SOCIAL SCIENCE REVIEW ARCHIVES
ISSN Online: 3006-4708
ISSN Print: 3006-4694
https://policyjournalofms.com

Balancing Artificial Intelligence and Human Insight in Early Childhood Education: Implications for Child Development

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Abstract
Artificial intelligence technology is increasingly integrated into education, offering potential benefits for personalized feedback and data-driven insights. However, its effectiveness in early childhood education, particularly in terms of teachers' perceptions and experiences, remains underexplored. This study aimed to evaluate the effectiveness of AI-driven tools in early childhood education, focusing on learning outcomes, usability, feedback quality, and teacher workload in preschool and kindergarten settings. A mixed-methods design was used, comprising a survey of 40 teachers and semi-structured interviews with 10 participants. Quantitative data were analyzed through descriptive statistics and ANOVA, while qualitative data were analyzed using thematic analysis. 80% of teachers believed AI tools enhance learning outcomes, with experienced teachers more favorable toward AI feedback. Challenges included AI's inability to interpret social cues, emphasizing the need for human interaction in early learning. AI tools should complement human teaching, with a focus on teacher training and balancing AI with human interaction in early education.

Keywords: AI in Education, Early Childhood Education, AI-Driven Assessment, Teacher Perception, Cognitive Development

Introduction
Artificial Intelligence (AI) is increasingly being integrated into early childhood education (ECE), offering significant benefits for young learners. AI tools have been shown to improve children's understanding of AI, machine learning, and robotics, while also enhancing skills such as creativity, emotional control, and computational thinking (Su & Yang, 2022). The implementation of AI in ECE curricula focuses on developing AI literacy through knowledge, skills, and attitudes, with social robots proving effective as learning companions (Su & Zhong, 2022). AI technologies, particularly AI-based robots, have been applied to improve social interaction in children with autism spectrum disorder (Yi et al., 2023). Introducing AI concepts at an early age contributes to children's creativity, collaboration, and comprehension abilities (Liu & Kromer, 2020). While research in this field is growing, there is a need for standardization of AI curricula in ECE and further exploration of effective teaching methods (Su & Zhong, 2022; Yi et al., 2023). Early childhood education represents a critical developmental stage where accurate and meaningful assessment is key to supporting children's learning and growth. As artificial intelligence (AI) technologies evolve, they present new opportunities to enhance these assessments through automated systems that provide real-time, data-driven feedback. However, despite the potential of AI to assist educators, it cannot entirely replace the nuanced insights that experienced educators

bring to classroom interactions. Research emphasizes that the quality of classroom experiences rather than isolated educational inputs like funding or class size is the primary driver of student progress, even for preschool-aged children (Reardon et al., 2013; Ching & Kuo, 2021). This study aims to address the growing need for robust assessment tools that not only gauge early cognitive and social development but also support educators in providing adaptive feedback. Traditional assessment methods in early childhood education often focus on summative evaluations that measure learning outcomes post-instruction (Lee & Kozlowski, 2022). However, formative assessments that provide real-time insights are essential for guiding instructional adjustments. To address this, there is a need to develop a comprehensive assessment system that integrates both formative and summative approaches, offering a complete view of a child's progress across different stages of learning (Herman, 2010; Gunter & Gunter, 2021). The foundational goal of early childhood education is to foster holistic growth intellectual, emotional, social, and physical through diverse instructional practices. Effective education for young children relies on a mix of structured and experiential learning that includes play-based activities, interactive discussions, and group projects, all designed to cultivate critical thinking, empathy, creativity, and problem-solving skills (Bredekamp & Joseph, 2011). Through play, for example, children develop essential social skills and emotional self-regulation, which are further strengthened by personalized learning approaches that recognize individual strengths, interests, and developmental needs (Gullo, 2005).

The Role of Assessment Tools in Early Childhood Education

A range of assessment tools is essential to capture the diverse developmental milestones in early childhood education. Observation-based assessments, standardized tests, and performance-based assessments each offer unique insights into children's learning and behavior (Crow et al., 2011; Cools et al., 2009). Observations allow educators to document children's behaviors in different settings, while standardized tests, such as the Woodcock-Johnson Achievement Test, help evaluate core skills like literacy and numeracy. Additionally, performance-based assessments emphasize the application of learned skills in practical contexts, encouraging children to demonstrate problem-solving and critical thinking in real-life scenarios (Smith & Thompson, 2020). Other valuable tools include portfolios, which showcase a child's work over time, and checklists, which document developmental milestones based on predefined criteria. Formative assessments, used continuously during the learning process, enable educators to adapt instruction to better meet individual needs, thereby fostering more effective learning (Dunphy, 2010). Authentic assessments, rooted in real-world experiences, gauge children's capacity to apply their knowledge, thus preparing them for future challenges (Sala-Sebastier et al., 2022). Research has shown that early childhood teachers often experience significant stress, which can impact their effectiveness in the classroom, highlighting the importance of exploring factors that can help mitigate this stress, such as psychological capital (PsyCap), as demonstrated in a comparative study by Qayyum (2019).

