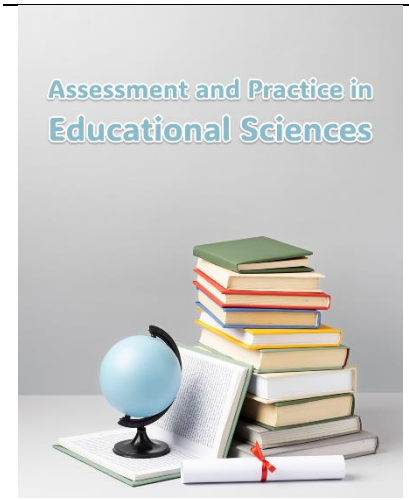
Assessment and Practice in Educational Sciences



Teachers' Interpretations of Learning Engagement in the Artificial Intelligence Era: A Qualitative Model

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Article type:
Original Research

Article history:
Received 01 September 2025
Revised 22 November 2025
Accepted 30 November 2025
Initial Publish 06 January 2026
Published online 01 March 2026

How to cite this article:
Danesh, A., & Memari, S. (2026). Teachers' Interpretations of Learning Engagement in the Artificial Intelligence Era: A Qualitative Model. *Assessment and Practice in Educational Sciences*, *4*(2), 1-11. https://doi.org/10.61838/japes.173

ABSTRACT

The objective of this study was to explore how teachers interpret learning engagement in AI-mediated classrooms and develop a qualitative model based on their lived professional experiences. This qualitative study used a phenomenological–interpretive design to explore teachers' conceptualizations of engagement in the context of artificial intelligence. Data were collected through semi-structured, in-depth interviews with 24 teachers from Tehran selected via purposive sampling to ensure variation in teaching level, experience, and familiarity with AI-supported tools. Interviews lasted 45–75 minutes, were audio-recorded, transcribed verbatim, and analyzed using thematic analysis supported by NVivo software. Coding proceeded through open, axial, and selective stages, and theoretical saturation was achieved after 24 interviews. Trustworthiness was ensured through peer debriefing, constant comparison, and analytic memoing. Analysis yielded four overarching themes: (1) redefinition of learning engagement, (2) AI as a catalyst for instructional transformation, (3) challenges and tensions in AI-supported engagement, and (4) shifts in teacher professional identity. Teachers reported that AI reshapes cognitive, emotional, and behavioral facets of engagement through adaptive feedback, analytics, and interactive tools. AI-personalized pathways strengthened perceived cognitive engagement, while real-time data influenced how teachers inferred students' attention and persistence. However, concerns emerged regarding algorithmic accuracy, over-reliance on automation, and pedagogical misalignment. Teachers also described evolving roles as facilitators of human–AI interaction, interpreting engagement through both professional judgment and AI signals. These inferential results indicate that teacher interpretations are hybrid, negotiated, and context-dependent. Teachers in AI-enhanced classrooms reconceptualize learning engagement as a multidimensional and technology-mediated construct shaped by analytics, emotional responses, behavioral cues, and evolving professional identities. The resulting qualitative model underscores the need for AI literacy, critical interpretation of automated insights, and balanced integration of human expertise and intelligent systems.

Keywords: Artificial Intelligence; Learning Engagement; Teacher Perceptions; Qualitative Model; Phenomenology; AI-Mediated Learning

Introduction

The rapid advancement of artificial intelligence (AI) has transformed educational ecosystems worldwide, prompting a fundamental rethinking of instructional roles, learning processes, and classroom engagement. From adaptive learning platforms to automated assessment systems, AI is now deeply embedded in teaching and learning practices across disciplines and educational levels. Scholars increasingly emphasize that AI is not merely an auxiliary technological tool but an evolving pedagogical force that reshapes both human practices and institutional expectations (1). Within this context, teachers' interpretations of learning engagement—what it looks like, how it develops, and how it is supported—are undergoing profound shifts, particularly as digital infrastructures and generative systems integrate into classroom routines (2). Research indicates

that the introduction of sophisticated AI systems challenges teachers to reconceptualize engagement from static behavioral indicators toward complex cognitive, emotional, and interactive constructs mediated by intelligent technologies (3).

