

# Teachers' Perceptions of AI Integration in Early Childhood Education: A Qualitative Study in the Context of Oman Vision 2040 and SDG 4

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**Abstract:** *Artificial intelligence (AI) is increasingly recognized as a transformative force in education, yet its integration in early childhood settings remains underexplored. This study investigates the perceptions of kindergarten teachers in Muscat regarding the incorporation of AI in education, aligning with Oman Vision 2040 and Sustainable Development Goal (SDG) 4, which emphasizes inclusive and equitable quality education for all. Using a qualitative approach, eight Omani teachers from kindergartens in Muscat participated in focus group discussions. Data were analyzed thematically to identify key themes. Findings indicate that participants had limited conceptual understanding of AI but acknowledged its potential to support adaptive learning, personalize instruction, and stimulate creativity among young learners. However, teachers expressed concerns about inadequate infrastructure, time constraints, ethical considerations, and the lack of local research on AI applications in early education in Oman. These challenges highlight the need for systematic planning and professional development to ensure effective implementation. The study recommends customized training programs for teachers, gradual introduction of AI tools to complement rather than replace educators, and improved technological infrastructure supported by continuous technical assistance. Additionally, pilot programs, inclusion of AI in teacher preparation curricula, and development of culturally relevant resources in Arabic are essential to promote safe and meaningful integration. Addressing these gaps, Oman can advance its Vision 2040 objectives and contribute to SDG 4 by enhancing access to quality early childhood education through responsible AI adoption.*

**Keywords:** Artificial Intelligence, Early Childhood Education, Technology in ECE, Teacher Perceptions, Oman Vision 2040, SDG 4 Quality Education

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## 1. Introduction

Artificial intelligence (AI) has become one of the most influential technological developments shaping contemporary societies, with significant implications for education. AI is commonly understood as the capacity of computational systems to perform tasks that typically require human intelligence, including reasoning, learning, and decision-making (Russell & Norvig, 2021). In educational contexts, AI-driven technologies such as adaptive learning systems, intelligent tutoring environments, and learning analytics have been increasingly adopted to

enhance instructional effectiveness and personalise learning experiences (Ertmer et al., 2012; UNESCO, 2021). International policy frameworks emphasise that the strategic integration of AI in education can improve educational quality, promote equity, and support the development of future-ready competencies (UNESCO, 2021).

However, the successful implementation of AI in educational settings depends not only on technological infrastructure but also on teachers' understanding, acceptance, and pedagogical readiness. Research consistently highlights that teachers play a central role in mediating the use of educational technologies and shaping how innovations are translated into classroom practice (Luckin et al., 2016). Without sufficient conceptual understanding and professional support, AI technologies risk being underutilised or misapplied, particularly in contexts that require developmentally sensitive pedagogical approaches.

Early childhood education and care (ECEC), especially at the kindergarten level, represents a foundational stage in children's cognitive, social, emotional, and linguistic development. Teaching and learning experiences during this period have long-term implications for children's academic trajectories and socio-emotional well-being. Recent studies indicate that integrating digital and intelligent technologies into early childhood education can support play-based learning, enhance engagement, and provide opportunities for adaptive and personalised instruction when implemented appropriately (Gogoi & Kakoti, 2020; Su & Yang, 2022). Nevertheless, the use of AI in early childhood settings remains a complex issue due to concerns about developmental appropriateness, ethical considerations, and the preservation of meaningful human interaction.

Globally, scholarly interest in AI applications for early childhood education has increased, with research highlighting the potential of conversational agents, educational robots, and intelligent learning environments to support early literacy, numeracy, and problem-solving skills (Ayanwale et al., 2022; Yi et al., 2024). At the same time, emerging literature cautions that AI technologies must be carefully designed and implemented to avoid reinforcing biases, compromising children's data privacy, or diminishing the relational role of teachers (Brandhofer & Tengler, 2025; Aldhilan et al., 2025). These concerns are particularly salient in kindergarten contexts, where emotional security, social interaction, and guided exploration are central to effective learning.