Rationale of the Study

With the rising importance of digital literacy and computational thinking, there is an increasing demand for sophisticated self-assessment tools in early childhood education. While AI-powered tools can enhance assessment efficiency through swift data analysis, they often lack the contextual awareness that human educators bring. This study seeks to explore the complementary roles of AI and human educators, aiming to develop a hybrid model that combines AI-driven analytics with educators' intuitive understanding. This model could support the real-time assessment needs of teachers while maintaining the human elements critical to interpreting and applying feedback effectively in early childhood settings.

Research Questions

- What are the current AI-driven tools used for assessment and feedback in early childhood education, and how effective are they in enhancing educational practices?
- How do human educators contribute to the interpretation and contextualization of AI-generated data?
- What are the key components of a hybrid model that combines AI tools with human expertise for improved assessment practices?

Research Objectives

- To evaluate the effectiveness of current AI-driven tools for assessment and feedback in early childhood education.
- To analyze how human educators contextualize and interpret AI-generated data.
- To propose a hybrid model that integrates AI tools with human expertise for more insightful and actionable assessment practices.

Significance of the Research

This study holds the potential to transform early childhood education by enhancing assessment and feedback processes through an AI-human hybrid model. Given the foundational nature of early childhood in cognitive, emotional, and social development, implementing advanced assessment practices can help optimize learning outcomes and instructional quality. By proposing a framework where AI complements, rather than replaces, human expertise, this research fills an existing gap in current educational practices, ultimately benefiting both educators and students. This hybrid model could lead to more adaptive and responsive classroom environments, where AI assists with data processing and pattern recognition, while educators apply nuanced understanding to guide children's learning effectively.

Literature Review

AI in Early Childhood Education

Artificial Intelligence encompasses a wide range of technologies, including natural language processing, machine learning, and computer vision (Jin, 2019). These technologies can be leveraged to create interactive and personalized learning experiences for young children. Natural language processing, for instance, can enable AI-powered virtual assistants to engage in natural conversations with children, providing them with personalized feedback and support. Machine learning algorithms can analyze children's learning patterns and adjust the curriculum and teaching strategies accordingly, ensuring that each child receives the support they need to thrive. (Mohamed et al., 2020). Many people are wondering how early childhood education can benefit from artificial intelligence (AI). The increasing demand for effective and personalized teaching tools, along with the rapid development of technology, helps explain the rise of AI in this field. Designed with early childhood assessment in mind, AI-powered solutions have the potential to impact the current educational landscape by providing valuable insights into child development.

- **Adaptive Learning Systems**

Adaptive learning systems are one of the significant areas where AI is making strides. These platforms are designed to adjust the track and level of difficulty based on each student's performance. Lee et al. (2020) found that flexible learning helps differentiate learning, meaning teachers can tailor instruction to meet students' specific needs. These systems use machine learning algorithms to analyze student responses and activity patterns, which enables teachers to identify areas where students could benefit from additional support.

- **AI-Assisted Tutoring**

AI-assisted tutoring systems have shown promise in improving learning outcomes and increasing access to quality education, particularly in mathematics and programming (Aleven et al., 2023; Le et al., 2013). These systems employ various AI techniques to provide personalized feedback, identify student intentions, and customize learning materials (Le et al., 2013; Woolf, 2003). Recent advances have expanded the application of AI in tutoring across multiple sectors, with a focus on developing interactive and adaptive systems (Ismail Yesir & Rawat, 2023). Evaluations of AI-supported tutoring have demonstrated increased learning, reduced costs, and improved grades (Woolf, 2003). Additionally, these systems can positively influence students' confidence and self-image in subjects like mathematics (Woolf, 2003). While most existing approaches support individual learning, there is potential for developing AI-assisted collaborative learning environments (Le et al., 2013). As research in this field progresses, there is a growing emphasis on creating human-AI hybrid tutoring systems to scale up access to high-quality learning opportunities (Aleven et al., 2023).

- **Tracking Developmental Milestones**

In addition, AI tools are increasingly being used to track key developmental milestones. AI can assess various aspects of child development, including motor skills, language abilities, and behavior. AI systems can track changes in student performance over time, enabling teachers and parents to monitor essential developmental milestones. Gomaa et al. (2019) found that these tools could make growth assessments more accurate and help teachers identify areas for early intervention when needed, thereby providing timely support to children who may require additional help.

- **Limitations of AI in Early Childhood Education**

Despite these advances, human educators still play a crucial role in interpreting the information provided by AI systems. Even though AI can be competent and accurate, it lacks the ability to understand the emotional and social dimensions of early childhood development. AI systems often miss out on key elements such as the emotional and behavioral aspects that are critical in understanding a child's overall well-being. Harris et al. (2020) noted that while AI can offer quantitative insights, it cannot fully comprehend the social and emotional aspects of a child's growth. For this reason, it is important to combine AI-driven metrics with human intelligence to gain a more complete understanding of student development and learning.

