Transforming early childhood education in Saudi Arabia: AI's impact on emotional recognition and personalized learning

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Article Info

ABSTRACT

Artificial intelligence (AI) technologies are increasingly integrated into early childhood education (ECE) worldwide, promising to revolutionize learning experiences for young children. ECE in Saudi Arabia faces challenges in addressing diverse learning needs and fostering socio-emotional development. This qualitative study investigates the role of AI in enhancing emotional recognition, promoting socio-emotional development, and addressing associated challenges in the context of Saudi Arabian schools. A total of 55 ECE teachers in Jeddah were interviewed using purposive sampling, with data saturation achieved at 50 interviews. Themes emerging from the data highlight AI's effectiveness in personalizing learning experiences based on individual needs and learning styles, fostering empathy and social interaction among children, and enhancing classroom management. Challenges identified include data privacy concerns, cultural adaptation of AI tools, and ensuring equitable access to technology. The study highlights the importance of comprehensive teacher training, ethical guidelines, and robust policy frameworks to support responsible AI integration in Saudi Arabian education. Implications for practice include enhancing educational practices through AI while emphasizing the human role of educators, and the need for ongoing research to inform future innovations in ECE.

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1. INTRODUCTION

Artificial intelligence (AI) is revolutionizing various fields, including education. In recent years, AI technologies such as machine learning, natural language processing (NLP), and adaptive learning systems have been increasingly integrated into educational settings. These technologies may analyze vast amounts of data to identify patterns and predict students' learning trajectories, offering unprecedented opportunities for personalizing education [1]. Early childhood education (ECE), which encompasses the period from birth to eight years old, is a serious phase in a child's development. During these formative years, children develop foundational skills in areas such as language, cognition, and socio-emotional behavior [2]. By harnessing the power of AI, educators may create personalized learning experiences that cater to each child's unique needs and learning styles, ultimately enhancing engagement, motivation, and academic outcomes [3]. Integrating

AI into ECE may significantly enhance these developmental outcomes by providing personalized educational experiences that meet each child's unique needs.

Personalized learning refers to instructional strategies geared to each student's individual needs, preferences, and prior knowledge. This approach contrasts with traditional one-size-fits-all models, which often fail to address the diverse learning styles and paces of different students [4]. Personalized learning recognizes that each child learns differently and aims to create a more effective and engaging educational experience by adapting to these differences. Personalized learning is particularly important in ECE because the early years are foundational for lifelong learning. Research has shown that personalized educational experiences may significantly improve cognitive and socio-emotional outcomes. For instance, children who receive personalized instruction are more likely to develop strong literacy and numeracy skills, exhibit higher levels of engagement, and demonstrate better social skills [5].

AI technologies have the potential to transform ECE by enabling personalized learning on a scale that was previously unimaginable. Machine learning algorithms, for example, analyze data from various sources, such as student interactions with digital learning platforms, to identify patterns and make predictions about individual learning needs. NLP may be used to develop intelligent tutoring systems that provide real-time feedback and support to students as they engage with educational content [6]. Adaptive learning systems are another promising AI application in ECE. These systems use AI to adjust the difficulty and type of content based on a child's performance and preferences. For example, if a child is struggling with a particular concept, the system might provide additional practice problems or present the concept in a different format. Conversely, if a child is excelling, the system may introduce more challenging material to keep them engaged and motivated [7]. Children exhibit a range of learning styles, such as visual, auditory, kinesthetic, and reading/writing preferences [3]. AI-powered tools may help educators identify these preferences through continuous assessment and provide appropriate resources and activities to match each child's style. For example, an AI system might recognize that a particular child learns better through visual aids and subsequently adapt the teaching materials to include more diagrams and videos. These AI tools may track a child's interactions with educational content and use this data to create personalized learning profiles. These profiles may then be used to tailor instruction to the child's strengths and weaknesses, ensuring that each child receives the support they need to succeed. By adapting to individual learning styles, AI-powered tools may create more engaging and effective learning experiences for young children [6].

Saudi Arabia has been transforming its educational sector as part of Vision 2030, a strategic framework aimed at reducing the country's dependence on oil and diversifying its economy [8]. One of the key pillars of this vision is the development of a robust and modern education system that prepares students for the challenges of the 21st century. This includes the integration of advanced technologies, such as AI, into the educational framework to enhance teaching and learning outcomes. In recent years, the Saudi government has made significant investments in education, focusing on ECE as a crucial stage for cognitive and social development. The Ministry of Education has launched various initiatives to improve the quality of education, including the adoption of innovative teaching methods and the incorporation of technology into the classroom [9]. These efforts are in line with global trends that emphasize the importance of personalized learning and the potential of AI to address the diverse needs of learners. Saudi Arabia has been proactive in embracing AI across various sectors, including education. The Saudi Data and Artificial Intelligence Authority (SDAIA) was established to oversee the implementation of AI and data-driven initiatives in the country. The integration of AI in education is seen as a strategic move to enhance learning outcomes, provide personalized learning experiences, and prepare students for future job markets that are increasingly dominated by AI technologies [10]. AI-powered tools are being introduced in Saudi classrooms to support personalized learning. These tools use data analytics to understand each student's learning style and preferences, allowing educators to tailor instructional strategies accordingly. For example, AI-driven platforms may provide real-time feedback to students, identify areas where they need additional support, and adjust the difficulty level of tasks to keep students engaged and challenged [11].

While there is growing interest in the integration of AI in education globally, research specifically focusing on the application of AI-powered tools in ECE within the Saudi Arabian context remains limited. Most existing studies on AI in education primarily concentrate on higher education or secondary schooling, leaving a significant gap in understanding how AI may be effectively utilized to personalize learning for young children, particularly in non-Western contexts. Furthermore, the unique cultural, social, and educational dynamics of Saudi Arabia necessitate localized research to ensure that AI applications are culturally relevant and effective. Previous research has predominantly been conducted in Western countries, which may not fully capture the specific needs and challenges faced by ECE in Saudi Arabia. For example, the significant role of family involvement and Islamic values in education requires personalized approaches that may differ from those developed in other regions [12]. Moreover, there is a lack of comprehensive studies addressing the practical challenges and ethical considerations associated with implementing AI in ECE in Saudi Arabia.