Within the local context, the Sultanate of Oman has demonstrated increasing commitment to educational digitalisation and innovation, aligned with broader national development priorities. National strategies emphasise the role of advanced technologies, including artificial intelligence, in building a knowledge-based society and enhancing the quality of education (UNESCO, 2021). Despite these policy-level commitments, empirical research examining the integration of AI in early childhood education within Oman remains limited. In particular, there is a scarcity of studies exploring kindergarten teachers' perceptions, readiness, and concerns regarding AI adoption in classroom practice.

Existing international evidence suggests that teachers' limited conceptual understanding of AI, combined with insufficient professional development and infrastructural support, constitutes a major barrier to effective implementation in early childhood settings (Ozturk, 2025; Gogoi & Kakoti, 2020). Given that the primary agents of educational change, understanding their perceptions of artificial intelligence is essential to informing policy decisions, curriculum development, and teacher education programmes.

Accordingly, this study aims to explore the perceptions of kindergarten teachers in Muscat regarding the integration of artificial intelligence (AI) in early childhood education. Specifically, the study inquires about (1) the level of kindergarten teachers' knowledge of the concept of artificial intelligence, (2) how teachers perceive the opportunities and educational benefits of integrating AI in early childhood education, (3) the key challenges and concerns teachers face when employing AI technologies, and (4) the recommendations that may contribute to improving teachers' readiness to adopt AI in kindergarten classrooms. Exploring teachers' perspectives, this study contributes to the growing body of research on AI in early childhood education and provides context-specific insights to support evidence-based educational planning, teacher preparation, and responsible innovation.

## **2. Artificial Intelligence in Education**

Artificial intelligence (AI) has increasingly been positioned as a transformative force in educational systems, reshaping how teaching and learning processes are designed, delivered, and evaluated. Conceptually, AI refers to computational systems capable of performing tasks that typically require human intelligence, including reasoning, learning, and problem-solving (Russell & Norvig, 2021). Within education, AI applications encompass intelligent tutoring systems, adaptive learning environments, learning analytics, and automated feedback mechanisms, all of which aim to personalise instruction and enhance learning outcomes.

Research indicates that AI has the potential to support more responsive and learner-centred educational experiences by adapting content and pacing to individual learners' needs (Luckin et al., 2016). At the policy level, international frameworks emphasise that AI can contribute to educational equity, efficiency, and quality when implemented responsibly and ethically (UNESCO, 2021). However, the literature also cautions that technological innovation alone does not guarantee pedagogical improvement. Instead, the effectiveness of AI in education depends heavily on teachers' pedagogical integration, institutional readiness, and ethical governance structures.

### **2.1 AI in Early Childhood Education and Care**

The integration of artificial intelligence in early childhood education and care (ECCE) remains an emerging area of research. ECCE settings are characterised by play-based learning, social interaction, and emotional development, which necessitate careful consideration of the developmental appropriateness of AI technologies. A growing body of literature indicates that, when appropriately designed, AI-supported tools can enhance engagement, support exploratory learning, and offer adaptive feedback aligned with children's developmental needs (Su & Yang, 2022; Yi et al., 2024).

Technological integration in ECCE has been shown to support early literacy, numeracy, and problem-solving skills through interactive and intelligent learning environments (Gogoi & Kakoti, 2020). However, scholars caution that excessive or poorly designed technology use may disrupt social interaction and diminish opportunities for meaningful teacher-child engagement. As such, AI applications in early childhood education must be carefully embedded within pedagogical frameworks that prioritise play, interaction, and emotional security.

### **2.2 Teachers' Role, Readiness, and Acceptance of AI**

Teachers play a central role in shaping how AI technologies are interpreted and enacted within classroom practice. The literature consistently identifies teachers' beliefs, attitudes, and

competencies as critical determinants of successful technology integration (Ertmer et al., 2012). In early childhood contexts, teachers act as mediators who ensure that technological tools align with developmental goals and pedagogical principles.

Recent studies indicate that many teachers exhibit limited conceptual understanding of artificial intelligence, often associating it with advanced automation rather than classroom-relevant applications (Ayanwale et al., 2022). This limited understanding can negatively influence teachers' readiness and intention to integrate AI into teaching practice. Research further suggests that teachers' acceptance of AI is influenced by perceived usefulness, ease of use, and ethical considerations (Brandhofer & Tengler, 2025). Targeted professional development that emphasises pedagogical applications and ethical awareness is therefore essential for fostering positive attitudes toward AI adoption.