The literature consistently highlights that AI generates new opportunities for personalized instruction, interactive learning, and real-time analytics, thereby altering teacher decision-making processes. For example, Ranes (4) argues that AI-enhanced learning environments allow teachers to monitor micro-patterns of student participation that were previously invisible. Peneyra et al. (5) similarly demonstrate that AI tools enable teachers to identify fluctuations in student engagement rapidly and adjust pedagogical strategies accordingly. This increasing reliance on automated insights raises questions about how teachers conceptualize engagement in settings where algorithms influence pacing, content exposure, and learner behavior. Furthermore, AI systems—through multimodal feedback, prediction models, and adaptive recommendations—are beginning to function as teaching assistants, thereby shaping how educators interpret the meaning and trajectory of student involvement in learning tasks (6).

However, while many educational scholars celebrate these innovations, others express concerns regarding the conceptual ambiguities that AI creates in instructional contexts. Nirchi et al. (7) note that teachers often experience uncertainty about how to interpret algorithm-driven engagement metrics or reconcile them with their own pedagogical judgments. Mukherjee et al. (8) further argue that AI may create tensions by redefining the very notion of "active" participation, particularly in science classrooms where traditional methods emphasize hands-on experimentation. Moore et al. (9) found that middle school instructors struggled to determine whether AI-generated participation cues accurately reflected genuine cognitive engagement. As AI tools introduce new modes of interaction—chat-based queries, automated feedback loops, and digital collaboration—the challenge lies in understanding how teachers reconstruct the meaning of engagement across these evolving modalities.

The transformative potential of AI is especially evident in language, literacy, and communication-oriented disciplines. Kumari et al. (10) describe AI as an "algorithmic adjuvant" that reshapes classroom discourse, enabling responsive scaffolding and dynamic text-based interactions. Kosmas et al. (11) demonstrate that integrating AI in literacy lessons enhances multimodal engagement, especially when teachers co-design learning pathways aligned with individual student profiles. Kohnke and Zou (12) emphasize that TESOL educators increasingly rely on frameworks such as TPACK and SAMR to navigate AI integration, suggesting that engagement is no longer viewed merely as behavioral persistence but as an interplay of digital creativity, cognitive demand, and interactive exploration. Kartinah et al. (13) similarly highlight how AI-mediated materials influence teachers' recognition of student motivation by making learning sequences more interactive and visual.

These shifts also raise questions about teacher agency and professional autonomy. Kanvaria (14) argues that mathematics teachers engaging with AI tools often perceive changes in the cognitive load required for learning tasks, leading them to reinterpret engagement as a dynamic feedback process between learner and system. Meanwhile, Jivtode (15) highlights that AI may alter students' academic development trajectories, which consequently changes how teachers assess persistence and involvement in learning. Gurion et al. (16) emphasize that teachers increasingly view engagement through the lens of learning styles that emerge from human–AI interaction. Dong (17) further asserts that AI shifts key components of classroom quality by introducing continuous analytics, prompting teachers to adapt their perceptions of attentiveness and responsiveness.

Across global educational contexts, researchers also note significant cultural and contextual variations in how teachers interpret AI-driven engagement. For instance, Chetia (18) finds that digital education environments in South Asia produce unique engagement cues shaped by students' technological exposure. Chen (19) identifies adaptation strategies among Chinese teachers as they negotiate AI-supported instruction, which redefines their understanding of cognitive and behavioral engagement in English language classrooms. Çelenk and Büyükahıska (20) explore self-efficacy among K12 foreign-language teachers and show that their beliefs about AI proficiency influence how they interpret classroom involvement, especially when

learners rely heavily on AI-generated guidance. Boysen (21) similarly notes that psychology teachers must reinterpret engagement within the broader context of AI-based cognitive modeling.