Human Cognition and Contextual Interpretation

A deep understanding of the human condition is essential for developing social-emotional skills in children. While AI can process vast amounts of data and recognize patterns, it still cannot understand the social cues, emotional responses, or environmental factors that influence children's behavior. Harris et al. (2020) pointed out that AI's inability to recognize these nuances limits its effectiveness in understanding a child's needs. Teachers, on the other hand, possess the emotional intelligence to detect when students are experiencing anxiety, depression, or stress, which can impact their ability to learn effectively. Human experience also enables a more nuanced understanding of children's development, taking into account individual differences and environmental influences. Thompson et al. (2019) found that various factors, such as a child's background and family life, affect their development in complex, non-linear ways. This is something that human educators are better equipped to assess. In contrast, AI systems often rely on standardized developmental models that overlook a child's unique characteristics, leading to the risk of over-diagnosis or misdiagnosis.

- **AI's Struggles with Context**

Additionally, AI struggles with understanding complex social dynamics in the classroom. While AI systems can track progress and provide feedback, Parker and Lee (2021) argued that they often fail to capture the intricacies of classroom relationships, leadership, and peer interactions. Teachers use their cognitive abilities to assess student performance, not just based on academic outcomes but also considering behavioral patterns and peer relationships. Because of AI's current limitations, it is essential for human knowledge and insight to be integrated into the educational process to foster cognitive and social development.

- **Game-Based Learning and AI's Limitations**

Another challenge AI faces in early childhood education lies in game-based learning, which is a fundamental aspect of preschool education programs. Gupta et al. (2019) found that while AI systems can track physical movements and academic progress, they cannot fully grasp the deeper meanings inherent in play-based learning. Play is crucial for developing cognitive skills like thinking, creativity, and communication, and these aspects of learning require human cognition. AI, in its current form, cannot replicate the cognitive understanding needed to assess the value of these learning experiences.

Issues in Assessment

Many challenges affect the validity and integrity of assessment methods used in early childhood education. These challenges vary depending on the content and nature of the assessment. Wigglesworth et al. (2011) highlighted the difficulty of finding a balance between standardized assessments and recognizing each student's unique abilities, academic strengths, and behaviors. Standardized tests often fail to capture a child's full range of competencies and may present an incomplete picture of their abilities.

- **High-Stakes Testing and Stress**

According to Ginsburg (2009), high-stakes tests such as those used to determine school rankings, teacher evaluations, or student progress can increase stress levels among students. The pressure of such tests may narrow the focus to exam preparation, reducing attention to holistic development and creativity. Test anxiety can significantly impact a student's performance, making it difficult for them to demonstrate their true knowledge and skills. Bird and Charteris (2021) argued that students experiencing test anxiety may struggle to show their potential, leading to inaccurate assessments.

- **Cultural Bias in Assessments**

Additionally, assessments may suffer from cultural bias. Haywood and Tzuriel (2002) emphasized that questions or prompts that are culturally unfamiliar or language-dependent can unfairly penalize students from diverse backgrounds, affecting the validity of the evaluation. Teachers' biases and subjectivity can also impact the assessment process, leading to inconsistencies in grading and unfair evaluations. Moreover, when testing time is limited, it can be challenging to conduct a comprehensive assessment of a student's abilities.

- **Lack of Resources and Teacher Training**

Denham et al. (2009) pointed out that assessments often focus on basic knowledge rather than higher-order thinking skills, problem-solving, and creativity. This limitation arises because traditional assessments are time-consuming and fail to capture the broader spectrum of student abilities. For assessments to be meaningful and effective, teachers need access to adequate resources, including training and tools. Romasz et al. (2004) argued that insufficient funding and inadequate teacher preparation can hinder the implementation of valid and reliable assessments.

To address these issues, it is necessary to employ diverse assessment methods, invest in teacher professional development, and emphasize holistic development rather than focusing solely on standardized test scores (Lee & McLeod, 2023).

Role of Feedback in Early Learning

Feedback plays a central role in early childhood education by supporting learning, promoting growth, and providing a foundation for emotional development. Research conducted between 2019 and 2021 has shown that both human input and AI-driven problem-solving work differently in early childhood education, with each offering distinct benefits. Human relationships in early education are crucial, particularly for emotional development (Liu & Zhang, 2021).

- **AI-Driven Feedback**

Zhang et al. (2020) demonstrated that AI-driven feedback can be highly effective in providing immediate, consistent responses to student performance. These systems excel in environments where rapid feedback is needed, such as in repetitive tasks like mathematics or vocabulary. Jones and Wright (2019) explained that AI systems can adapt the difficulty of tasks based on a child's performance, offering personalized feedback that helps improve academic skills. However, such feedback often lacks the emotional nuances necessary for early childhood education.