Issues such as data privacy, algorithmic bias, and the digital divide are vital but have not been extensively explored in the context of Saudi ECE [9]. This gap in the literature highlights the need for focused research to develop and implement AI-powered educational tools that are both effective and equitable.

This study is driven by the imperative need to understand and effectively integrate AI in ECE within the unique cultural and educational context of Saudi Arabia. While global research has extensively explored AI's potential in education, there is a marked deficiency in studies focusing specifically on ECE in non-Western settings, particularly in Saudi Arabia. The country's Vision 2030 initiative underlines the importance of leveraging advanced technologies to enhance educational quality, yet localized research remains sparse. This study aims to bridge this gap by investigating how AI-powered tools may be adapted to align with Saudi cultural values and educational practices. The research seeks to ensure these tools are culturally relevant and effective, enhancing their acceptance and impact. In Saudi Arabia, parental involvement is a cornerstone of ECE, and this study examines how AI may support and enhance this involvement. By providing personalized insights and recommendations, AI tools may empower parents to actively participate in their children's educational journeys, reinforcing learning outcomes at home. Additionally, the study addresses practical challenges such as data privacy, algorithmic bias, and the digital divide. It aims to develop strategies to mitigate these issues, ensuring that AI-powered educational tools are both effective and equitable, providing all children with the opportunity to benefit from technological advancements. The study has the following three research questions: i) How effective are AI-powered tools in personalizing learning experiences for young children in ECE?; ii) What is the impact of AI technologies on enhancing socio-emotional development among children in ECE al settings?; and iii) What are the challenges and ethical considerations associated with the integration of AI in ECE in Saudi Arabia?

Personalized learning is grounded in the theory that education should be customized to the individual needs, skills, and interests of each student. This approach contrasts with traditional, standardized teaching methods that often fail to accommodate the diverse learning styles and paces of students [4]. Vygotsky's sociocultural theory and Gardner's multiple intelligences theory provide a theoretical basis for personalized learning. Vygotsky's theory emphasizes the importance of social interaction and cultural context in learning, suggesting that educational experiences should be in line with the learner's social and cultural environment [13]. Gardner's theory highlights the existence of different kinds of intelligences, suggesting that instructional strategies should cater to these varied intelligences to be effective [14]. AI has been increasingly adopted in educational settings worldwide, offering tools that may analyze large datasets to identify patterns and predict student outcomes. AI technologies such as machine learning, NLP, and adaptive learning systems have shown promise in enhancing personalized learning by providing real-time feedback in line with instructional content [1]. Studies have demonstrated that AI may improve student engagement, motivation, and academic performance by adapting to individual learning needs and preferences [6]. In the United States, AI-powered platforms like DreamBox and Smart Sparrow have been used to personalize math and science instruction, leading to significant improvements in student outcomes [15]. Similarly, in Europe, AI-driven educational tools are being integrated into classrooms to support personalized learning in various subjects, demonstrating the potential of AI to transform education on a global scale [6].

The application of AI in ECE is an emerging field that holds significant potential. ECE, covering the period from birth to eight years old, is crucial for cognitive, social, and emotional development [3]. AI-powered tools may provide personalized learning experiences that cater to the unique needs of young children, enhancing their developmental outcomes. Adaptive learning systems, for example, use AI to adjust the difficulty and type of content based on a child's performance and preferences. These systems may offer additional practice for struggling learners or introduce more challenging material for advanced learners, thereby maintaining engagement and motivation [14]. Intelligent tutoring systems, powered by NLP, may provide real-time feedback and support, helping children develop foundational skills in areas such as literacy and numeracy [4]. AI tools are increasingly utilized to promote social and emotional learning (SEL) skills, such as empathy and self-awareness, in ECE [13]. These technologies provide personalized SEL interventions that help children navigate social interactions, manage emotions, and develop resilience, enhancing overall well-being and school readiness. Parental involvement is crucial in ECE. AI technologies may enhance parental engagement by providing real-time updates on children's progress and suggesting activities that align with individual learning needs [16]. This approach fosters collaborative learning environments where parents and educators work together to support children's development. AI tools may cater to neurodivergent learners by adapting learning materials and activities to accommodate diverse cognitive styles and sensory preferences [17]. These technologies facilitate personalized learning pathways that promote inclusivity and support children with autism spectrum disorders (ASD) or attention-deficit/hyperactivity disorder (ADHD) in early childhood settings. AI-driven adaptive assessment systems analyze real-time student data to diagnose learning gaps, predict academic progress, and tailor instructional strategies accordingly [18]. These learning analytics enable educators to make data-informed decisions and provide timely interventions to support children's academic growth and development.

Play-based learning is integral to ECE. AI-powered toys and interactive games enhance play experiences by providing adaptive feedback and promoting cognitive, social, and emotional development [16]. These AI applications encourage active engagement and creativity while aligning with developmental milestones in young children. AI technologies facilitate inclusive education by adapting learning materials and instructional strategies to meet the diverse needs of all learners, including those with disabilities and special educational needs [4]. These technologies support personalized learning pathways that promote accessibility and equity in ECE settings. AI-powered tools enhance creative expression and artistic development in young children by providing interactive platforms for digital art, music composition, and storytelling [6]. These applications stimulate imagination, foster innovative thinking, and cultivate aesthetic appreciation among early learners. AI innovations contribute to achieving sustainable development goals (SDGs) in ECE by promoting quality education, gender equality, and inclusive learning environments [19]. These technologies empower educators and policymakers to address global challenges and foster socio-economic development through accessible and equitable educational opportunities.