In addition to influencing instructional routines, AI technologies also reshape the broader discourse of educational change. Alenezi and Alenezi (22) highlight that both teachers and students perceive AI as altering the rhythm of classroom interactions, affecting institutional norms and expectations regarding participation. Adigun (23) stresses that inclusive education requires trainers to understand how AI influences engagement differently for diverse learners. Abdulmumin (24) emphasizes that educators require strong AI literacy to anticipate how learners respond to AI-mediated environments. These insights align with discussions by Zhang (25), who suggests that AI's impact on classroom teaching necessitates a reconceptualization of both teaching quality and student responsiveness.

Moreover, teachers across regions are experiencing rapid cultural and professional shifts due to AI integration. Utami et al. (26) describe a cultural change among mathematics teachers who navigate the AI revolution by reconstructing their beliefs about engagement and technology. Meylani (27) synthesizes qualitative evidence showing that AI reshapes teacher identity, pedagogical confidence, and definitions of student involvement. Lettieri and Pasquali (28) describe a blending of human and artificial cognition, suggesting that modern classrooms cannot conceptualize engagement without acknowledging AI-mediated cognitive scaffolding. Kumar (29) reinforces this argument, noting that AI fundamentally redefines learning experiences, making engagement more interactive, adaptive, and dialogic. Kirmani et al. (30) caution that AI may also create tensions by disrupting established pedagogical norms, motivating teachers to renegotiate their role in orchestrating engagement. Islam et al. (31) similarly document shifts in middle school classrooms where both teachers and students renegotiate expectations for participation.

Hegadi (32) argues that progressive teachers increasingly view AI as an essential component of modern pedagogy, with engagement emerging through experimentation, exploration, and autonomy. Arora and Pillai (33) extend this discussion to generative AI, illustrating how new tools amplify student creativity and reshape how teachers recognize involvement in learning. Tang et al. (3) reinforce this argument by demonstrating that generative AI can effectively support teaching tasks, prompting teachers to adjust their engagement frameworks accordingly. The cumulative literature suggests that teachers' interpretations of engagement are shaped not only by technological features but also by psychological, cultural, professional, and epistemological considerations.

Despite the growing volume of research, a clear gap remains concerning how teachers *themselves*—as reflective practitioners—define, interpret, and respond to learning engagement in AI-mediated classrooms. Much of the existing literature focuses on technical affordances, student perceptions, or institutional outcomes, while fewer studies explore teachers' subjective conceptualizations grounded in their lived experience. As teachers remain central actors in shaping the ethical, pedagogical, and relational dynamics of AI-enhanced learning, understanding their interpretations is critical for designing systems that genuinely support meaningful engagement.

Therefore, the aim of this study is to explore teachers' interpretations of learning engagement in the Artificial Intelligence era and develop a qualitative model based on their lived experiences.

Methods and Materials

This study employed a qualitative research design using a phenomenological–interpretive approach to explore teachers' interpretations of learning engagement in the era of artificial intelligence. The qualitative orientation was selected because it allows for an in-depth examination of teachers' subjective meanings, cognitive frames, and experiential interpretations regarding the integration of AI into teaching–learning processes. The target population consisted of school teachers working in

Tehran across different educational levels. Purposive sampling with maximum variation was used to ensure the inclusion of participants with diverse teaching backgrounds, years of professional experience, disciplinary fields, and familiarity with AI-based technologies in instructional settings.

A total of 24 teachers participated in the study. Sampling continued until theoretical saturation was reached—meaning no new conceptual categories or interpretive insights emerged from additional interviews. Participants were approached with the assistance of school administrators and teacher networks, and inclusion criteria required having at least three years of teaching experience and prior exposure to digital or AI-mediated educational tools. All participants provided informed consent, and confidentiality was assured throughout the research process.