- **Human Feedback and Emotional Development**

Human feedback, by contrast, is crucial in supporting children's emotional development. Matthews and Simons (2021) emphasized that human teachers provide more than just intellectual feedback; they offer encouragement, inspiration, and empathy, which are key to building a child's self-esteem and confidence. Teachers' understanding of students' emotions allows them to tailor feedback in ways that help children feel safe, supported, and motivated to engage with their learning.

- **Social Learning and Human Interaction**

Research by Miller and Ahmed (2020) illustrated the impact of feedback on social learning. Early learning is highly influenced by interactions between teachers and students, where body language, tone of voice, and facial expressions all play a role. These cues help children understand both emotional and intellectual feedback. Zhang et al. (2020), Taylor et al. (2019), and Matthews and Simons (2021) concluded that human feedback is essential for fostering a positive learning experience, as it supports both cognitive and emotional growth.

While AI tools offer valuable benefits in terms of providing immediate, personalized feedback and tracking academic progress, they are not a substitute for the human element in early childhood education. Human educators bring emotional intelligence, empathy, and an understanding of social cues, which are essential for fostering holistic child development. As AI continues to evolve, the integration of AI-driven insights with human expertise will create a more effective and comprehensive approach to early childhood education, ensuring that both cognitive and emotional needs are met.

ECE in Pakistani Context

- **Teacher Burnout and Stress in Early Childhood Education**

Teacher burnout and stress are significant concerns in early childhood education, as they directly impact educators' effectiveness and the overall learning environment. Aboagye et al. (2018) conducted a cross-cultural examination of preschool teacher burnout, using the Maslach Burnout Inventory for Educators (MBI-ES). Their findings emphasized that burnout is a prevalent issue with consistent measurement across cultures, underscoring the need for supportive measures to reduce stress among educators. Complementing this, Qayyum (2019) examined the role of

psychological capital (PsyCap) in moderating and mediating teacher stress, finding that positive PsyCap (such as hope, resilience, and self-efficacy) can help mitigate stress levels, leading to improved job satisfaction and commitment among early childhood teachers.

- **Language and Cognitive Development in Early Education**

Language development plays a foundational role in early education, influencing both cognitive skills and academic success. Tanveer, Qureshi, Hassan, and Qayyum (2020) studied Urdu language morphology through a corpus-based analysis of affixes, offering valuable insights for early language instruction in Urdu-speaking contexts. Their research contributes to understanding how morphological awareness can support language learning in young children, potentially enhancing cognitive and literacy skills in multilingual educational settings.

- **Social-Emotional Skills and Problem-Solving Abilities**

Social-emotional skills and problem-solving are essential developmental areas in early childhood education, fostering well-rounded growth and preparing children for complex social interactions. Qayyum, Saeed, Hassan, and Qureshi (2024a) explored university students' problem-solving skills, highlighting the importance of developing these skills from early childhood to support later academic success and adaptability. Furthermore, Qayyum, Saeed, Awais, and Qureshi (2024b) conducted a comparative analysis on social-emotional skills in young children, finding that structured ECE programs significantly enhance children's abilities to manage emotions and build positive social relationships. Their work emphasizes the need for early interventions that cultivate emotional intelligence and interpersonal skills.

- **Parental Engagement in Early Childhood Education**

Parental involvement is critical for children's educational outcomes, as it reinforces learning at home and encourages positive attitudes toward education. Qayyum, Saeed, and Qureshi (2024c) examined parental engagement in Punjab's ECE programs, revealing that active parental involvement is associated with better developmental outcomes in children. This theme is further supported by Qayyum, Nadeem, and Saeed (2024d), who investigated parental perceptions of ECE benefits in Pakistan. Their findings demonstrate that when parents value early childhood education, children are more likely to receive the support they need for cognitive and social development, highlighting the importance of building strong parent-school partnerships.

- **Technology and the Digital Divide in Early Childhood Education**

The integration of technology in early education poses both opportunities and challenges, particularly as it relates to access and its potential impact on young learners. Qayyum, Kashif, and Shahid (2024e) addressed the effects of excessive smartphone use on young children's cognitive development, finding that overuse can hinder academic achievement and impact cognitive growth negatively. Additionally, Qayyum, Tabassum, and Kashif (2024f) studied the digital divide in ECE settings, noting that disparities in access to digital resources can limit educators' ability to incorporate technology effectively, especially in under-resourced areas like Punjab. These findings underscore the need for balanced, mindful integration of digital tools in early education while addressing inequalities in technology access.

- **Math Education and Educator Enthusiasm**

Early childhood education also encompasses foundational math skills, which are crucial for later academic achievement. Qayyum, Sialvi, and Saeed (2024g) conducted a qualitative study on educators' experiences teaching math to young children, focusing on the role of enthusiasm and engagement in fostering mathematical interest. Their findings highlight that educators' passion for

teaching math can significantly influence children's motivation and enthusiasm for learning mathematical concepts, advocating for supportive training and resources to sustain teachers' enthusiasm in the classroom. The reviewed literature provides a comprehensive view of the various factors influencing early childhood education, from addressing teacher burnout and promoting language development to enhancing social-emotional skills and navigating the challenges posed by technology. Each theme highlights essential considerations for improving ECE quality and accessibility, underscoring the value of holistic approaches that involve teachers, parents, and technology in creating enriched learning environments.

