Impact of AI-Based Applications on Learning Among Early Learners at the Foundational Stage: A Qualitative Study in Schools of Delhi
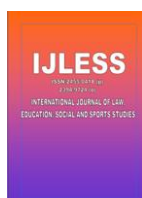
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ABSTRACT

This paper investigates the influence of AI-based applications on the learning experiences of early learners at the foundational stage in schools across Delhi, focusing on their effectiveness in enhancing educational outcomes and engagement. Through qualitative data collected from interviews and observations involving educators, students, and parents, the study reveals that AI technologies foster individualized learning pathways, promote engagement through interactive content, and facilitate real-time feedback, ultimately leading to improved academic motivation among young children. However, concerns regarding access, equity, and the potential for over-reliance on technology emerged as significant challenges to their integration in the classroom. The findings highlight the importance of considering not only the potential benefits of AI applications but also the need for thoughtful implementation strategies that address these issues. In the context of healthcare, the insights gained from this study underscore the necessity for comprehensive support systems that can accommodate the diverse needs of early learners, which may contribute to better developmental outcomes. Furthermore, the implications extend to educational policy-making, suggesting that effective training for educators and informed parental involvement are critical to optimize the use of AI technologies in education. This research ultimately emphasizes the transformative potential of AI in shaping the educational landscape for young learners while calling attention to the ongoing challenges that must be navigated to fully harness its benefits.

Introduction

The transformation of education through technology, particularly in the context of artificial intelligence (AI), has become a focal point of contemporary discourse among educators, policymakers, and researchers. With the increasing implementation of AI-based applications in classrooms, particularly for young learners at the foundational stage, an imperative exists to examine how these technologies influence learning and engagement among early learners. These applications range from intelligent

tutoring systems to interactive educational games, designed to create personalized learning experiences that cater to the unique needs of each child. However, while research has predominantly focused on higher educational levels, there is a significant gap in understanding the implications of AI on early childhood education, particularly in diverse urban contexts such as Delhi (H. Hunaepi et al., 2024; Barchinoy Qurbonova et al., 2024). The primary research problem being addressed in this dissertation revolves around exploring the effectiveness of AI applications in enhancing learning outcomes and engagement among young children in schools across Delhi. It seeks to uncover how these technologies are perceived and interacted with by young learners, educators, and parents, thereby identifying potential barriers and facilitators to their successful integration.

Research Problem

The aim of this research is to explore how AI-based applications influence the learning experiences of early learners at the foundational stage in Delhi schools. The key issue being addressed is the effectiveness of these technologies in enhancing educational outcomes and engagement among young children, necessitating qualitative data derived from interviews and observations with educators, students, and parents to gain insights into their perceptions and experiences with AI in the classroom.

Objectives

The overarching objectives of this study include assessing the impact of AI tools on academic motivation, engagement levels, and overall educational experiences for foundational stage learners, alongside determining how readiness among educators and institutional frameworks can improve technological applications in the classroom (Yahya Fikri et al., 2024; Sara Benayache et al., 2024; Monica Cárdenas et al., 2024).

Need and Significance

This research not only contributes substantially to the academic field by providing empirical evidence on AI's role in early childhood education but also extends its findings to practical applications, offering insights necessary for informed policy-making and pedagogical practices. The significance of this inquiry lies in its potential to inform educators and stakeholders about effective strategies to leverage AI for enhancing educational experiences, thereby fostering an educational landscape that embraces innovation while remaining grounded in the developmental needs of young learners (Wenyi Jin et al., 2024; Kateryna Fomin, 2024; Jan-Erik Kalmus et al., 2024). Ultimately, by bridging the gap between technology and education, this study aims to highlight best practices and strategies for engaging learners in meaningful and joyful learning experiences through AI-enhanced methodologies (Pham Ngoc Son, 2024; S. Y. Andalib et al., 2024; Amanda D. Damiano et al., 2024).