Data were collected through semi-structured, in-depth interviews, which allowed participants to express their perspectives freely while ensuring that core research questions were consistently addressed. An interview guide with open-ended questions was developed to explore teachers' perceptions of student learning engagement, their understanding of AI-supported learning environments, and their interpretations of behavioral, cognitive, and emotional aspects of engagement in AI-mediated classrooms.

Interviews were conducted face-to-face at locations convenient for the participants, primarily in schools or quiet workplace settings in Tehran. Each interview lasted between 45 and 75 minutes and was audio-recorded with permission. Field notes were taken to capture contextual observations and non-verbal cues. All recordings were transcribed verbatim immediately after each session. Data collection spanned approximately three months, continuing until theoretical saturation was achieved after the 24th interview.

Data analysis followed a thematic analysis procedure, utilizing both inductive and interpretive coding strategies. Transcribed interviews were imported into NVivo qualitative analysis software to facilitate systematic coding, memoing, data retrieval, and categorization. Analysis began with open coding, during which meaningful units of text were identified and assigned initial codes. Through iterative comparison and constant reflection, codes were refined, merged, or expanded to form more abstract categories.

Axial coding was then used to explore relationships between categories, revealing how teachers make sense of learning engagement in AI-enhanced educational contexts. The final stage involved selective coding, integrating core categories into a coherent conceptual model that reflected the participants' shared and divergent interpretations. Throughout the analytic process, the researcher maintained analytic memos, engaged in peer debriefing sessions to enhance credibility, and continuously compared new data with emerging themes to ensure consistency and depth of interpretation. Data saturation was confirmed when no new themes or insights were observed in the final interviews.

Findings and Results

A total of 24 teachers from Tehran participated in the study, representing a diverse range of demographic and professional backgrounds. Of the participants, 14 were female (58.3%) and 10 were male (41.7%). The age of participants ranged from 27 to 54 years, with the majority falling in the 36–45 age group (n = 11, 45.8%), followed by those aged 46–54 (n = 7, 29.2%) and 27–35 (n = 6, 25%). In terms of teaching experience, 9 teachers (37.5%) had 6–10 years of experience, 8 teachers (33.3%) had more than 15 years, 5 teachers (20.8%) had 11–15 years, and 2 teachers (8.3%) had 3–5 years of experience. Participants taught across different educational levels, including primary school (n = 8), lower secondary (n = 7), upper secondary (n = 6), and technical–vocational education (n = 3). Regarding familiarity with AI-based educational tools, 10 teachers (41.7%) reported moderate familiarity, 7 teachers (29.2%) reported high familiarity, and 7 teachers (29.2%) reported low familiarity. This

diversity facilitated a rich exploration of teachers' interpretations and experiences with learning engagement in the artificial intelligence era.