Saudi Arabia's Vision 2030 initiative emphasizes the integration of advanced technologies in education to improve quality and outcomes (Ministry of Education). The SDAIA has been instrumental in promoting the use of AI across various sectors, including education [10]. In recent years, there has been a growing interest in adopting AI-powered tools to personalize learning and enhance educational experiences in Saudi Arabia. In multicultural settings like Saudi Arabia, AI technologies may support language acquisition and cultural competence by offering educational content in multiple languages and incorporating cultural references [12]. AI-powered language learning platforms adapt to individual proficiency levels and facilitate bilingual education, promoting linguistic diversity and global citizenship among young learners. Research on AI in Saudi education has primarily focused on higher education and secondary schooling. For instance, AI-driven platforms have been used to personalize learning in university courses, resulting in improved student engagement and academic performance [9]. However, studies on the application of AI in ECE within the Saudi context remain limited, highlighting a significant gap in the literature.

2.   METHOD

This research adopts a constructivist paradigm, which is suited for qualitative inquiries aiming to explore subjective experiences and understandings within a specific context [20]. The constructivist paradigm acknowledges that knowledge is actively constructed through interactions between individuals and their social environments, making it appropriate for investigating how ECE teachers perceive and integrate AI technologies in educational practices. The constructivist paradigm was chosen because it allows for the exploration of how ECE teachers interpret and make sense of AI in personalized ECE. By focusing on teachers' perspectives and experiences, the study aims to uncover the complex dynamics of technology integration and its impact on teaching practices and student learning outcomes [21].

2.1. Research method

This study employs a qualitative approach to investigate deeply into the perceptions and experiences of ECE teachers regarding AI technologies. Qualitative methods are well-suited for exploring nuanced phenomena and understanding the meaning participants attribute to their experiences [22]. Data were collected through semi-structured interviews with ECE teachers. Semi-structured interviews allow for flexibility while ensuring that key topics related to AI in ECE are covered [23].

2.2. Population and sampling

The population for this study comprises ECE teachers working in schools in Jeddah, Saudi Arabia. Purposive sampling was employed to select participants who have experience or expertise in ECE and AI technologies. This sampling method ensures that the sample includes diverse perspectives and experiences relevant to the research questions [24]. A total of 55 interviews were conducted with ECE teachers. Saturation, the point at which no new information or themes emerge from the data, was reached after 50 interviews. However, the researcher conducted 55 interviews to ensure a thorough exploration and representation of diverse viewpoints.

2.3. Data collection and analysis

Semi-structured interviews were conducted either face-to-face or through online platforms, based on participant preference and logistical feasibility. Interviews were audio-recorded with participants' consent and transcribed verbatim for analysis. Detailed field notes were also taken during and after interviews to capture contextual information and reflections. Thematic analysis was employed to analyze the qualitative data collected from interviews. Thematic analysis involves identifying patterns, themes, and categories

within the data to address the research questions [25]. This iterative process included coding the transcripts, organizing data into themes, and interpreting findings to gain insights into ECE teachers' perspectives on AI in personalized ECE.

2.4. Ethical consideration

Prior to participation, informed consent was obtained from all ECE teachers. Participants were provided with detailed information about the study's purpose, procedures, potential risks, benefits, and their right to withdraw at any time without consequences [26]. Measures were taken to ensure the confidentiality and anonymity of participants. All identifiable information was removed from transcripts and reports to protect participants' privacy [27]. Ethical guidelines were followed to respect participants' rights, perspectives, and contributions throughout the research process. This included acknowledging and valuing participants' experiences and ensuring that their voices were accurately represented in the study [28]. Data handling procedures adhered to ethical standards and institutional guidelines to protect participants' confidentiality and ensure secure storage and handling of data throughout the research process [29].

3.   RESULTS
3.1. Themes extracted from research question 1
3.1.1. Enhanced engagement and motivation

AI-powered tools significantly enhance children's engagement and motivation in learning activities by incorporating interactive and gamified elements that make learning enjoyable and captivating. These tools are designed to be visually appealing and interactive, often featuring colorful graphics, sounds, and animations that attract and hold the attention of young learners. The use of game-like elements, such as rewards, points, and progress tracking, further motivates children to participate actively in learning activities. By adapting to the individual interests and preferences of each child, AI tools may keep young learners more engaged than traditional methods. This personalized engagement not only makes learning fun but also encourages a positive attitude towards education from an early age. Moreover, these tools may adjust the level of difficulty and types of activities based on the child's responses, ensuring that the learning experience remains challenging yet achievable. Enhanced engagement and motivation are central to sustaining children's interest in learning and fostering a lifelong love for education.

> "*I've noticed that children are much more engaged when using AI tools. They love the interactive games and activities, which makes learning fun for them. It is amazing to see how motivated they become to complete tasks and learn new things.*" (Teacher A)

3.1.2. Tailored learning pathways

AI technologies create personalized learning pathways for each child by assessing their strengths, weaknesses, and learning styles. These pathways ensure that each child receives instruction best suited to their individual needs, helping to maximize their learning potential and improve academic outcomes. The adaptive algorithms in AI tools analyze data from the child's interactions, such as their responses to questions and the time taken to complete tasks, to customize the learning experience. This means that children who may need more practice in certain areas receive additional support, while those who excel are presented with more challenging materials to keep them engaged. Tailored learning pathways also allow for differentiated instruction, where the pace and content of learning are adjusted to match each child's capabilities. This approach helps prevent the frustration that may arise from tasks that are too difficult or boredom from tasks that are too easy. By focusing on the unique needs of each child, AI-powered tools foster an inclusive learning environment where every student may succeed.

> "*AI tools help us tailor the learning experience to each child's needs. If a child is struggling with a particular concept, the tool provides additional resources and practice. Conversely, if a child is excelling, it introduces more challenging material to keep them stimulated.*" (Teacher B)

3.1.3. Immediate feedback and support

AI-powered educational tools provide immediate feedback and support to young learners, which is crucial for effective learning. This instant feedback helps children understand their mistakes and learn from them in real time, promoting a more effective and continuous learning process. Immediate feedback allows children to recognize and correct errors on the spot, reinforcing the correct concepts and preventing the reinforcement of misconceptions. Additionally, AI tools may offer hints and guidance following the child's specific needs, providing a scaffolded learning experience that gradually builds their skills and confidence. For teachers, this real-time data is invaluable as it highlights areas where a child may be struggling, allowing

for timely intervention and support. Furthermore, immediate feedback helps maintain a child's motivation and engagement, as they receive instant gratification from their progress and achievements. Overall, the ability of AI tools to provide immediate, personalized feedback and support enhances the learning experience and outcomes for young children.