Research Methodology

Research Design

This study adopted a mixed methods approach to combine both qualitative and quantitative data, aiming to provide a comprehensive understanding of cognitive assessment and counseling in preschool and kindergarten settings. The primary objective was to evaluate the effectiveness of AI-enabled systems and the role of human educators in interpreting and applying these systems. This approach allows for a more nuanced exploration of how AI tools and human insights can interact to enhance early childhood education.

Population

The study was conducted in the Lahore district, focusing on 50 primary schools. The target population included preschools and kindergartens that utilized AI-driven assessment and feedback tools. Education stakeholders, such as teachers who integrate these technologies into their classrooms and staff responsible for incorporating technology into the curriculum, were also key participants in the study.

Sampling

Purposive sampling was used to select the sample to ensure it was representative of the population under study. Out of the 50 schools, 20 were selected based on their use of AI assessment tools. A total of 40 teachers from these schools participated in the study. This sample size was chosen to provide a robust dataset that captures a wide range of experiences without overwhelming the research process.

Research Instruments

Two data collection tools were used in this study: surveys and semi-structured interviews. The survey included Likert-scale questions (Bae & Yoon, 2020) to assess teachers' perceptions of the usefulness, usability, and impact of AI-driven tools on learning outcomes. To gather more in-depth qualitative data, 10 teachers from the sample were selected for semi-structured interviews. These interviews aimed to explore teachers' views on the importance of the human perspective in interpreting AI-driven content and its impact on the social and emotional development of children.

Data Collection

Data collection occurred in two stages. Initially, 40 teachers from the 20 selected schools completed the survey. Each teacher had one week to fill out the survey. Following the survey, 10 teachers were chosen to participate in semi-structured interviews, which lasted between 30 to 45 minutes. These interviews focused on understanding how teachers use AI-generated data to provide feedback to students, with particular emphasis on the interaction between AI systems and human insight.

Data Analysis

The quantitative data collected from the surveys were analyzed using descriptive statistics (mean, frequency, and percentage) to summarize teachers' perceptions of AI tools in early childhood education. To determine any significant differences in the application and knowledge of AI tools between schools or teachers, inferential statistical tests, such as t-tests and ANOVA, were applied.

The qualitative data from the semi-structured interviews were analyzed thematically. Key themes related to the limitations of AI in early childhood education and the role of human educators in interpreting AI feedback emerged from this analysis. Coding was employed to categorize responses into relevant themes, which provided insights into the interaction between AI technology and human interpretation in educational contexts.

Results

This chapter presents the results of the study, organized according to the research objectives and questions. The findings from the quantitative data, including surveys and statistical analyses, are followed by qualitative insights gathered from semi-structured interviews. This mixed-methods approach provides a comprehensive understanding of teachers' perceptions of AI-driven tools in early childhood education.

Overview of Descriptive Statistics

This section summarizes the perceptions of teachers regarding AI-driven tools in early childhood education. Table 4.1 presents the mean scores (M), standard deviations (SD), and the percentage distribution of responses for five key items related to the effectiveness and usability of AI tools.

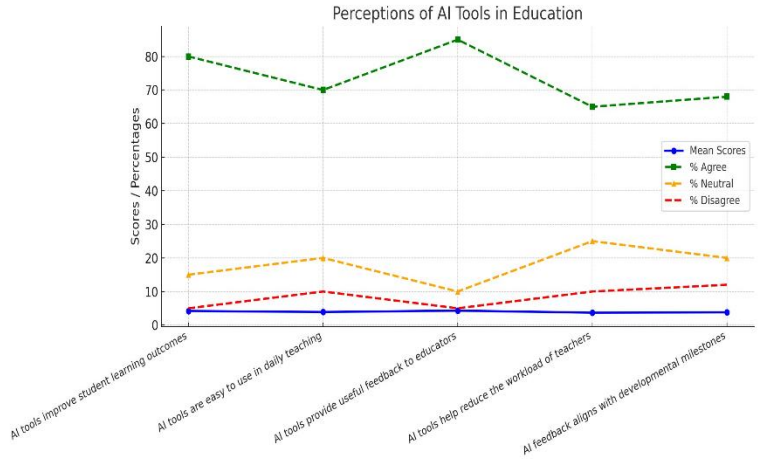
Table 4.1: Descriptive Statistics of ECE Teachers' Perceptions of AI-Driven Tools (N = 40)

Item	M	SD	Agree	Neutral	Disagree
1. AI tools improve student learning outcomes	4.2	0.7	80%	15%	5%
2. AI tools are easy to use in daily teaching	3.9	0.9	70%	20%	10%
3. AI tools provide useful feedback to educators	4.3	0.6	85%	10%	5%
4. AI tools help reduce the workload of teachers	3.7	1.1	65%	25%	10%
5. AI feedback aligns with developmental milestones	3.8	0.8	68%	20%	12%

Key Findings from Descriptive Statistics

The table highlights several key insights regarding the perception of AI tools in education. Teachers overwhelmingly view these tools as effective in improving student learning outcomes, with a high mean score of 4.2. A significant 80% of teachers agreed that AI tools enhance educational performance, reflecting a positive perception of their impact on learning. Regarding ease of use, the tools received a mean score of 3.9, with 70% of teachers agreeing that they are user-friendly. However, a standard deviation of 0.9 indicates some variability in responses, suggesting that while the majority fined the tools accessible, a subset of educator's experiences challenges in integrating them into their teaching practices.