Table 1. Themes, Subthemes, and Concepts

Main Theme (Category)	Subtheme (Subcategory)	Concepts (Open Codes)
1. Redefinition of Learning Engagement in the AI Era	1.1 Cognitive Adaptation to AI-Mediated Tasks	adjusting to AI feedback; interpreting algorithmic suggestions; increased self-regulation; rapid shift between tasks
	1.2 Emotional Responses to AI-Supported Learning	excitement about AI tools; reduced anxiety during tasks; frustration with unfamiliar technology; curiosity-driven engagement; perceived loss of control
	1.3 Behavioral Changes in Classroom Participation	increased on-task behavior; faster completion of assignments; selective attention guided by AI tools; reliance on automated prompts
	1.4 Teacher Perceptions of Student Autonomy	students planning tasks via AI; independent practice sessions; reduced need for teacher scaffolding; self-paced learning
	1.5 Engagement as a Multi-Dimensional Construct	integration of cognitive-emotional engagement; fluid boundaries between engagement types; AI reshaping engagement indicators
	1.6 Shifts in Teachers' Roles in Engagement Monitoring	relying on AI analytics; reduced manual observation; responding to real-time engagement alerts; tracking micro-engagement patterns
2. AI as a Catalyst for Instructional Transformation	2.1 Personalization of Learning Paths	adaptive tasks; differentiated pacing; AI-generated learning recommendations; tailored difficulty levels
	2.2 Data-Driven Insights for Instruction	interpreting dashboards; tracking engagement metrics; identifying behavioral trends; adjusting teaching strategies
	2.3 Integration of AI Tools into Pedagogy	embedding AI apps; hybrid instructional routines; AI-supported feedback cycle; real-time assessment
	2.4 Facilitating Collaborative Learning with AI	AI-managed group formation; monitoring group engagement; balancing participation; promoting peer feedback
	2.5 Enhancement of Interactive Learning Environments	gamified AI platforms; interactive simulations; voice-responsive systems; multimodal learning tasks; instant rewards
3. Challenges and Tensions in AI-Supported Engagement	3.1 Over-dependency on AI Tools	relying on automation; decreased critical thinking; avoidance of complex tasks; superficial engagement
	3.2 Ethical Concerns and Fairness Issues	algorithmic bias; unequal resource access; concerns about data privacy; fairness in automated scoring
	3.3 Teacher Skepticism Toward AI Insights	distrust of analytics; questioning AI accuracy; comparing human vs. AI judgment; reluctance to adopt recommendations
	3.4 Emotional Disengagement Triggered by Technology	boredom with repetitive AI tasks; tech-related frustration; fear of making mistakes in AI systems
	3.5 Classroom Management Difficulties	distractions caused by devices; monitoring multiple AI tools; troubleshooting technical issues; loss of classroom control
	3.6 Pedagogical Misalignment	traditional methods conflicting with AI design; rigid AI pacing; mismatch between curriculum and AI recommendations
	3.7 Digital Inequality Among Students	varying digital literacy; uneven access to devices; different levels of AI readiness
4. Teacher Professional Identity in the AI Era	4.1 Redefining the Teacher's Role	shift from instructor to facilitator; guiding AI-mediated learning; monitoring student-AI interactions; coaching digital skills
	4.2 Competency Development for AI Integration	training needs; ongoing digital skill-building; learning from colleagues; experimenting with new tools
	4.3 Professional Confidence and Self-Efficacy	increased competence after practice; anxiety about technological errors; balancing human and AI authority; willingness to innovate
	4.4 Values and Beliefs About AI in Education	beliefs about AI benefits; ethical teaching values; concerns about losing pedagogical essence; philosophy of human–AI balance
	4.5 Teacher–Student Relationship in AI-Rich Environments	maintaining emotional connection; reduced face-to-face communication; leveraging AI to personalize support; shifts in relational dynamics
	4.6 Reflective Practices for AI-Enhanced Teaching	analyzing teaching with AI data; reflective journaling; peer reflection on AI use; iterative modification of teaching methods
	4.7 Empowerment Through AI Literacy	feeling empowered by digital fluency; advocating AI use; mentoring peers; sense of professional growth

Teachers described a fundamental shift in how they interpret student engagement when artificial intelligence becomes part of the learning environment. Participants emphasized that learners show new forms of cognitive adaptation—such as interpreting algorithmic suggestions or navigating AI-generated feedback—and that students often demonstrate stronger self-regulation in tasks guided by AI. Emotional patterns of engagement were also reinterpreted: teachers noted a mixture of

excitement, curiosity, and frustration toward AI-supported tasks. One teacher explained, “When students receive instant feedback from the AI, you can see their eyes light up—they want to fix mistakes immediately.” Behaviorally, teachers observed increased on-task activity, quicker task completion, and heightened attention to automated prompts. Several participants highlighted the growing autonomy of students, referring to independent planning, self-paced learning, and reduced reliance on teacher support. As one interviewee stated, “My students now try to solve everything with the AI first; they only come to me when they can’t interpret something the system says.” Teachers also reported that AI analytics shifted their monitoring role, enabling real-time tracking of micro-engagement indicators. This redefinition of engagement reflects a multidimensional interpretation shaped by cognitive, emotional, and behavioral signals mediated through AI platforms.