### **2.3 Ethical, Pedagogical, and Practical Challenges**

Despite the potential benefits of AI in early childhood education, the literature highlights several ethical and practical challenges. Ethical concerns related to children's data privacy, algorithmic bias, and surveillance are particularly salient in early childhood contexts, where children represent a vulnerable population (UNESCO, 2021). Ensuring transparency, data protection, and ethical governance is therefore a prerequisite for responsible AI integration.

From a pedagogical perspective, scholars emphasise that AI should function as a supportive tool rather than a replacement for the human teacher. Research on play-based robotics activities indicates that while AI-enhanced tools can increase engagement and motivation, they may also introduce challenges related to classroom management and the balance between technology use and human interaction (Aldhilan et al., 2025). Similarly, Ozturk (2025) highlights the need to preserve the relational and socio-emotional dimensions of learning when integrating AI into early childhood STEM education.

Practical barriers such as limited infrastructure, insufficient access to resources, and inadequate institutional support further complicate AI adoption in early childhood settings (Gogoi & Kakoti, 2020). These challenges underscore the importance of systemic planning and sustained support mechanisms.

### **2.4 Policy Perspectives and Research Gap**

International policy emphasizes that AI integration in education should be guided by ethical principles, inclusivity, and teacher capacity building (UNESCO, 2021). While policy discourse increasingly acknowledges the role of AI in transforming education, empirical research focusing on early childhood contexts remains limited. In particular, there is a scarcity of qualitative studies examining kindergarten teachers' perceptions, experiences, and concerns regarding AI integration.

Moreover, existing research has largely focused on general education or STEM-specific applications, with fewer studies addressing early childhood educators' readiness and acceptance of AI technologies. This gap is especially evident in non-Western contexts, where cultural, infrastructural, and pedagogical factors may shape technology adoption differently. Addressing these gaps, the present study explores kindergarten teachers' perceptions of the integration of artificial intelligence in early childhood education in Muscat, Oman.

### **3. Research Methods**

This study employed a qualitative research design to explore kindergarten teachers' perceptions of integrating artificial intelligence (AI) into early childhood education. A qualitative approach was considered appropriate given the exploratory nature of the study and the limited empirical research addressing AI integration in early childhood contexts, particularly within Oman. Qualitative inquiry allows for an in-depth understanding of participants' meanings, experiences, and interpretations, enabling researchers to capture nuanced perspectives that may not be accessible through quantitative methods (Creswell & Poth, 2018; Merriam & Tisdell, 2016). In this study, the focus was placed on understanding how teachers conceptualise AI, perceive its potential benefits, and articulate the challenges and support needed for its effective implementation.

Data were collected through a focus group discussion (FGD), a method widely recognised for its effectiveness in eliciting rich, interactive data through group dialogue and shared reflection (Krueger & Casey, 2015; Morgan, 1997). The use of a focus group was particularly suitable for this study, as it enabled participants to exchange experiences, respond to one another's viewpoints, and collectively construct meaning around an emerging educational phenomenon. Such interaction is especially valuable when examining professional perceptions and practices, as it can reveal areas of consensus, divergence, and negotiation among participants (Barbour, 2018).

The focus group consisted of eight kindergarten teachers from the Muscat Governorate, including four teachers from public schools and four from private schools. Participants were purposively selected to ensure representation across different institutional settings and to capture a range of perspectives on AI integration in early childhood education. All participants were in-service kindergarten teachers with direct classroom experience, which allowed the discussion to be grounded in authentic professional contexts. The focus group session lasted approximately 90 minutes and was conducted in a setting that ensured comfort, confidentiality, and open communication.

Prior to the discussion, participants were informed about the purpose of the study, the voluntary nature of participation, and ethical considerations related to confidentiality and data use. Written informed consent was obtained from all participants. With participants' permission, the focus group discussion was audio-recorded to ensure accurate documentation of the dialogue. The recording was subsequently transcribed verbatim to facilitate systematic analysis. The discussion was guided by a semi-structured protocol consisting of open-ended questions that explored teachers' understanding of artificial intelligence, perceived benefits of AI use with children, anticipated challenges and concerns, professional development needs, and suggestions for enhancing AI integration in early childhood education in Oman.

