Children's Voice in AI-Mediated STEAM Learning: A Qualitative Study in Early Childhood Education

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Abstract
Children's voice is central to participatory early childhood education, yet little is known about how conversational artificial intelligence (AI) may mediate children's expression and participation within STEAM learning. This qualitative descriptive study examined how ChatGPT Voice mediated children's voice during AI-supported STEAM activities in an early childhood education setting in Central Java, Indonesia. Participants were 20 children aged 5–6 years and two classroom teachers. Data were generated from May to July 2026 through eight classroom observation sessions lasting approximately 45–60 minutes each across six AI-mediated STEAM activities, semi-structured interviews with the two teachers, and documentation, and were analyzed thematically. Five qualitative patterns were identified: AI opened an additional space for expression; functioned as a responsive interactional audience; accompanied task-level agency; provided shared prompts for collaborative voice; and exposed developmental and communicative barriers requiring teacher mediation. These findings represent context-bound qualitative patterns rather than evidence that ChatGPT Voice directly increased children's participation. Conversational AI may therefore complement, rather than replace, teacher-led participatory pedagogy when interaction is developmentally appropriate, critically mediated, and embedded in hands-on and peer-collaborative activity.

1. Introduction

Children's participation is increasingly understood as a substantive dimension of educational quality rather than a symbolic invitation to speak. In early childhood education (ECE), children's voice encompasses opportunities to express perspectives, be listened to, and exercise meaningful influence over experiences that concern them. Lundy's (2007) The rights-based model distinguishes four interdependent conditions space, voice, audience, and influence and remains useful for examining whether participation extends beyond verbal expression. Recent scholarship similarly emphasizes that young children's participation is relational, context-dependent, and shaped by how adults organize pedagogical opportunities and respond to children's contributions (Correia, Aguiar, & Amaro, 2023; Hayes, 2024; Heikka, Kettukangas, Turja, & Heiskanen, 2022). Studies of children's narratives and pedagogical documentation further demonstrate that voice can be expressed through dialogue, play, artifacts, and digitally mediated forms, provided that adults take children's meaning-making seriously (Knauf & Lepold, 2021; Pascal & Bertram, 2021).

At the same time, artificial intelligence (AI) is entering ECE through social robots, conversational systems, and AI-supported learning resources. Reviews indicate that AI applications can support inquiry, computational thinking, creativity, and interaction, but the evidence base for young children remains comparatively small and pedagogically heterogeneous (Crescenzi-Lanna, 2023; Su & Yang, 2022). Research on AI-interfaced robotic toys shows that young children can engage in collaborative and creative inquiry around intelligent technologies (Kewalramani & Veresov, 2022), while recent AI-literacy studies report benefits from both cooperative play and structured instruction (Su, Yang, Yim, Li, & Hu, 2024). Nevertheless, implementation depends on age-appropriate task design, teacher knowledge, and careful attention to accuracy, privacy, fairness, and children's well-being (Holmes et al., 2022; Su, Ng, & Chu, 2023).

Generative conversational AI introduces a distinct pedagogical affordance: children can address a system in natural language and receive immediate, contingent responses. Early childhood teachers and experts identify possibilities for inquiry, idea generation, and pedagogical support, but also raise concerns about response accuracy, developmental appropriateness, accountability, and over-reliance on AI (Luo et al., 2024; Su & Yang, 2022; Uğraş & Uğraş, 2025). These concerns are especially important for voice-based interaction because fluent responses can be interpreted as understanding or empathy even though an AI system does not possess human

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care, moral judgment, or educational responsibility. Accordingly, conversational AI is more defensibly conceptualized as an interactional resource within a human-guided learning ecology than as an autonomous teaching agent (Holmes et al., 2022; Jeon & Lee, 2023).

STEAM learning offers a productive context in which to examine this relationship because it foregrounds inquiry, design, experimentation, creativity, and collaborative problem-solving. A recent scoping review shows that early childhood STEAM commonly relies on integrated, hands-on activities in which children explore problems and construct solutions across disciplinary boundaries (Su, Yim, Wegerif, & Chu, 2025). Empirical studies also indicate that developmentally appropriate robotics and STEAM activities can foster computational thinking, expressive language, and collaborative inquiry (Kewalramani & Veresov, 2022; Sung, Lee, & Chun, 2023). In Indonesia, STEAM-oriented ECE has likewise been discussed as a way to organize integrated problem-solving and project experiences within early learning (Hasibuan, Fitri, & Dewi, 2022; Motimona & Maryatun, 2023).