Teachers consistently described AI as an influential driver of instructional change, particularly through the personalization of learning paths. They noted that AI systems offer adaptive tasks, differentiated pacing, and tailored recommendations, allowing them to address individual student needs more effectively. One participant shared, “For the first time I feel like I can give every student a different assignment without spending hours preparing it.” Teachers highlighted how data-driven insights—such as engagement dashboards or automated behavioral trends—helped refine instructional decisions. Integration of AI tools into pedagogy also emerged strongly, with interviewees describing hybrid routines combining human instruction and real-time AI feedback. AI additionally enhanced collaborative learning: automated group formation, monitoring of group participation, and structured peer-feedback mechanisms were widely noted. Teachers emphasized the emergence of more interactive learning environments, supported by gamified platforms, simulations, and multimodal tasks. One teacher reflected, “When students work with the AI simulations, they become so immersed that even the quieter students start asking questions.” Overall, AI was perceived as a central force reshaping classroom dynamics and instructional possibilities.

Despite its benefits, teachers reported significant challenges associated with AI-mediated learning. Many described an emerging over-dependency on AI tools, where students expect automation to solve problems and display reduced critical thinking. As one teacher noted, “Some students don’t even try anymore; they just wait for the AI to give them the next hint.” Ethical concerns—including algorithmic bias, fairness in automated scoring, and data privacy—were also emphasized, with one participant expressing, “I worry the AI might treat students differently without us noticing.” Teachers displayed varying levels of skepticism toward AI insights, often comparing algorithmic judgments with their own intuition. Emotional disengagement was another tension, as repetitive AI tasks sometimes triggered boredom or anxiety among learners. Teachers also described classroom management difficulties, particularly with device-related distractions and technical troubleshooting. In several cases, participants felt that AI-generated pacing or activities did not align with curriculum requirements, creating pedagogical misalignment. Digital inequality surfaced as a persistent barrier, with varying levels of student device access and digital proficiency. Together, these tensions highlight that AI integration is neither linear nor universally positive, requiring ongoing negotiation within the classroom context.

The introduction of AI in classrooms led teachers to re-evaluate their professional identity, competencies, and pedagogical values. Participants described a shift from being content deliverers to facilitators and learning coaches, guiding students’ interactions with AI tools rather than providing direct instruction. One teacher reflected, “I feel less like a lecturer now and more like someone who helps students make sense of what the AI tells them.” Developing AI-related competencies—such as digital fluency, tool literacy, and peer-supported learning—was seen as essential for maintaining relevance in the AI era. Professional confidence varied: while some felt empowered by mastering AI tools, others expressed anxiety about technological errors and the perceived loss of authority when AI provides feedback. Teachers also explored how AI intersected with their values and beliefs, especially concerning the preservation of human connection in learning. The teacher–student relationship was described as evolving, with AI sometimes reducing face-to-face interaction but also creating opportunities for personalized

support. As one participant stated, “I still connect with students, but now I use the AI data to understand them better.” Reflective practices—such as analyzing AI-generated engagement patterns or journaling about AI-assisted lessons—played an important role in shaping teachers’ sense of growth and empowerment. Overall, teachers viewed the development of AI literacy as a pathway toward professional empowerment rather than displacement.

Discussion and Conclusion

The findings of this study reveal that teachers’ interpretations of learning engagement in the Artificial Intelligence era are undergoing a multidimensional transformation shaped by cognitive, emotional, behavioral, and technological factors. The first major theme—redefinition of learning engagement—demonstrates that AI-infused classrooms compel teachers to move beyond traditional, behaviorally oriented indicators of engagement toward more complex and fluid conceptualizations. Participants reported that engagement is now deeply influenced by AI-generated feedback cycles, real-time analytics, and the adaptive nature of digital tasks. These findings align closely with recent evidence showing that AI reshapes teachers’ perceptions of participation and attentiveness by making invisible cognitive processes more visible and quantifiable (1). Similarly, Velmurugan et al. assert that immersive AI environments alter both teacher roles and student engagement pathways by promoting continual interaction between learner and technology (2). The growing prominence of algorithmic cues, such as predictive analytics and automated prompts, supports Tang et al.’s argument that generative AI can serve as an effective teaching assistant by offering continuous signals that teachers use to infer engagement (3). These insights collectively indicate that AI has not merely enhanced learning processes but has fundamentally restructured the very frameworks through which teachers interpret student involvement.