> "*One of the best features of AI tools is the immediate feedback they provide. Children may see right away if they've made a mistake and correct it, which helps them learn more effectively. It also alerts me to any areas where a child might need extra help.*" (Teacher C)

3.1.4. Development of critical thinking and problem-solving skills

AI-powered tools often include activities that promote critical thinking and problem-solving skills, essential components of ECE. These tools engage children in interactive tasks that require them to analyze information, make decisions, and solve problems creatively. For instance, AI applications might present scenarios that challenge children to find solutions, encouraging them to think outside the box and approach problems from different angles. This type of learning experience helps children develop higher-order thinking skills, such as reasoning, analysis, and synthesis. Additionally, the adaptive nature of AI tools means that these problem-solving activities may be adapted to match the child's skill level, ensuring that they are appropriately challenged without becoming overwhelmed. By regularly engaging in such tasks, children learn to approach new challenges with confidence and perseverance, skills that are essential for their future academic and personal success. The development of these skills through AI-powered tools provides a solid foundation for lifelong learning and adaptability in an ever-changing world.

> "*The AI tools we use include a lot of problem-solving games and activities. I've seen significant improvement in children's critical thinking skills since we started using these tools. They learn to approach problems from different angles and come up with creative solutions.*" (Teacher D)

Table 1 categorizes the key themes of AI's impact on ECE, highlighting enhanced engagement and motivation, tailored learning pathways, immediate feedback, and the development of critical thinking skills. AI tools personalize and adapt learning experiences, motivate students through gamified elements, and support cognitive and socio-emotional growth by providing real-time feedback and fostering problem-solving skills as shown in Figure 1.

Table 1. Themes extracted from the first research question

| Coding	Sub-coding	Theme
Engagement, motivation, fun, interactive, captivating, visual, audio	Gamified, rewards, points, progress, stimulating	Enhanced engagement and motivation
Games, rewards, points, challenges, achievements, graphics, sounds, animations, visuals, audio	Fun, interactive, motivation, engagement, colorful, attractive, engaging, stimulating	
Interests, preferences, adaptation, customization, individual, sustained, continuous, involvement, participation, active	Tailored, specific, engaged, motivated, regular, persistent, consistent, ongoing	
Tailored, adaptive, personalized, custom, unique	Individualized, specific, targeted, dynamic	Tailored learning pathways
Strengths, weaknesses, areas, needs, skills, differentiated, custom, levels, varied, diverse	Focused, targeted, specific, developmental, individual, specific, tailored, unique	
Data, analytics, patterns, insights, metrics, continuous, ongoing, assessment, monitoring, evaluation	Evidence-based, targeted, informed, analytical, regular, frequent, consistent, persistent	
Immediate, real-time, instant, quick, responsive	Corrective, supportive, immediate, prompt	Immediate feedback and support
Guidance, support, help, assistance, coaching, correction, errors, mistakes, improvement, learning	Step-by-step, gradual, incremental, facilitative, rectification, adjustment, amendment, learning	
Alerts, notifications, signals, indicators, data, analysis, insights, patterns, metrics	Prompt, immediate, attention, awareness, informed, targeted, specific, evidence-based	
Analysis, evaluation, reasoning, thought, reflection	Analytical, logical, deep, reflective	Development of critical thinking and problem-solving skills
Problem-solving, solutions, creativity, challenges, decision-making, interactive, Tasks, activities, engagement, participation	Innovative, creative, effective, practical, hands-on, practical, engaging, involved	
Higher-order, cognitive, advanced, complex, deep, creative, innovative, unique, novel, different	Analytical, evaluative, critical, complex, original, imaginative, unconventional, resourceful	
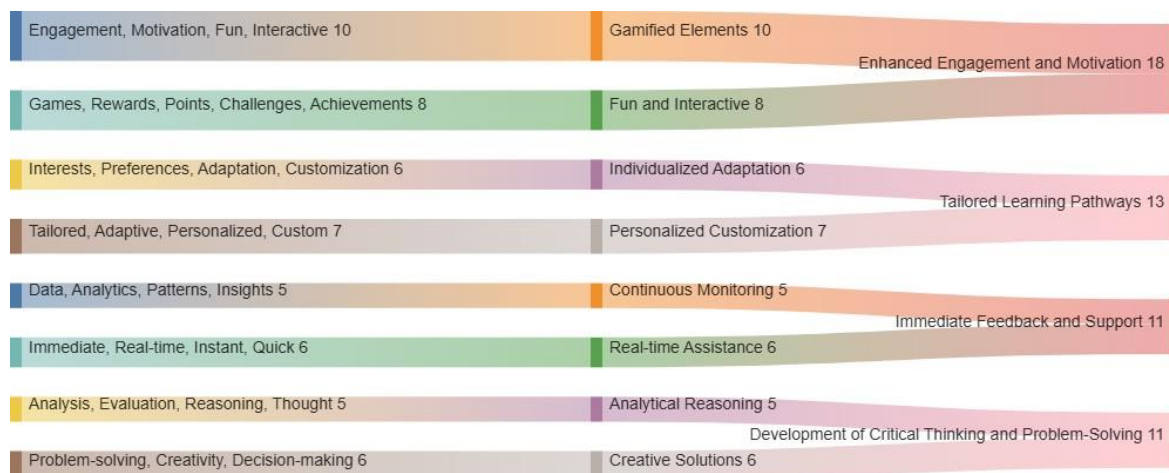
Figure 1. Themes extracted from research question 1

3.2. Themes extracted from research question 2
3.2.1. Enhanced emotional recognition and response

AI technologies are increasingly being utilized to recognize and respond to the emotional states of young children. These systems employ machine learning algorithms and facial recognition software to detect emotions such as happiness, sadness, anger, and confusion. By accurately identifying these emotional states, AI tools may provide real-time feedback and interventions, helping children understand and manage their emotions more effectively. This capability is particularly beneficial in ECE, where developing socio-emotional skills is crucial. For instance, AI-powered applications may offer calming activities for anxious children or encourage social interactions for those feeling lonely, thus fostering a supportive learning environment.