AI tools are also highly regarded for their usefulness in providing feedback to educators. This category achieved the highest mean score of 4.3, with 85% of respondents expressing agreement. This strong endorsement highlights the value teachers place on AI-generated feedback in supporting their instructional strategies. In contrast, teachers were less certain about the ability of AI tools to reduce their workload. The mean score for this category was 3.7, with 65% agreement. A higher standard deviation of 1.1 reflects greater



variation in opinions, with some educators perceiving a reduction in workload while others see little to no benefit in this regard.

Finally, AI feedback is considered reasonably aligned with developmental milestones, as indicated by a mean score of 3.8 and 68% agreement. However, a notable 12% of teachers disagreed, revealing some skepticism about the tools' accuracy in addressing developmental stages. Overall, the table provides valuable insights into the benefits and challenges of integrating AI in education from teachers' perspectives.

Comparison by Teacher Experience: Independent T-Test

This section examines whether teachers' perceptions of AI-driven tools differ based on their experience. Table 4.2 presents the results of an independent t-test comparing the responses of experienced versus less experienced teachers.

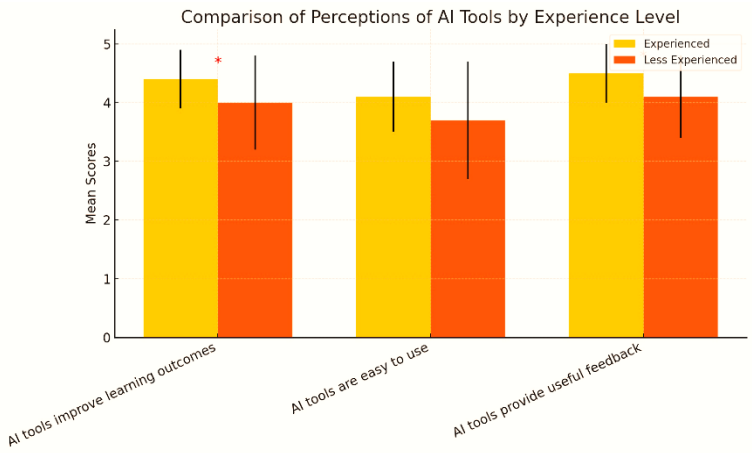
Table 4.2: Independent t-test: Perception of AI-Driven Tools by Teaching Experience

Variable	M (Experienced)	SD (Experienced)	M (Less Experienced)	SD (Less Experienced)	t	p
AI tools improve learning outcomes	4.4	0.5	4.0	0.8	2.10	0.042*
AI tools are easy to use	4.1	0.6	3.7	1.0	1.89	0.063
AI tools provide useful feedback	4.5	0.5	4.1	0.7	2.35	0.024*

Note: *Statistically significant at $p < 0.05$.

The t-test results reveal notable differences in teachers' perceptions of AI tools based on their level of experience. Regarding the improvement of learning outcomes, more experienced teachers rated AI tools as more effective (M = 4.4) compared to their less experienced counterparts (M = 4.0). This difference was statistically significant (t = 2.10, p = 0.042), indicating that seasoned educators are more likely to see AI tools as beneficial for enhancing student performance. In terms of ease of use, experienced teachers gave a higher mean score (M = 4.1) compared to less experienced teachers (M = 3.7). However, this difference was not statistically significant at the conventional 0.05 threshold (p = 0.063). This suggests that while experienced teachers may find AI tools slightly easier to use, the difference in perceptions across experience levels is not pronounced.

The perceived usefulness of AI feedback showed a significant difference between the two groups. Experienced teachers rated AI feedback more favorably (M = 4.5) than their less experienced colleagues (M = 4.1), with this difference reaching statistical significance (t = 2.35, p = 0.024). This finding indicates that experienced educators find AI-generated feedback more relevant and useful in their teaching practices. Overall, the results highlight that teaching experience influences how educators perceive and value AI tools in the classroom. Here is a bar chart comparing the mean scores of perceptions about AI tools between experienced and less experienced participants. Error bars represent the standard deviations. Statistically significant results ($p < 0.05$) are marked with a red asterisk (*) above the relevant bars.