The findings also illuminate how AI acts as a catalyst for instructional transformation, an insight that resonates with a substantial body of current research. Teachers in this study highlighted that personalized learning pathways—generated through adaptive algorithms—allowed them to observe deeper and more individualized engagement patterns. This is strongly supported by Ranes (4), who argues that AI-driven personalization enhances the precision with which teachers identify micro-engagement behaviors. Peneyra et al. (5) also show that teachers increasingly rely on technology-mediated cues to make sense of how students interact with content, particularly in English and literature classrooms. In Philippine learning environments, Oligario (6) reports similar shifts, noting that AI amplifies interpretive clarity by enabling teachers to differentiate between passive digital activity and genuine cognitive engagement. The current study extends these insights by demonstrating that teachers do not simply “receive” AI-generated indicators but critically interpret them within their pedagogical contexts. As AI tools embed themselves into classroom routines, teachers adaptively negotiate between automated insights and their professional judgment, suggesting that engagement interpretation becomes a hybridized cognitive process.

Teachers’ observations that AI influences emotional engagement—by eliciting curiosity, excitement, or frustration—mirror the concerns raised in earlier work. Nirchi et al. (7) note that new teachers often experience tension when interpreting student emotions in AI-mediated tasks, as digital interfaces obscure some affective cues while amplifying others. Mukherjee et al. (8) similarly highlight that AI may disrupt the natural flow of emotional engagement, especially in science classrooms where human interaction historically plays a central role in motivation. The present study confirms these patterns: teachers reported fluctuating emotional engagement levels based on students’ familiarity with AI tools, the transparency of system feedback, and the consistency of task difficulty. This aligns with Moore et al. (9), who show that culturally responsive pedagogy becomes more complicated when emotional dynamics must be inferred through digital signals rather than conventional social interactions.

Although AI offers numerous benefits, the findings clearly indicate that teachers also experience significant challenges and tensions when interpreting engagement in AI-rich learning environments. Participants described over-dependence on AI tools among students, echoing Chen's (19) findings that technological reliance may weaken students' independent learning behaviors. The teachers' concerns about algorithmic fairness and accuracy directly align with the critical perspectives raised by Chetia (18), who emphasizes the unresolved ethical issues surrounding AI-based assessment. Additionally, the skepticism teachers expressed toward AI-generated metrics reflects Çelenk and Büyükahıska's study (20), which found that teacher self-efficacy in AI significantly influences how they perceive the reliability of automated insights. Such skepticism suggests that teachers continue to value human judgment as an essential component of interpreting engagement. These tensions reinforce Boysen's argument (21) that AI does not eliminate the need for teacher expertise but instead amplifies the need for critical understanding and methodological rigor.

Another significant finding relates to teachers' professional identity restructuring in response to AI integration. Participants reported shifts from being primary knowledge providers toward acting as facilitators and mediators of interactions between students and AI systems. This phenomenon is widely documented in the literature. Alenezi and Alenezi (22) argue that both teachers and students perceive AI as redistributing instructional authority. Adigun (23) emphasizes that trainers and educators must undergo professional upskilling to adapt to AI's expanding instructional role. The present study similarly found that teachers require continuous capacity-building to effectively interpret and respond to engagement signals. Teachers also described changing beliefs and values about the nature of meaningful engagement, which aligns with Abdulmumin's argument (24) that AI literacy is becoming a foundational component of modern pedagogical competence.