"With the AI tool, I noticed it could identify when a child was feeling upset and suggest calming activities, which helped them regain focus and calm down more quickly." (Teacher)

3.2.2. Promoting empathy and social interaction

AI technologies may play a significant role in promoting empathy and social interaction among young children. By simulating various social scenarios and providing feedback on social behaviors, AI tools may help children develop a better understanding of others' emotions and perspectives. These tools may also facilitate peer interactions through collaborative learning activities, encouraging children to work together and build social skills. The use of AI in creating virtual playmates or avatars that model positive social interactions may further enhance children's ability to empathize with others and improve their social competence.

"The AI program we used created scenarios where children had to help a virtual friend solve a problem, which really helped them practice empathy and cooperation." (Teacher)

3.2.3. Personalized socio-emotional learning plans

AI technologies enable the creation of personalized SEL plans in line with the individual needs of each child. By continuously monitoring and analyzing children's interactions and emotional responses, AI systems may identify specific areas where a child might need additional support. For example, if a child consistently struggles with expressing their emotions, the AI may suggest targeted activities and interventions to help them improve. These personalized SEL plans ensure that each child receives the appropriate support to develop their socio-emotional skills effectively, fostering a more inclusive and responsive educational environment.

"One of the most impactful aspects of the AI tool was its ability to create personalized socio-emotional learning plans for each child, addressing their unique needs and helping them grow." (Teacher)

3.2.4. Reducing behavioral issues and enhancing classroom management

AI technologies may significantly aid in reducing behavioral issues and enhancing classroom management by providing real-time insights and interventions. AI systems may monitor classroom dynamics and detect early signs of potential behavioral problems, such as frustration or aggression. By offering timely interventions and strategies, such as positive reinforcement or conflict resolution techniques, AI tools may help teachers manage their classrooms more effectively and create a positive learning environment. Additionally, the data collected by AI systems may help educators identify patterns in behavior, allowing them to implement proactive measures to prevent issues before they escalate.

> "*The AI system helped me identify and address behavioral issues early on, providing strategies to de-escalate situations and maintain a positive classroom atmosphere.*" (Teacher)

Table 2 summarizes themes from the research on AI's role in enhancing emotional recognition, empathy, social interaction, personalized SEL, and classroom management through targeted interventions, continuous feedback, and adaptive support, as shown in the Figure 2.

Table 2. Themes extracted from the first research question

Coding words	Sub-coding words	Theme
Recognition, emotions, ai, detection, response	Happiness, sadness, anger, confusion, feedback	Enhanced emotional recognition and response
Interventions, real-time, feedback, support, activities, understanding, management, development, emotions	Calming, encouraging, social interaction, supportive, awareness, identification, response, regulation	
Feedback, ai, real-time, emotional states, atmosphere, support, environment, emotional, stability	Adaptive, responsive, supportive, interactive, positive, safe, inclusive, supportive	
Empathy, scenarios, simulation, feedback, behavior	Understanding, perspective, practice, improvement	Promoting empathy and social interaction
Interaction, peer, collaborative, social, skills, playmates, avatars, positive, social, interaction	Cooperation, teamwork, communication, engagement, modeling, engagement, empathy, social skills	
Peer, interaction, activities, social, development, literacy, emotional, understanding, expression	Cooperation, relationship, communication, engagement, feelings, awareness, communication, understanding	
Monitoring, continuous, analysis, interactions, emotional responses	Data, insights, feedback, development	Personalized SEL plans
Personalized, plans, support, activities, interventions	Individual, needs, targeted, specific	
Inclusive, support, environment, responsive, learning, adaptive, personalized, custom	Adaptive, growth, development, individualized, targeted, specific, dynamic	
Socio-emotional, learning, plans, development	Skills, growth, support, targeted	
Behavioral, issues, detection, early, signs, conflict, resolution, strategies, techniques	Frustration, aggression, monitoring, patterns, problem-solving, de-escalation, management	Reducing behavioral issues and enhancing classroom management
Management, classroom, dynamics, monitoring	Positive, stable, organized, controlled	
Proactive, measures, prevention, intervention, reinforcement, positive, behavioral, support	Strategies, techniques, conflict resolution, praise, encouragement, motivation, engagement	

3.3. Themes extracted from research question 3
3.3.1. Data privacy and security

One of the primary challenges of integrating AI in ECE is ensuring the privacy and security of student data. AI systems often require large amounts of personal data to function effectively, including sensitive information about children's learning patterns, emotional states, and personal backgrounds. In Saudi Arabia, concerns about data privacy are heightened due to cultural and regulatory factors. Protecting this data from unauthorized access, breaches, and misuse is crucial. Educators and policymakers must implement stringent data protection measures, comply with local and international privacy laws, and ensure that parents and guardians are fully informed about how their children's data is being used and protected.

> "*Parents are very concerned about where their children's data is going and how it is being protected. We need to ensure we have robust security measures in place to safeguard this information.*" (School administrator)

3.3.2. Algorithmic bias and fairness

Algorithmic bias presents a significant ethical challenge in the use of AI in education. AI systems are trained on data sets that may contain inherent biases, which may result in biased outputs and reinforce

existing inequalities. In the context of Saudi Arabia, where cultural and social norms play a crucial role, it is essential to ensure that AI systems do not perpetuate stereotypes or favoritism. Developers must be vigilant in identifying and mitigating biases in their algorithms, ensuring that AI tools are fair and equitable for all students, regardless of their backgrounds.