Data analysis was conducted using thematic analysis, a widely adopted method for identifying, analysing, and interpreting patterns of meaning within qualitative data (Braun & Clarke, 2006, 2019). The analytical process followed an iterative and systematic approach, beginning with familiarisation through repeated reading of the transcripts. This was followed by open coding, during which meaningful units of data were identified and labelled. Related codes were then grouped into broader categories, leading to the development of preliminary themes. These themes were reviewed, refined, and interpreted to ensure coherence, internal consistency, and relevance to the research questions.

## 4. Findings

The findings of this study are derived from a thematic analysis of a focus group discussion conducted with eight kindergarten teachers from public and private schools in the Muscat Governorate. Analysis of the data yielded four interrelated themes that reflect teachers' understanding of artificial intelligence (AI), their perceptions of its educational potential, the challenges and concerns associated with its integration, and their views on the support required for effective implementation. Table 1 presents an overview of these themes, including key codes, sub-themes, and analytical conclusions.

**Table 1: Thematic Analysis Summary of FGD Findings**

Main Theme	Key Codes	Sub-theme	Summary of Teachers' Views	Analytical Conclusion
<b>#1 Teachers' level of knowledge about AI</b>	Artificial intelligence, robot, software, ambiguity, unclear	Limited understanding of the concept	Most teachers possessed general and superficial knowledge of AI, associating it mainly with robots and smart devices, while lacking understanding of its educational applications.	There is a pressing need for specialized orientation and training programs to clarify the concept and its applications in early childhood education.
<b>#2 Teachers' perceptions of opportunities and benefits of AI</b>	Interaction, engagement, personalized learning, creativity development, assistance	Support for interactive and adaptive learning	Teachers viewed AI as a tool that can make learning more engaging for children and help design activities tailored to each child's abilities. They emphasized that AI serves as a support tool for the teacher, not a replacement.	An initial positive of AI's value exists, despite limited theoretical understanding.
<b>#3 Main challenges and concerns</b>	Weak infrastructure, time, privacy, loss of human interaction	Practical and ethical challenges	Concerns were raised about the scarcity of devices, time constraints, difficulty monitoring children while using technology, and potential privacy violations or a reduction in human interaction in the classroom.	Challenges are linked to technical, professional, ethical, and security dimensions.
<b>#4 Suggestions to enhance teachers' readiness</b>	Training, technical support, Arabic content, policies, pilot testing	Capacity building and infrastructure development	Teachers highlighted the importance of continuous practical training, availability of Arabic content for children, adequate infrastructure, and conducting pilot projects before full implementation.	There is clear awareness of the need for prior preparation, gradual implementation, and continuous technical support.

### 4.1 Theme 1: Teachers' Level of Knowledge about Artificial Intelligence

The findings indicate that teachers' understanding of artificial intelligence was largely limited and conceptual rather than pedagogical. Most participants described AI using general or technical terms, such as robots or smart devices, without linking the concept to teaching and learning processes in kindergarten settings. This lack of clarity was reflected in participants' expressions of uncertainty and ambiguity.

This theme on the limited understanding of AI is supported by the following excerpts from the focus group discussion. Participant #2 stated, "When I hear artificial intelligence, I mostly think

about robots or machines, but I am not really sure how it can be used in kindergarten teaching.” Similarly, Participant #5 noted, “We hear a lot about AI in the media, but honestly, the concept is still unclear to me in terms of educational use with young children.” Another participant explained this uncertainty more explicitly, with Participant #7 stating, “I know AI is something advanced, but I don’t know how it works in learning activities or how it fits our curriculum.” These responses illustrate that while teachers are aware of AI as a contemporary technological concept, they lack a grounded understanding of its educational applications, particularly within early childhood contexts.

#### **4.2 Theme 2: Teachers’ Perceptions of Opportunities and Benefits of AI**

Despite limited conceptual understanding, teachers expressed conditional optimism regarding the potential benefits of AI in early childhood education. Participants highlighted opportunities for enhancing children’s engagement, supporting personalised learning, and fostering creativity. Importantly, teachers consistently framed AI as a supportive tool that should complement, rather than replace, the teacher’s role.