Despite these developments, three bodies of literature remain only weakly connected: children's voice and participation, conversational AI, and early childhood STEAM pedagogy. Existing AI-in-ECE research has focused mainly on AI literacy, robotics, teacher perceptions, and learning outcomes, whereas children's voice research has concentrated on participatory pedagogy and adult listening. Research on STEAM, meanwhile, has emphasized inquiry, design, experimentation, and collaborative problem-solving. What remains insufficiently examined is how conversational AI enters this relational and activity-based ecology: whether it opens additional space for children's expression, how its immediate responsiveness differs from accountable human listening, and how AI-generated responses become resources for task-level agency and peer meaning-making. The novelty of the present study therefore lies in examining children's voice, conversational AI, and STEAM together within a single rights-informed analytical frame, rather than treating AI use primarily as a technology-adoption or learning-outcome issue (Holmes et al., 2022; Lundy, 2007). Accordingly, the study asks: How does ChatGPT Voice mediate children's voice during STEAM learning in an early childhood classroom? It aims to identify the forms of expression, responsiveness, agency, collaboration, and teacher mediation that emerge when conversational AI is incorporated into STEAM activities with children aged 5–6 years.

2. Method

2.1. Study Design

A qualitative descriptive design was used to examine how children's voice emerged during AI-mediated STEAM learning in its natural classroom context. This design was selected because the study sought a close, experience-near account of children's participation and teacher observations rather than causal estimates or hypothesis testing (Creswell & Poth, 2018). The unit of analytic interest was the pattern of interaction among children, teachers, and ChatGPT Voice during STEAM activities.

2.2. Setting and Participants

The study was conducted from May to July 2026 in an early childhood education setting in Central Java, Indonesia, where STEAM activities were implemented with ChatGPT Voice. Participants were 20 children aged 5–6 years and two classroom teachers who were directly involved in these activities. Because the participating classroom cohort was small and all members met the study criteria, all 20 children and both teachers were included using a total-sampling (census) strategy. Participant codes C1–C20 and T1–T2 were used in the dataset and reporting.

2.3. AI-Mediated STEAM Learning Context

ChatGPT Voice was used as a conversational resource across six hands-on STEAM activities conducted during the study period. The documented activity contexts included flotation exploration and bridge construction. Interaction followed child-initiated and teacher-supported patterns such as asking for explanations, testing design possibilities, comparing alternatives, and responding to follow-up questions. Examples documented in the dataset include explanatory questions such as "I want to know why a ship can float while a stone sinks" (C3) and design-testing questions such as "If I make the bridge longer, will it still be strong?" (C5). Teachers remained present to help children formulate questions, clarify lengthy or difficult explanations, connect AI responses to material investigation, and sustain peer discussion.

2.4. Data Collection

Data were generated over a three-month period from May to July 2026 through eight classroom observation sessions, each lasting approximately 45–60 minutes, semi-structured interviews with the two classroom teachers, and documentation. The eight observations covered six AI-mediated STEAM activities and focused on children's verbal participation, questions, explanations, peer interaction, decision-making, and responses during the activities. The teacher interviews elicited perceptions of children's communication, engagement, participation, and the need for pedagogical mediation. Documentation comprised field notes,

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photographs of learning activities, children's learning products, and records of classroom interactions. These sources were examined together to support triangulation across observed behavior, teacher accounts, and documentary evidence.

2.5. Data Analysis and Trustworthiness

Data were analyzed thematically following Braun and Clarke's (2006) procedures of familiarization, initial coding, theme development, theme review, theme definition, and reporting. Observation notes, interview transcripts, and documentary records were read iteratively. Initial semantic codes captured observable or reported instances of questioning, idea expression, acknowledgement, material choice, design revision, peer negotiation, comprehension difficulty, and teacher support. Related codes were then compared across the three data sources and grouped into broader candidate themes concerning space for expression, responsive audience, task-level agency, collaborative voice, and barriers requiring mediation. Candidate themes were reviewed against the underlying records to ensure internal coherence and distinction between themes, then refined and named in relation to the research question. Trustworthiness was supported through triangulation of the three data sources, teacher member checking of interpretations, peer debriefing, continued review of coded material, and contextual description, consistent with the credibility, dependability, confirmability, and transferability principles articulated by Lincoln and Guba (1985). Because the study did not employ an independent second-coder procedure, no inter-coder reliability statistic is reported.

3. Results and Discussion

3.1. Results

Across eight classroom observations, child utterances, teacher interviews, and documentary records, five recurrent themes characterized how children's voice was mediated during the six AI-supported STEAM activities. The analysis is presented as a set of context-bound qualitative patterns within one ECE setting. Each theme is grounded in converging observational and participant evidence where available, and quotations are retained with participant codes to preserve traceability to the dataset.

3.1.1. Theme 1: AI Opened an Additional Space for Expression

Children frequently initiated questions, proposed materials, and explained design ideas while using ChatGPT Voice. Their utterances moved beyond brief responses to teacher prompts and included self-initiated inquiry, for example, "I want to know why a ship can float while a stone sinks" (C3) and "If I make the bridge longer, will it still be strong?" (C5). Children also articulated alternative design choices, such as combining cardboard and straws or changing a bridge configuration. Teacher T1 observed that children who usually listened to peers became more active in speaking and asking questions during the AI-supported activities. Across observations and interviews, the central pattern was an increase in opportunities to externalize curiosity and reasoning.