Thematic Analysis from Semi-Structured Interviews

This section presents the results of the thematic analysis conducted on the qualitative data collected from semi-structured interviews with 10 teachers. Table 4.3 summarizes the key themes identified and the frequency of their mentions.

Table 4.3: Thematic Analysis: Key Themes from Semi-Structured Interviews (N = 10)

Theme	Frequency of Mentions	Example Quote
Importance of human interpretation in AI feedback	9/10	"AI provides data, but as teachers, we need to contextualize it for each child."
Emotional support alongside AI feedback	8/10	"Children need encouragement, not just data-driven feedback."
Limitations of AI in recognizing social cues	7/10	"AI misses out on social dynamics that happen in a classroom setting."

Key Findings from Interviews

1. **Human Interpretation in AI Feedback:**
   - Nine out of ten teachers emphasized the importance of human interpretation when using AI feedback. Teachers recognized that while AI provides valuable data, it is essential for educators to contextualize the information according to each child's unique needs.
2. **Emotional Support:**
   - Eight teachers mentioned the necessity of providing emotional support alongside AI feedback. They stressed that AI can offer data-driven insights, but it cannot replace the encouragement and motivation that students need.
3. **Limitations of AI in Social Analysis:**
   - Seven teachers pointed out that AI tools struggle to recognize the social dynamics present in the classroom. AI might fail to capture non-verbal cues, group interactions, and the emotional atmosphere of the classroom.

Differences in AI Feedback Satisfaction across Schools

To explore variations in satisfaction with AI feedback across different schools, an ANOVA was conducted. The results are summarized in Table 4.4.

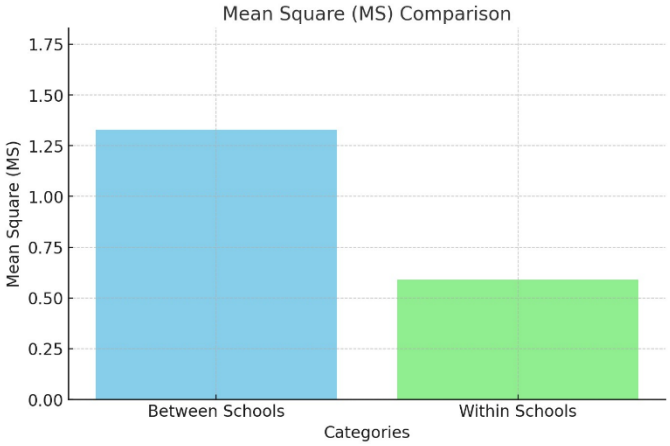
Table 4.4: ANOVA: Differences in AI Feedback Satisfaction across Schools (N = 20 Schools)

Source	SS	df	MS	F	p
Between Schools	25.24	19	1.33	3.21	0.015*
Within Schools	35.40	60	0.59		
Total	60.64	79			

Note: *Statistically significant at $p < 0.05$.

Key Findings from ANOVA

Variation in Satisfaction across Schools:
The ANOVA results show statistically significant differences in satisfaction with AI feedback across schools ($F = 3.21$, $p = 0.015$). This indicates that some schools report higher satisfaction with AI feedback than others, highlighting the potential influence of factors such as school resources, training, and support.



Summary of Results

- **AI Tools and Learning Outcomes:** Teachers generally perceive AI tools as effective in improving learning outcomes, with higher ratings from experienced educators.
- **Usability:** While most teachers find AI tools easy to use, some challenges were noted, particularly by less experienced teachers.
- **Feedback Usefulness:** AI tools were rated highly for their ability to provide useful feedback, particularly by more experienced teachers.
- **Qualitative Insights:** Teachers emphasized the need for human interpretation of AI feedback, the importance of emotional support, and the limitations of AI in recognizing social cues.
- **Variations across Schools:** Differences in satisfaction with AI feedback were observed across schools, indicating the role of contextual factors.

This chapter has presented the results of the study in a clear and systematic manner, combining both quantitative and qualitative data. The findings will be further discussed in Chapter 5, where implications for practice, policy, and future research will be explored.

Discussion, Conclusion and Suggestions

Discussion

This chapter discusses the findings presented in Chapter 4, relating them to the research objectives, existing literature, and the theoretical framework. The discussion is organized into key themes, such as the perceived effectiveness of AI tools in enhancing learning outcomes, their usability, feedback quality, and the role of teacher experience. It also considers the qualitative insights derived from semi-structured interviews and the variations in AI feedback satisfaction across schools. The results will be examined in light of the study's research questions, and implications for practice, policy, and future research will be drawn.

AI Tools and Learning Outcomes

The results revealed a strong consensus among teachers that AI tools positively impact student learning outcomes. A mean score of 4.2 and 80% agreement suggest that teachers believe AI can enhance educational performance. This aligns with prior studies that highlight the potential of AI to provide personalized learning experiences, identify student needs, and offer targeted interventions, ultimately leading to improved academic outcomes (Luckin et al., 2016). However, the research also highlighted some variation in responses, especially among teachers with less experience, suggesting that less experienced teachers might be less confident in using AI tools or might not yet fully appreciate the impact of AI on learning outcomes. The finding that more experienced teachers rated AI tools as more effective for improving learning outcomes ($M = 4.4$) compared to their less experienced counterparts ($M = 4.0$) suggests that familiarity with teaching

and learning processes may enhance teachers' ability to understand and leverage the benefits of AI (Clark et al., 2020).