The international literature reinforces these interpretations. For example, Zhang (25) highlights that teachers must adapt to new classroom dynamics in AI contexts, while Utami et al. (26) describe a cultural shift among mathematics teachers who reevaluate their professional identities as AI becomes more integrated. Meylani (27) synthesizes similar findings, showing that AI influences teachers' confidence, pedagogical autonomy, and interpretations of student behavior. Lettieri and Pasquali (28) introduce a philosophical dimension, arguing that modern learning requires blending human and artificial cognition—an idea reflected in this study's findings, as teachers increasingly interpret engagement across human–AI partnerships. Kumar (29) frames this shift more practically, noting that AI transforms learning into an adaptive and dialogic experience. Kirmani et al. (30) caution, however, that these transformations may disrupt established pedagogical norms, which the present study also confirms through teachers' accounts of tensions between human expertise and AI-generated recommendations.

The participants' descriptions of changing teacher–student relationships further align with global trends. Islam et al. (31) observed that AI reshapes classroom interactions by redefining the expectations that teachers and students have of one another. Hegadi (32) similarly notes that AI fosters progressive teaching practices by integrating exploration and autonomy into the classroom, compelling teachers to reinterpret the nature of meaningful engagement. Arora and Pillai (33) extend this by arguing that generative AI enables new forms of creative participation, thus redefining the indicators teachers use to assess involvement. These studies reinforce the present finding that AI enriches relational and instructional dimensions of engagement while simultaneously introducing new complexities.

Collectively, the results indicate that teachers' interpretations of engagement are shaped by a dynamic interplay between human judgment, automated analytics, cognitive processes, emotional cues, and evolving professional identities. This study provides concrete qualitative evidence that teachers actively negotiate, reinterpret, and sometimes challenge the engagement indicators produced by AI systems. Importantly, AI does not replace teachers' interpretive expertise; rather, it transforms it, requiring continuous professional reflection and recalibration.

This study, although extensive in its qualitative depth, has certain limitations that should be acknowledged. First, the participants were drawn exclusively from Tehran, which may limit the transferability of findings to other cultural or educational contexts with different levels of technological infrastructure or pedagogical traditions. Second, the use of semi-structured interviews may have resulted in variations in how participants articulated their interpretations, and observational data were not included to triangulate reported engagement patterns. Third, while data saturation was achieved, qualitative findings remain interpretive in nature and are influenced by the researcher's positionality. Lastly, the study focused on teachers' perceptions without systematically examining student perspectives, which might offer complementary insights into how engagement manifests in AI-mediated environments.

Future studies should expand the scope of investigation to include teachers from diverse geographic regions and educational systems to enhance cross-cultural comparisons of AI-mediated engagement. Longitudinal studies could provide insight into how teachers' perceptions evolve as AI tools become more seamlessly integrated into daily practice. Additionally, incorporating classroom observations and digital trace data would enrich the triangulation of engagement indicators and strengthen the empirical grounding of findings. Exploring students' and administrators' perspectives would also offer a more holistic view of how AI influences engagement across levels of the educational ecosystem. Finally, interdisciplinary studies combining educational psychology, human–computer interaction, and data science would deepen our understanding of how engagement is constructed in increasingly automated learning environments.

The findings suggest that teachers need systematic professional development to effectively interpret AI-generated engagement metrics and integrate them into pedagogically sound decisions. Schools should design training programs focused on AI literacy, ethical data use, and digital assessment. Moreover, AI tools should be incorporated in ways that preserve the central role of human judgment, ensuring that teachers remain empowered to contextualize automated insights within their instructional goals. At the classroom level, teachers can use AI to personalize learning pathways while maintaining a balance between technology-driven activities and relational, human-centered interactions. These strategies will help create classroom environments where AI enhances—rather than replaces—teacher expertise and student engagement.

Acknowledgments

We would like to express our appreciation and gratitude to all those who helped us carrying out this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

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