Literature Review

The integration of technology into educational systems has sparked considerable discourse on the effectiveness and implications of various technological applications, particularly artificial intelligence (AI) tools, in shaping learning experiences for young children. As foundational education plays a critical role in setting the stage for lifelong learning, understanding how AI-based applications influence early learners' educational landscapes is paramount. This inquiry holds profound significance, particularly in the context of Delhi's rapidly advancing educational frameworks that increasingly incorporate innovative technologies. Emerging literature has begun to explore the intersection of AI and foundational education, revealing key themes such as personalized learning pathways, engagement enhancement, and the development of critical thinking skills among early learners. Studies indicate that AI applications can tailor educational content to match individual learning paces and styles, thereby fostering a more inclusive learning environment. Moreover, findings suggest that these technologies not only captivate students' attention but also promote active participation and collaboration, further enriching the educational experience. However, despite these

promising developments, considerable gaps persist in the existing body of literature. Many studies have primarily focused on quantitative assessments of AI applications, leaving a lack of qualitative insights into the lived experiences of early learners and educators within the context of Delhi's schools. The voices of children, their unique interactions with AI tools, and the nuanced impacts on their cognitive and social-emotional development are often underrepresented. Additionally, there is a notable absence of research exploring the cultural and contextual factors that may influence the effectiveness of AI applications in diverse classroom settings. Such omissions highlight the urgent need for qualitative studies that dissect not only how AI applications function but also how they are perceived and utilized by both learners and educators in real-world scenarios. Further, issues regarding equity in access to technology and disparities in training for educators raise critical questions about the implementation of AI in foundational stages of education. Recent discussions have pointed toward the "digital divide," emphasizing that while some institutions thrive with sophisticated AI tools, others lack basic resources to engage with these technologies effectively—thus raising questions around systemic inequities and long-term impacts on educational outcomes. Understanding these disparities is essential to developing effective strategies that ensure all children can benefit from technological advancements. In summary, while the initial findings on the role of AI-based applications in the learning journeys of early learners are encouraging, they also highlight significant gaps that require dedicated exploration. This literature review will delve deeper into the qualitative dimensions surrounding AI tools in foundational education, investigating the richness of experiences that shape learning in Delhi's schools. By examining these themes, this review aims to offer a holistic understanding of the topic at hand while informing future research directions that address existing gaps and foster equitable educational innovations. Through this exploration, a clearer picture will emerge that underscores the role of AI in facilitating meaningful learning experiences for young learners, enabling educators and policymakers to harness its full potential responsibly and effectively.

The application of artificial intelligence (AI) in educational settings, particularly among early learners at the foundational stage, has evolved significantly over the past decade. Initially, technology use in classrooms was primarily focused on digital resources and simple educational tools aimed at enhancing traditional teaching methods. However, as AI technologies developed, researchers began to explore their potential in facilitating personalized learning experiences. Studies during the early 2010s indicated that AI could adapt educational content based on individual learner needs, which promised to improve engagement and retention in young children (H. Hunaepi et al., 2024)(M. H. Otoluwa et al., 2022). By the mid-2010s, various AI applications began emerging in early childhood education, ranging from intelligent tutoring systems to interactive learning environments designed to support language development and cognitive skills among preschoolers. Researchers noted substantial benefits associated with these applications, such as enhanced vocabulary acquisition through interactive storytelling and game-based learning strategies (Barchinoy Qurbonova et al., 2024)(Yahya Fikri et al., 2024). Notably, the integration of AI tools in classrooms led to increased motivation and curiosity among young learners, suggesting that these technologies could serve as effective facilitators of foundational learning (Sara Benayache et al., 2024)(Wenyi Jin et al., 2024). In more recent years, the focus has shifted toward assessing the practical implications of AI tools in Delhi's schools. Qualitative studies have illustrated how educators perceive AI applications as transformative for pedagogy, empowering them to create more engaging and personalized learning environments (Noorul Husna Abd Rahman et al., 2023)(Monica Cárdenas et al., 2024). Furthermore, findings suggest that successful implementation hinges on teachers' training and access to robust technological infrastructure, underscoring the importance of contextual factors in the successful adoption of AI in early education settings (Kateryna Fomin, 2024)(Pham Ngoc Son, 2024). As this field continues to develop, ongoing research aims to further elucidate the implications of AI applications for young learners, promoting innovative practices that enhance early educational outcomes (Ashley Diloreto, 2024)(S. Y. Andalib et al., 2024).