Implication: Educators with varying levels of experience might require differentiated professional development and training to maximize the effectiveness of AI tools in improving learning outcomes. Schools could consider offering targeted training for less experienced teachers to build their confidence in using AI tools.

Usability of AI Tools in Teaching

The study found that 70% of teachers agreed that AI tools were easy to use, with a mean score of 3.9. This indicates a generally positive perception of the tools' usability, but the standard deviation (0.9) suggests there was some variability in responses. Some teachers, particularly those with less experience, might find the tools more challenging to integrate into their daily teaching practices. This finding aligns with previous research indicating that while AI tools can simplify teaching tasks, their integration into existing classroom practices often requires a learning curve (Popenici & Kerr, 2017). In this study, less experienced teachers rated the ease of use lower (M = 3.7), indicating that familiarity with the tools plays a significant role in teachers' perceptions of usability.

Implication: The usability of AI tools should be continually assessed, and professional development opportunities should be offered to help teachers build the skills necessary to use these tools effectively. Training should emphasize practical strategies for integrating AI into daily teaching practices to make the tools more user-friendly for all educators.

Feedback Quality: AI vs. Human Interpretation

The study found that AI-driven tools were highly valued for their ability to provide useful feedback to educators, with a mean score of 4.3 and 85% of teachers agreeing. Teachers perceived AI feedback as particularly relevant, which supports findings from other studies that emphasize AI's role in providing timely and actionable insights for educators (Woolf, 2010). However, qualitative data revealed a deeper concern: teachers stressed the importance of human interpretation in AI feedback. Nine out of ten teachers highlighted that AI provides valuable data, but human judgment is essential for contextualizing and interpreting that feedback effectively. This aligns with existing literature that suggests AI should complement, rather than replace, human teachers, especially in the areas of emotional support, social interactions, and understanding individual student needs (Baker et al., 2017).

Implication: AI tools should be used as supplements to, rather than replacements for, teacher expertise. Educators need training on how to effectively integrate AI feedback with their own insights to maximize its utility in the classroom.

Emotional Support and Teacher-Student Interactions

A significant theme emerged in the qualitative data regarding the emotional support that AI tools cannot provide. Eight teachers emphasized that children need encouragement and motivation, not just data-driven feedback. AI can deliver accurate assessments of a child's performance, but it cannot replace the human connection essential to student well-being and growth (Mooij & Slof, 2020). AI tools are limited in their ability to recognize the emotional and social dynamics of classroom interactions, as discussed by seven participants in relation to AI's inability to fully grasp social cues. This limitation echoes concerns in the literature about AI's struggle to replicate the

nuanced understanding that teachers have of their students' emotional states and social relationships (Jisc, 2018).

Implication: While AI can enhance learning through personalized feedback and assessments, it is crucial to maintain the role of the teacher as the primary source of emotional support and social guidance for students. AI tools should be used to augment, rather than replace, these critical human aspects of teaching.

Variations in AI Feedback Satisfaction across Schools

The ANOVA results indicated significant variation in satisfaction with AI feedback across schools ($F = 3.21$, $p = 0.015$), suggesting that some schools are more satisfied with AI feedback than others. This variability could be attributed to differences in school resources, such as access to technology, teacher training, and administrative support. Schools with better resources and support may be more successful in implementing AI tools effectively. This finding is consistent with research indicating that the successful implementation of AI in education is often dependent on the context in which it is used, including factors like infrastructure, teacher support, and student engagement (Chassignol et al., 2020).

Implication: Schools should ensure equitable access to AI tools and resources and provide ongoing support to teachers to ensure consistent implementation. Policymakers should consider these contextual factors when planning the integration of AI in education to ensure that all schools can benefit from its potential.

Conclusion

In conclusion, this study provides strong evidence that AI-driven tools have the potential to enhance learning outcomes, reduce teacher workload, and provide valuable feedback. However, the successful implementation of AI tools requires careful attention to teacher experience, usability, and emotional support in the classroom. While AI can support educational goals, it is clear that human interpretation and teacher-student relationships remain fundamental to the educational process. The findings underscore the need for ongoing teacher training, resource allocation, and thoughtful integration of AI tools into the broader educational ecosystem.

Suggestions for Future Research

Future research could explore the long-term effects of AI tools on teaching and learning outcomes, particularly focusing on their impact on student engagement, motivation, and achievement over time. Additionally, investigating the role of AI in personalized learning, particularly for students with diverse learning needs, would be valuable. Finally, future studies could examine how AI tools can be integrated with other educational technologies and strategies to create a more comprehensive, effective, and inclusive educational experience.

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