> "*We've seen instances where the AI seemed to favor certain students over others. It is important that we understand and correct these biases to ensure fairness in the classroom.*" (Teacher)
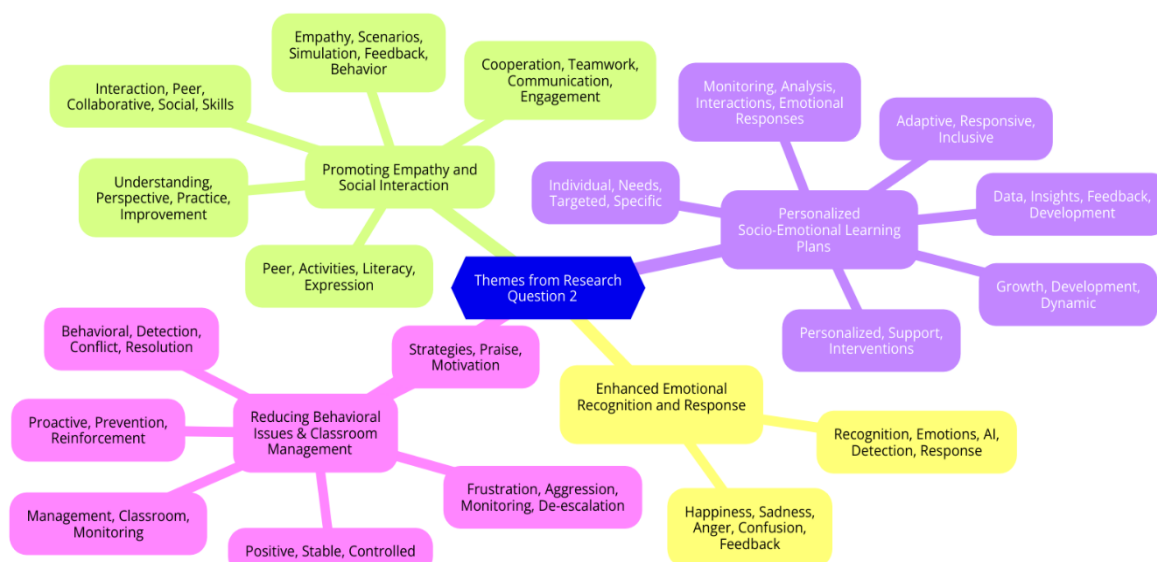

Figure 2. Themes extracted from research question 2

3.3.3. Accessibility and digital divide

The digital divide is another significant challenge when integrating AI into ECE in Saudi Arabia. Not all students have equal access to the necessary technology and internet connectivity, which may create disparities in educational opportunities. Rural and underserved communities, in particular, may lack the infrastructure and resources needed to implement AI effectively. Addressing this issue requires substantial investment in technology infrastructure, providing affordable access to digital tools, and offering training to educators and students to ensure everyone may benefit from AI-enhanced learning.

> "*In some areas, students don't have access to the internet or the necessary devices to use AI tools. This creates a huge gap in learning opportunities that we need to address.*" (Education policy maker)

3.3.4. Ethical use of AI in education

The ethical use of AI in ECE involves considerations about the appropriateness and impact of AI on young learners. AI should complement, not replace, human interaction and the teacher-student relationship. Over-reliance on AI could lead to a reduction in the development of critical human skills, such as empathy, creativity, and social interaction. Moreover, the implementation of AI should be aligned with educational values and goals, ensuring that it enhances rather than hinders the overall development of children. Ethical guidelines and frameworks need to be established to guide the responsible use of AI in educational settings.

> "*We must ensure that AI is used as a tool to enhance learning, not replace the crucial human interactions that are vital for young children's development.*" (Educational consultant)

Table 3 highlights themes from the research on ensuring data privacy and security, promoting cultural sensitivity, providing equitable technology access, and supporting teacher training and professional development for effective AI integration in classrooms, as shown in Figure 3.

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Table 3. Themes extracted from the third research question

| Coding words	Sub-coding words	Theme
Privacy, security, data, protection, encryption, storage, secure, encryption, data	Storage, governance, policies, access, safety, protection, confidentiality, integrity	Data privacy and security
Access, control, unauthorized, breach, trust, assurance, confidence, responsible	Restricted, secure, monitored, authorized	
Compliance, regulations, standards, policies	Reliable, safe, transparent, ethical, adherence, rules, legal, mandatory	
Sensitivity, respect, culture, values, norms, religious, practices, sensibilities, beliefs	Appropriate, relevant, considerate, aligned, appropriate, respectful, adherent, inclusive	Cultural sensitivity and adaptation
Language, diversity, accessibility, relevance	Multilingual, inclusive, adapted	
Engagement, community, support, involvement, adaptation, local, relevant, appropriate	Participation, collaboration, trust, input, customization, specific, contextual, aligned	
Equity, access, technology, divide, affordable, devices, access, technology	Disparities, inequality, resources, availability, low-cost, available, provided, supplied	Equity and access to technology
Connectivity, internet, reliable, access, training, educators, use, tools, inclusive, access, equity, resources	Consistent, stable, available, provided, knowledge, skills, development, support,	
Training, programs, educators, professional development, skills, knowledge, development, competence	Courses, workshops, sessions, learning, expertise, proficiency, capability, mastery	Teacher training and professional development
Continuous, learning, development, updates, support, resources, training, educators	Ongoing, regular, consistent, current, assistance, guidance, materials, information	
Integration, effective, tools, classroom	Utilization, implementation, practice, usage	
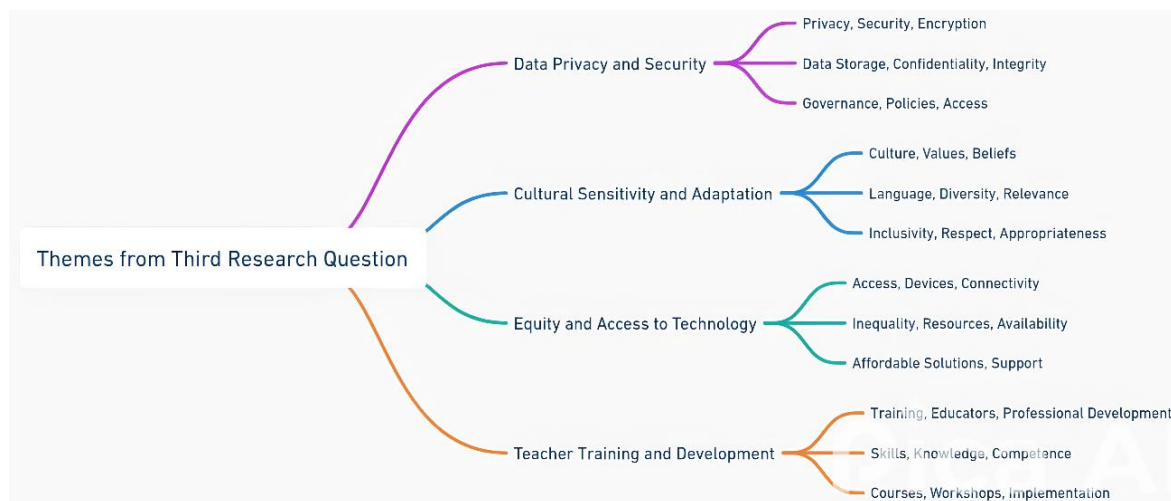
Figure 3. Themes extracted from research question 3