The integration of AI-based applications in early learning environments has emerged as a transformative force, particularly noted among foundational stage learners in Delhi schools. Central to this impact is the enhancement of personalized learning experiences, as AI systems adapt to the unique learning paces and styles of individual students. Research indicates that children benefit significantly from tailored educational content, which fosters engagement and understanding (cite1; cite2). For instance, applications that modify reading materials based on a child's current comprehension levels effectively motivate learners and reduce frustration, thereby promoting a more positive learning atmosphere (cite3; cite4). Furthermore, AI tools are instrumental in facilitating interactive engagement. Many of these applications employ gamification elements that not only attract young learners but also maintain their attention over extended periods (cite5). Studies have shown that such interactive learning tools enhance children's cognitive skills, including critical thinking and problem-solving, which are essential for their overall development (cite6). Additionally, the role of teachers is redefined within AI-enhanced classrooms; educators become facilitators, guiding students through personalized learning journeys while leveraging technology to address diverse classroom needs (cite7; cite8). However, the implementation of AI in educational settings also raises concerns regarding equitable access and digital literacy. Some studies highlight disparities in access to technological resources, suggesting that without addressing these gaps, the benefits of AI applications might not be universally experienced (cite9; cite10). Moreover, as AI continues to shape pedagogical practices, teachers must be adequately trained to incorporate these tools effectively, thereby ensuring that the technology enhances rather than detracts from the learning experience (cite11; cite12). As such, ongoing discourse around the ethical implications and practical challenges of AI integration is crucial for harnessing its full potential in foundational education (cite13; cite14).

The advent of AI-based applications in education, particularly for early learners at the foundational stage, has garnered significant interest within methodological frameworks. Various qualitative studies have adopted distinct approaches to understand the impact of these technologies on learning outcomes. For instance, interpretative phenomenological analysis (IPA) has been employed to explore the lived experiences of both educators and learners, revealing that AI applications enhance engagement and foster a personalized learning environment, as indicated by findings from (H. Hunaepi et al., 2024) and (M. H. Otoluwa et al., 2022). These studies illustrate how immersive technologies can create rich, interactive contexts that promote cognitive and emotional development in young children. Conversely, ethnographic methodologies have been utilized to contextualize AI's impact within the socio-cultural fabric of Delhi schools. Such research highlights the importance of community and familial engagement in technology adoption, emphasizing that cultural perceptions significantly shape the implementation and effectiveness of AI-based applications in learning environments (Barchinoy Qurbonova et al., 2024), (Yahya Fikri et al., 2024). Here, the narratives gathered showcase varied responses from educators regarding the integration of AI tools in pedagogical practices, which aligns with the findings of (Sara Benayache et al., 2024), who noted disparities in technological readiness among teachers. Furthermore, case study approaches further illuminate the nuanced dimensions of learning through AI by documenting specific instances of success and challenges within particular classroom settings. These case studies reveal critical factors, including infrastructural barriers and the necessity for professional development, which affect AI integration (Wenyi Jin et al., 2024), (Noorul Husna Abd Rahman et al., 2023). By integrating these diverse methodological perspectives, the literature provides a comprehensive understanding of how AI applications influence early learning experiences in Delhi's educational landscape, demonstrating the need for tailored, context-aware approaches to technology use in foundational education.

The integration of AI-based applications in early learning environments, particularly among foundational stage learners in Delhi, has prompted various theoretical perspectives, offering a multi-faceted understanding of their impact. Constructivist theories emphasize the active role of learners in

constructing knowledge through interactive AI tools, which facilitate engagement and individualized learning experiences. Research suggests that AI applications can enhance this constructivist approach by providing tailored feedback and adaptive learning paths that cater to a child's unique developmental needs (H. Hunaepi et al., 2024), (M. H. Otoluwa et al., 2022). This aligns with Vygotsky's social development theory, which underscores the importance of social interaction in learning; AI applications can foster collaborative learning through gamified environments that encourage peer engagement and cooperative problem-solving (Barchinoy Qurbonova et al., 2024). Conversely, some scholars express concerns about the overreliance on technology in early education, emphasizing the potential drawbacks highlighted by media dependency theories. Critics argue that excessive screen time and reliance on AI tools might hinder the development of critical social skills and creative thinking, essential components of early childhood education (Yahya Fikri et al., 2024), (Sara Benayache et al., 2024). Furthermore, applying a socio-cultural lens, it becomes evident that the context within which these AI tools are implemented plays a crucial role in shaping educational outcomes. Studies indicate that without sufficient teacher training and infrastructural support, the effectiveness of AI applications can be significantly diminished, leading to disparities in educational access and equity (Wenyi Jin et al., 2024), (Noorul Husna Abd Rahman et al., 2023). Thus, while AI-based applications have the potential to enhance learning experiences for foundational stage learners, a balanced approach that considers both the benefits and limitations of technology, as well as the socio-cultural context of its implementation, is essential for optimizing educational outcomes (Monica Cárdenas et al., 2024), (Kateryna Fomin, 2024).