#### **4.3 Theme 3: Professional, Technical, and Ethical Challenges**

Challenges and concerns were one of the most dominant themes in the discussion. Teachers identified multiple barriers that could hinder AI integration, including limited infrastructure, insufficient time for training and implementation, and ethical concerns related to children’s privacy and reduced human interaction.

#### **4.4 Theme 4: Suggestions to Enhance Teachers’ Readiness**

All participants emphasised the urgent need for training, resources, and supportive policies to facilitate AI integration. Teachers expressed a strong preference for practical, hands-on training and highlighted the importance of Arabic-language content that is culturally and developmentally appropriate for young learners. A gradual, phased approach to implementation was also strongly advocated.

#### **4.5 Descriptive Summary of Focus Group Discussion Outcomes**

To complement the thematic analysis, a descriptive representation of the focus group discussion outcomes was developed to illustrate the relative emphasis placed on each theme during the discussion. As shown in Table 2, participants’ responses were distributed across four major thematic areas: knowledge of the concept of artificial intelligence, perceived opportunities and benefits, challenges and concerns, and development recommendations.

**Table 2: Descriptive Distribution of Themes in the FGD**

Theme	Frequency in Discussion (%)
Knowledge of the Concept	25%
Positive Perceptions of Opportunities and Benefits	30%
Challenges and Concerns	25%
Development Recommendations	20%

The descriptive distribution indicates that positive perceptions of opportunities and benefits (30%) and challenges and concerns (25%) were the most frequently discussed topics during the focus group session. In contrast, development recommendations (20%) and theoretical knowledge of AI (25%) received comparatively less attention. This pattern reflects teachers’ tendency to focus on the practical implications of artificial intelligence in early childhood education rather than on abstract or technical definitions.

## 5. Discussion

The present study contributes to the growing body of literature on artificial intelligence (AI) in early childhood education by offering context-specific insights into kindergarten teachers' perceptions in Muscat, Oman. Overall, the findings reveal a pattern of cautious optimism, where teachers recognise the educational potential of AI but remain constrained by limited conceptual understanding, insufficient training, infrastructural challenges, and ethical concerns. When examined in relation to existing studies, these findings both corroborate and extend prior research, particularly in highlighting the importance of age-appropriate design, ethical awareness, and teacher preparedness in early childhood contexts.

Consistent with Su and Wang's (2022) study, which highlighted the broad educational potential of AI alongside a lack of long-term empirical evidence, the teachers in this study demonstrated openness toward AI use but lacked clarity regarding its sustained pedagogical impact. This convergence suggests that while AI is widely perceived as promising, its application in early childhood education remains under-theorised and under-tested, reinforcing the need for developmentally appropriate instructional design and longitudinal evaluation. Extending this argument, Ni and Jia (2025) scoping review further identified a systemic imbalance in AI programmes, particularly in their insufficient attention to ethical considerations. This concern was strongly echoed by participants in the current study, who expressed apprehension regarding children's privacy, data protection, and the potential erosion of human interaction, thereby underscoring the necessity of embedding ethical literacy within teacher training initiatives.

Teachers' conditional acceptance of AI observed in this study is related with Kim et al.'s (2022) survey findings, which revealed that educators tend to accept AI technologies only when issues of transparency, control, and purpose are adequately addressed. Similarly, the kindergarten teachers in Muscat expressed willingness to engage with AI provided that it remains a supportive tool rather than a replacement for the teacher. This conditionality reflects a broader pattern in the literature, suggesting that acceptance of AI is not driven by technological novelty alone but by its perceived alignment with pedagogical values and professional identity.

The types of AI applications discussed by participants, such as interactive tools, personalised activities, and adaptive support, are in line with the technological trends identified by Yi et al. (2024), who reported the growing prevalence of educational robots and conversational agents in early childhood education. However, while Yi et al. emphasised technical advancement, the present study highlights the cultural and linguistic dimensions of implementation. Teachers' strong call for age-appropriate Arabic content indicates that without localisation, even technically advanced AI tools may remain pedagogically ineffective.

