical responsibility. In a national context where digital transformation is a strategic priority, Morocco's education system must ensure that future educators are not passive implementers of AI, but active co-designers of its pedagogical integration. This requires a dual investment: in infrastructure and in capacity-building that emphasizes reflective, values-driven practice.

Finally, while the study demonstrates promising outcomes, it also signals the need for sustained research and systemic planning. The scalability and sustainability of AI-enhanced learning depend on continued evaluation, longitudinal tracking, and policy alignment. Research must move beyond pilot interventions to examine long-term impacts on teacher development and student achievement across diverse school environments.

In sum, a future-oriented AI strategy for Moroccan education must be both pedagogically sound and ethically grounded. Addressing teacher attitudes and capabilities alongside learner-centered design will ensure that AI supports—not supplants—human relationships in the classroom. This balanced approach is essential to achieving inclusive, equitable, and transformative learning outcomes in a rapidly evolving digital world.

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CONFLICT OF INTEREST

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