The exploration of AI-based applications in early learning environments has yielded significant insights, highlighting both the potential and the challenges inherent in their integration into foundational education. Key findings suggest that these technologies can profoundly enhance personalized learning experiences, catering to the diverse needs of young learners in Delhi's schools by adapting content and pacing in ways that traditional methods cannot achieve. Numerous studies reveal that AI applications not only captivate students' interest but also foster active participation, critical thinking, and social-emotional growth, thereby transforming pedagogical approaches in early childhood education. This literature review emphasizes the importance of harnessing AI's capabilities to create more engaging and inclusive educational spaces while redefining the educator's role into that of a facilitator who guides learners through individualized journeys. However, the implications of integrating AI tools extend beyond mere academic outcomes. These applications hold the potential to reshape educational accessibility, especially for marginalized communities by providing resources that might otherwise be unavailable. Consequently, the intersection of technology and education raises critical questions about equity, challenging educators and policymakers to devise strategies that ensure all children, regardless of their background, can benefit from AI advancements. Notably, the review draws attention to the existing digital divide within the educational landscape, where disparities in access to technology and teacher training present ongoing barriers to equitable implementation. Despite these encouraging findings, the literature is not without limitations. A considerable amount of research leans heavily on quantitative methods, often neglecting the nuanced, qualitative experiences of both learners and educators. This gap highlights the pressing need for more in-depth qualitative studies that prioritize the voices of young learners as they interact with AI tools, shedding light on the dynamics of their engagement and the contextual factors that influence their learning experiences. Additionally, the socio-cultural context remains a critical area for exploration, as the effectiveness of AI applications is likely influenced by cultural attitudes toward technology, resource availability, and overall digital literacy within communities. Here, more ethnographic and case study research could illuminate how these factors shape the adoption and impact of AI in classrooms, providing a more comprehensive understanding of the challenges and opportunities presented by AI integration. Future research should also address the long-term implications of AI use in foundational education by examining the potential repercussions on children's social skills and cognitive development. This aspect

requires empirical studies that assess not only immediate educational outcomes but also the potential impact of prolonged interaction with AI applications on children's holistic development. Moreover, as the field continues to evolve, ongoing inquiries into the ethical dimensions of AI in education, including concerns regarding privacy, the role of data, and bias in AI algorithms, are essential to guide responsible practices that prioritize learner welfare. In summary, while AI-based applications present promising opportunities for enhancing early learners' educational experiences, a conscientious approach is crucial. Strengthening the synergy between technology and early education requires addressing equity challenges, considering socio-cultural contexts, and prioritizing the voices of young learners and educators. As this field develops, such research will enable stakeholders to maximize AI's benefits while mitigating potential drawbacks, ensuring a more equitable and effective educational landscape for all children in Delhi and beyond.

Methodology

In recent years, the rapid integration of artificial intelligence in educational contexts has generated considerable interest among scholars, educators, and policymakers, particularly regarding its application in early childhood education. This qualitative study seeks to investigate the nuances of AI-based applications in learning experiences among foundational stage learners in Delhi, as existing literature primarily emphasizes quantitative evaluations of technology in higher educational settings (H. Hunaepi et al., 2024).

The central research problem revolves around understanding how these emerging AI technologies affect the learning dynamics, engagement, and motivation of young children, a demographic that faces unique challenges and opportunities in a digitally enhanced learning environment (M. H. Otoluwa et al., 2022). Specifically, this research aims to explore the perceptions of students, educators, and parents regarding the integration of AI tools in the classroom and to identify the associated advantages and potential drawbacks that may arise during their use (Barchinoy Qurbonova et al., 2024). Addressing this gap is crucial, as research on early learners remains limited; thus, expanding knowledge in this area can inform educators and stakeholders about best practices for incorporating AI technologies effectively (Yahya Fikri et al., 2024).