Concerns regarding over-reliance on AI and the preservation of the teacher's role were also prominent in the findings. These concerns were also addressed in Chen et al.'s (2025) scoping study, which acknowledged AI's capacity to enhance language development while cautioning against excessive dependence that may undermine children's autonomy and social development. In this regard, the teachers' insistence on positioning AI as a *supportive aid* reinforces the conceptualisation of the teacher as a guiding facilitator.

Teachers' readiness to adopt AI was further shaped by their understanding of its educational benefits, a finding that parallels Yim's (2024) quantitative evidence demonstrating higher levels of acceptance when the instructional value of AI is clearly communicated. The present

study extends this insight by showing that clarity alone is insufficient without hands-on, practice-oriented training, particularly for teachers with limited prior exposure to AI. This aligns with Alghamdi and Alghizzi's (2023) mixed-methods findings, which identified persistent gaps in professional development as a major barrier to effective AI integration. Together, these studies emphasise the importance of institutionalised training programmes that move beyond awareness-raising toward sustained pedagogical capacity-building.

Ethical considerations emerged as a cross-cutting concern in both the current study and the wider literature. Ozturk's (2025) theoretical analysis underscores the necessity of a robust ethical framework to guide AI implementation, particularly in safeguarding children's rights and wellbeing. The teachers' concerns regarding privacy, surveillance, and reduced human interaction strongly support this call, suggesting that ethical governance must be integral—not peripheral—to AI adoption in early childhood education. Without clear policies and safeguards, teachers may remain hesitant to embrace AI despite recognising its potential benefits.

Finally, the findings were consistent with Aldhilan's (2025) field-based evidence, which demonstrated that AI-enhanced, play-based activities can positively influence children's motivation and learning behaviour, albeit within contexts supported by adequate resources and training. Similar to Aldhilan's study, teachers in Oman identified technical limitations and funding constraints as major obstacles, reinforcing the argument that pedagogical innovation must be accompanied by material and institutional investment.

## **6. Conclusion and Recommendation**

This study examined kindergarten teachers' perceptions of artificial intelligence (AI) integration in early childhood education in Muscat, Oman, and revealed a pattern of cautious optimism accompanied by notable constraints. While teachers recognised the potential of AI to enhance engagement, support personalised learning, and assist with instructional tasks, their understanding of AI remained largely introductory and shaped more by media exposure than by pedagogical experience. At the same time, concerns related to insufficient training, limited infrastructure, ethical risks, and the possible reduction of social interaction among young children emerged as significant barriers. These findings suggest that the effective integration of AI in early childhood education depends not only on technological advancement but also on teacher preparedness, institutional readiness, and the preservation of human-centred pedagogical practices.

Based on these findings, the study recommends a systematic and gradual approach to AI integration in early childhood education. Targeted professional development is essential to equip teachers with practical, classroom-relevant knowledge of AI and its ethical use with young learners. Training initiatives should emphasise hands-on applications and clarify the role of AI as a supportive tool rather than a replacement for the teacher. In parallel, improvements in technological infrastructure—particularly in public kindergartens—are necessary to ensure equitable access to AI-enabled resources. The development of age-appropriate, culturally relevant Arabic content is also critical to enhance pedagogical relevance and learner engagement. Furthermore, pilot implementation in selected kindergartens is recommended to allow for evaluation, contextual adaptation, and ethical oversight before wider adoption.

Despite its contributions, this study has several limitations. The findings are based on a single focus group involving a small number of kindergarten teachers from one geographical area,

which limits the generalisability of the results. Additionally, the study focused on teachers' perceptions rather than direct classroom implementation of AI tools, and did not include perspectives from school leaders, parents, or children. These limitations suggest caution in extrapolating the findings beyond the specific context studied.

Future research should expand on this work by involving larger and more diverse samples across different regions in Oman, as well as by incorporating multiple stakeholder perspectives. Longitudinal and mixed-methods studies are needed to examine how teachers' perceptions evolve with sustained training and real-world AI implementation. Further research should also empirically evaluate the impact of specific AI applications on young children's learning, social interaction, and development, with particular attention to ethical considerations and culturally responsive design. Such investigations would provide deeper insight into how AI can be responsibly and effectively integrated into early childhood education systems.

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### **Conflict of Interest Statement**

The authors declare that there is no conflict of interest regarding the publication of this study.

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