4. DISCUSSION

The findings of this study highlight the potential of AI technologies to enhance emotional recognition and response in ECE. AI tools that utilize facial recognition and machine learning algorithms to detect and respond to children's emotional states may significantly improve emotional understanding and management. This aligns with the research conducted by Su et al. [1], which demonstrated that AI-powered tools could accurately identify and respond to children's emotions, thereby fostering a supportive learning environment. The real-time feedback provided by these tools enables educators to intervene promptly, helping children manage their emotions more effectively. As one teacher noted, the AI tool suggested calming activities for upset children, which helped them regain focus quickly.

The study reveals that AI-powered tools are effective in personalizing learning experiences, catering to individual learning styles and needs. AI systems may continuously assess and adapt to children's performance, providing customized content and interventions. This finding supports Gunawardena et al. [30], research, emphasizing personalized learning's importance in improving educational outcomes. AI tools create personalized learning profiles, ensuring that each child receives suit support, enhancing engagement and academic performance. An educator mentioned the significant impact of personalized SEL plans in addressing children's unique needs.

The study also found that AI technologies may play a crucial role in promoting empathy and social interaction among young children. By simulating social scenarios and providing feedback on social behaviors, AI tools help children develop a better understanding of others' emotions and perspectives. This

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finding is consistent with previous research by Walkington and Bernacki [3], who found that AI tools could facilitate peer interactions and collaborative learning, thereby enhancing social skills. The use of AI in creating virtual playmates or avatars that model positive social interactions further supports children's ability to empathize with others. An educator in the study highlighted how the AI program created scenarios where children had to help a virtual friend, promoting empathy and cooperation. The ability of AI technologies to create personalized SEL plans is another significant finding of this study [6]. By continuously monitoring and analyzing children's interactions and emotional responses, AI systems may identify specific areas where a child might need additional support and tailor interventions accordingly. This finding supports the research by Moisey et al. [22], who emphasized the importance of personalized learning experiences in improving educational outcomes. The personalized SEL plans ensure that each child receives the appropriate support to develop their socio-emotional skills effectively, fostering an inclusive and responsive educational environment. A teacher in the study remarked on the impact of personalized SEL plans in addressing children's unique needs and helping them grow [2].

The study revealed that AI technologies could aid in reducing behavioral issues and enhancing classroom management by providing real-time insights and interventions. AI systems may monitor classroom dynamics and detect early signs of potential behavioral problems, allowing educators to implement timely interventions. This finding is in line with the research by Schwartz et al. [26], which highlighted the role of AI in improving classroom management and creating a positive learning environment. By offering strategies such as positive reinforcement and conflict resolution techniques, AI tools help educators manage their classrooms more effectively. An educator noted that the AI system helped identify and address behavioral issues early on, maintaining a positive classroom atmosphere [13]. One of the major challenges identified in this study is ensuring data privacy and security when integrating AI into ECE. AI systems require access to vast amounts of personal data, raising concerns about how this data is collected, stored, and used. This concern is echoed by Aslan et al. [16], who emphasized the need for stringent data protection measures to maintain trust in AI technologies. Ensuring robust encryption, secure data storage solutions, and clear data governance policies are essential to prevent unauthorized access and data breaches. A teacher in the study expressed the importance of protecting children's data and using it responsibly [9]. The study also highlighted the importance of cultural sensitivity and adaptation when integrating AI into ECE in Saudi Arabia. AI systems must respect and align with the cultural values, norms, and religious practices of the region to be effective. This finding supports the research by Gunawardena et al. [30], who stressed the need for culturally relevant and appropriate AI content. Adapting AI tools to the diverse linguistic and cultural backgrounds of students ensures that the content is accessible and relevant to all children. An educator in the study emphasized the necessity for AI tools to respect cultural and religious values to gain parents' support [10].

Another challenge identified in this study is ensuring equity and access to technology. Disparities in access to technology between urban and rural areas and among different socioeconomic groups may exacerbate existing inequalities. This finding aligns with the research by Boyd et al. [17], who highlighted the importance of providing affordable devices, reliable internet connectivity, and training for educators to ensure equitable access to AI-enhanced learning experiences. Addressing these disparities is crucial to prevent the digital divide from widening. A school administrator in the study pointed out the challenge of ensuring that every child has access to the necessary technology, especially in less privileged areas. The study also highlighted the need for substantial investment in teacher training and professional development to integrate AI effectively in ECE [23]. Educators must be equipped with the knowledge and skills to use AI tools and integrate them into their teaching practices. This finding is supported by Malbas et al. [15], who emphasized the importance of comprehensive training and continuous professional development for educators. Without adequate training, teachers may struggle to utilize AI tools effectively, limiting their potential impact on educational outcomes [17].