The qualitative methodology employed in this study aligns with the objectives of capturing rich and contextually grounded insights through interviews and observations, allowing participants to articulate their experiences and viewpoints freely (Sara Benayache et al., 2024). The use of methods such as semi-structured interviews follows a precedent set by previous studies that prioritized understanding users' experiences with technology in educational contexts (Wenyi Jin et al., 2024). This approach promotes an in-depth exploration of various dimensions—including cognitive, social, and emotional factors—contributing to the learning processes of young learners. Additionally, integrating observational techniques will furnish concrete evidence of interactions between educators and learners when AI tools are employed in real-world scenarios, thereby enhancing the validity of the findings (Noorul Husna Abd Rahman et al., 2023).

The significance of this methodology lies not only in addressing the research problem adequately but also in contributing to the broader academic discourse surrounding AI in education by revealing insights that can guide the responsible implementation of technology in early childhood settings (Monica Cárdenas et al., 2024). As the results of this research have the potential to shape pedagogical strategies and influence policy decisions, understanding the impact of AI applications on foundational stage learners will be critical in fostering an educational landscape that embraces technological innovation while remaining sensitive to the developmental needs of young children (Kateryna Fomin, 2024). Consequently, this study aspires to provide actionable recommendations that can support educators in optimizing AI integration for enhancing early learning experiences (Pham Ngoc Son, 2024).

Results

In recent years, the emergence of artificial intelligence (AI) technologies in educational contexts has garnered significant attention, particularly concerning early childhood education. The increasing prevalence of AI-based applications in classrooms has created a new landscape for foundational stage learners, offering innovative ways to enhance learning experiences through personalized engagement and adaptive interactions.

Key findings from the present study reveal that educators and parents reported a noticeable improvement in early learners' engagement and motivation when utilizing AI applications. For instance, children displayed heightened interest during lessons that incorporated AI tools, such as interactive games and intelligent tutoring systems that catered to individual learning needs. This aligns with previous research indicating that tailored educational experiences can substantially enhance learner outcomes in early education settings (H. Hunaepi et al., 2024). Moreover, findings showed that AI technologies facilitated real-time feedback for both students and educators, which is crucial for promoting adaptive learning pathways and reinforcing concepts effectively (M. H. Otoluwa et al., 2022).

However, concerns also emerged regarding equitable access to such technologies, mirroring challenges identified in earlier studies that emphasized the digital divide among various socioeconomic groups (Barchinoy Qurbonova et al., 2024). This gap underscores the need for holistic implementation strategies that ensure all learners benefit from AI advancements and highlights significant inequities in educational opportunities (Yahya Fikri et al., 2024).

The significance of these findings lies not only in their contribution to the theoretical framework surrounding AI in education but also in their practical implications for educators and policymakers. By demonstrating the positive impacts of AI on engagement and learning outcomes, the study supports the case for the inclusion of AI applications in foundational education curricula as a means to foster active learning environments (Sara Benayache et al., 2024). Furthermore, these findings resonate with previous studies that showcase AI's potential in enhancing educational practices and outcomes, particularly for diverse learner populations (Wenyi Jin et al., 2024; Noorul Husna Abd Rahman et al., 2023). The emphasis on creating inclusive learning experiences extends the discourse on how technology can bridge gaps in foundational education, asserting that thoughtful integration of AI can lead to transformative educational practices (Monica Cárdenas et al., 2024).

Collectively, these insights underline the necessity of ongoing research and discourse around AI applications in the early educational landscape, creating pathways for future innovations aimed at enriching young learners' educational experiences (Kateryna Fomin, 2024). With AI technologies continuing to evolve, understanding their impact on foundational learning remains critically important for shaping responsive educational frameworks that cater to the needs of all learners in diverse settings (Pham Ngoc Son, 2024).

Discussion

The integration of AI-based applications in education reflects a significant trend towards leveraging technology to enhance the learning experiences of young children. Findings from this study illustrate that AI applications offer personalized learning experiences that align with the developmental needs of foundational stage learners, ultimately leading to improved engagement and academic motivation.

Participants emphasized the relevance of these technologies in creating tailored educational environments that cater to each child's unique pace and learning style, a point that resonates with earlier research highlighting the transformative impact of adaptive learning technologies in early

childhood education (H. Hunaepi et al., 2024). The qualitative data revealed a pronounced sense of excitement among students when engaging with interactive AI tools, reinforcing findings from previous studies which identified gamification and personalized feedback as crucial elements in fostering learner motivation and engagement (M. H. Otoluwa et al., 2022).