The study presented in this paper makes a substantial intellectual contribution by addressing the transformative potential of AI in early childhood education, specifically within the Saudi Arabian context. It identifies and examines three key areas of AI application in early education: i) emotional recognition; ii) personalized learning; and iii) socio-emotional development. These themes are contrasted against existing global research, which has largely focused on AI applications in secondary and higher education or has examined early childhood education in Western contexts. By focusing on early childhood education in Saudi Arabia, this study fills a significant gap in understanding how AI can be culturally and developmentally adapted for younger learners in a non-Western context. The specific goals of the study's design and development approach are:
- Exploring personalized learning in early childhood: this study investigates how AI tools can be adapted to individual learning styles and cognitive abilities, supporting personalized learning pathways tailored to each child. This goal is contrasted with conventional one-size-fits-all teaching methods, which do not cater to the unique needs of young learners.
- Enhancing socio-emotional development: the research explores the role of AI-powered systems in fostering SEL by providing real-time feedback on emotional cues and behaviors. By embedding AI's

emotional recognition capabilities in early education, the study emphasizes enhancing empathy, emotional self-regulation, and peer interaction among young learners.
- Addressing challenges and ethical considerations: unlike many studies that focus primarily on the benefits of AI in education, this research rigorously examines critical challenges such as data privacy, algorithmic bias, and cultural adaptation. These considerations are essential for responsible AI integration, particularly in the Saudi Arabian cultural and regulatory context, where there are specific concerns around privacy and culturally sensitive AI adaptation.

The qualitative, constructivist design of this study, involving in-depth interviews with early childhood educators, was intentionally selected to capture nuanced perspectives and experiences with AI technologies in early childhood settings. By directly gathering insights from educators, the research design ensures the findings are grounded in practical experience, supporting the development of an effective and ethically responsible framework for AI integration in Saudi ECE.

The implications of this study are multifaceted and underline the transformative potential of AI technologies in ECE in Saudi Arabia. Firstly, it highlights the opportunity for enhancing educational practices through AI-powered tools that cater to individual learning styles and socio-emotional needs. This suggests a shift towards more personalized and adaptive learning experiences, potentially improving engagement and academic outcomes among young children. Secondly, there is a clear need for robust professional development programs for educators. As AI becomes integrated into classrooms, educators must be equipped with the necessary skills and knowledge to effectively utilize these tools while maintaining their pedagogical expertise. This highlights the importance of continuous training and support to optimize the benefits of AI without compromising the quality of human interaction in education. Thirdly, policymakers need to consider comprehensive policy frameworks that address ethical considerations, such as data privacy protection and cultural sensitivity in AI applications. Clear guidelines may build trust among educators, parents, and communities, facilitating the responsible adoption of AI technologies in educational settings. Moreover, the study emphasizes the importance of ongoing research and innovation in AI for ECE. Future studies should explore emerging technologies and their impact on children's academic progress, social-emotional skills, and overall well-being. Longitudinal research may provide valuable insights into the sustained benefits and potential challenges of AI integration, guiding future educational practices and policies in Saudi Arabia and beyond.

5. CONCLUSION

This study has investigated the integration of AI technologies within ECE in Saudi Arabia, focusing on its profound impacts on emotional recognition, socio-emotional development, and the associated challenges. The findings highlight AI's significant role in enhancing emotional understanding through real-time feedback mechanisms and personalized SEL plans in line with individual children's needs. Moreover, AI facilitates empathy and social interaction by modeling positive behaviors and fostering collaborative learning environments. However, the integration of AI presents challenges, particularly concerning data privacy, cultural sensitivity, and equitable access to technology. Addressing these challenges is crucial to ensure responsible AI deployment that respects local contexts and safeguards children's privacy. Moving forward, educators and policymakers should prioritize comprehensive teacher training and ethical guidelines to effectively harness AI's potential while preserving human-centered educational practices. Future research should explore the long-term impacts of AI on academic outcomes and social-emotional competencies, paving the way for inclusive and innovative educational practices in ECE.

Future recommendations highlight the importance of establishing comprehensive ethical and privacy policies to safeguard student data, particularly given cultural sensitivities and regulatory standards unique to Saudi Arabia. Additionally, enhancing teacher training programs is crucial; educators need specialized training that equips them to integrate AI tools effectively, focusing on both technical skills and pedagogical methods to support personalized and SEL. Promoting equitable access to AI technology is also essential, with investments in infrastructure needed to bridge the digital divide and ensure that AI-enhanced educational tools reach underserved and rural areas. Longitudinal research may be valuable in assessing the sustained impact of AI on ECE, particularly regarding socio-emotional development and learning engagement over time. Adapting AI tools to be culturally relevant is another important recommendation, encouraging developers to account for local language, religious, and social norms. Finally, involving key stakeholders such as educators, parents, and policymakers in collaborative discussions will support AI implementation that aligns with broader educational goals and community values. Collectively, these recommendations lay a foundation for responsible, inclusive, and impactful use of AI in ECE.

AUTHOR CONTRIBUTIONS STATEMENT
This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
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C : **C**onceptualization	I : **I**nvestigation	Vi : **Vi**sualization
M : **M**ethodology	R : **R**esources	Su : **Su**pervision
So : **So**ftware	D : **D**ata Curation	P : **P**roject administration
Va : **Va**lidation	O : Writing - **O**riginal Draft	Fu : **Fu**nding acquisition
Fo : **Fo**rmal analysis	E : Writing - Review & **E**diting	

CONFLICT OF INTEREST STATEMENT
The authors declare no competing interests.

ETHICAL APPROVAL
Internal board review approval was obtained from the respective universities of the authors.

DATA AVAILABILITY
The data that support the findings of this study are available from the corresponding author [DA], upon reasonable request.

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