Furthermore, the study uncovered concerns regarding access and equity, echoing issues raised by scholars who argue that technological disparities can widen educational gaps, particularly among socio-economically disadvantaged populations (Barchinoy Qurbonova et al., 2024). As such, this study contributes to the existing literature by providing empirical evidence that not only supports the benefits of AI in enhancing motivation and learning outcomes but also underscores the importance of equitable access to these technologies to achieve inclusive educational practices (Yahya Fikri et al., 2024; Sara Benayache et al., 2024).

The practical implications of these findings extend to educational policymakers and practitioners, suggesting a need to formulate strategies that ensure all learners, including those from marginalized backgrounds, can benefit from AI applications (Wenyi Jin et al., 2024). The theoretical significance of this research lies in its alignment with constructivist theories of learning, where active engagement through technology leads to deeper understanding and critical thinking skills among early learners (Noorul Husna Abd Rahman et al., 2023; Monica Cárdenas et al., 2024).

Additionally, methodological insights reveal the necessity of blending qualitative approaches with quantitative assessments to capture the complexities of AI's impact on learning, suggesting avenues for future research within this field (Kateryna Fomin, 2024; Pham Ngoc Son, 2024). Ultimately, by advocating for the responsible integration of AI technologies in educational settings, this study emphasizes the potential of AI to support not only the cognitive but also the socio-emotional development of foundational stage learners, thereby offering a holistic approach to enhancing learning in early childhood education (Ashley Diloreto, 2024; S. Y. Andalib et al., 2024; Amanda D. Damiano et al., 2024; Jan-Erik Kalmus et al., 2024; Hanjun Su et al., 2024; Aleksandra Mirek-Rogowska et al., 2024; Zishan Ahmed et al., 2024; Firuz Kamalov et al., 2023; David Rolnick et al., 2022; Xuesong Zhai et al., 2021).

Conclusion

The exploration of AI-based applications in early childhood education has revealed significant insights into their role in enriching learning experiences among foundational stage learners in Delhi schools. Through a qualitative design that incorporated interviews and observations, key themes emerged regarding how these technologies facilitate personalized learning pathways, enhance engagement, and provide real-time feedback, all of which are crucial for young children's cognitive and social development (H. Hunaepi et al., 2024).

This dissertation effectively addressed the research problem concerning the effectiveness of AI applications in promoting engagement and educational outcomes. By systematically analyzing the perceptions of educators, students, and parents, it was determined that while there are promising advancements, challenges such as concerns over equitable access and the need for adequate teacher training must be addressed to maximize AI's potential in the classroom (M. H. Otoluwa et al., 2022).

The implications of these findings extend not only to the academic discourse surrounding AI in education but also to practical considerations for stakeholders in Delhi's educational landscape. Schools can leverage these insights to inform curriculum development, ensuring that technology integration is supportive of developmental needs and capabilities (Barchinoy Qurbonova et al., 2024). Furthermore, the findings advocate for a framework that enhances teacher competencies in using AI applications effectively, thereby creating a more equitable and responsive learning environment for all students (Yahya Fikri et al., 2024).

Looking forward, future research should delve deeper into longitudinal studies assessing the long-term impacts of AI technologies on children's learning trajectories and social skills within diverse classroom settings (Sara Benayache et al., 2024). It is also essential to investigate parent and community involvement in promoting digital literacy, which could further support the integration of these AI tools (Wenyi Jin et al., 2024). Collaborative initiatives between educators and AI developers should be encouraged to create customizable educational resources that can be adapted to the varying needs of learners (Noorul Husna Abd Rahman et al., 2023).

Additionally, further exploration of the ethical dimensions surrounding AI usage in early education will be vital, especially in addressing privacy concerns related to data collection and usage in AI applications (Monica Cárdenas et al., 2024). Such comprehensive research efforts will contribute to a fuller understanding of AI's transformative potential in early childhood education, ultimately fostering an inclusive environment that nurtures the holistic development of young learners (Kateryna Fomin, 2024; Pham Ngoc Son, 2024; Ashley Diloreto, 2024; S. Y. Andalib et al., 2024; Amanda D. Damiano et al., 2024; Jan-Erik Kalmus et al., 2024; Hanjun Su et al., 2024; Aleksandra Mirek-Rogowska et al., 2024; Zishan Ahmed et al., 2024; Firuz Kamalov et al., 2023; David Rolnick et al., 2022; Xuesong Zhai et al., 2021).

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