3.1.2. Theme 2: AI Functioned as a Responsive Interactional Audience

Immediate AI responses appeared to sustain children's conversational engagement. Children commented that ChatGPT answered their questions, responded to their ideas, and sometimes prompted further thinking. C5 stated, "When I told my idea, ChatGPT said it was a good idea and asked me another question," while C3 reported wanting to learn more after receiving an explanation. Teacher T2 similarly noted that children often continued discussion after AI feedback and became more curious. The observed pattern was therefore not simply question-and-answer exchange but repeated conversational turns in which children treated the response as acknowledgement of their contribution.

3.1.3. Theme 3: AI-Supported Interaction Accompanied Task-Level Agency

Children remained decision-makers during problem-solving rather than automatically following AI suggestions. C2 explained, "ChatGPT gave me some ideas, but I chose to use straws because I thought they were lighter," and C1 described revising a bridge after it collapsed. Children tested alternatives, evaluated outcomes, and persisted with modifications. Teachers also reported greater willingness among children to explain reasons for their choices and to take responsibility for improving projects. These data indicate agency at the level directly observed in the study: choices about materials, designs, testing, and revision within the assigned STEAM tasks.

3.1.4. Theme 4: AI Responses Became Resources for Collaborative Voice

AI-generated responses frequently became shared objects of peer discussion. Children compared ideas, negotiated which materials might work, and combined proposed solutions. C5 stated, "My friend had a different idea, so we talked about which one would work better," while C3 described combining peers' ideas to strengthen

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the bridge. Teachers observed that children discussed AI responses with one another before making decisions. Thus, children's voice appeared not only as individual expression but also as collective meaning-making in which viewpoints were proposed, contested, and integrated.

3.1.5. Theme 5: Developmental and Communicative Barriers Required Teacher Mediation

The same interactions also exposed limits. Some children struggled to formulate questions, follow lengthy explanations, or understand AI-generated language. C4 reported, "ChatGPT talked too much, and I forgot the answer," while C5 said, "I wanted to ask something, but I did not know how to explain it." Teacher T1 noted that several children needed help interpreting certain explanations. Children also explicitly described seeking teacher clarification. These data show that access to a conversational interface did not by itself guarantee meaningful participation; teacher mediation remained necessary for comprehension, focus, and developmentally appropriate engagement. A summary of the key themes and representative evidence from the participants is presented in Table 1.

Table 1. Summary of Themes and Representative Evidence

Theme	Analytic focus	Representative evidence
1. Space for expression	Questions, ideas, explanations, and alternative solutions	C3: "I want to know why a ship can float while a stone sinks." T1: previously quieter children became more active in speaking and asking questions.
2. Responsive audience	Immediate acknowledgement and continued conversational turns	C5: "When I told my idea, ChatGPT said it was a good idea and asked me another question."
3. Task-level agency	Choice, experimentation, evaluation, and revision	C2: "ChatGPT gave me some ideas, but I chose to use straws because I thought they were lighter."
4. Collaborative voice	Peer idea sharing, negotiation, and collective problem-solving	C5: "My friend had a different idea, so we talked about which one would work better."
5. Barriers and mediation	Comprehension, question formulation, response length, and teacher scaffolding	C4: "ChatGPT talked too much, and I forgot the answer." T2: children still needed guidance to understand information and stay focused.

3.2. Discussion

The findings refine the claim that conversational AI can "support children's voice" by showing that such support was not an automatic consequence of technology use. Its value depended on the pedagogical purpose of the activity, the teacher's active mediation, the developmental appropriateness of the interaction, and opportunities for peer dialogue and hands-on inquiry. Theme 1 most directly corresponds to the space and voice dimensions of Lundy's (2007) framework: children were afforded an additional conversational route for asking questions, proposing ideas, and articulating explanations. This is consistent with contemporary participation research emphasizing that voice depends on pedagogical conditions that make expression possible and consequential (Correia et al., 2023; Hayes, 2024). It also extends work on AI-interfaced toys, where intelligent technologies have been used to stimulate creative and collaborative inquiry among young children (Kewalramani & Veresov, 2022). In the present study, the salient affordance was therefore not the AI system in isolation but the combination of voice interaction, hands-on STEAM problems, peer engagement, and teacher-supported opportunities to continue the conversation.

Theme 2 requires a theoretically important distinction between responsiveness and accountable human audience. ChatGPT Voice functioned as an interactionally responsive system because it produced immediate, contingent replies that children often treated as acknowledgement. Yet this responsiveness is not equivalent to the normative "audience" in rights-based participation, which involves people or institutions capable of listening, taking responsibility, exercising judgment, and acting on children's views (Lundy, 2007). The distinction is especially important because fluent conversational AI can invite anthropomorphic interpretations: a child may experience a response as if the system understands, cares, or endorses an idea, even though the system has no human responsibility, empathy, or pedagogical accountability. This possibility makes teacher mediation central rather than optional. Expert and teacher studies in ECE similarly recommend positioning ChatGPT as an augmenting resource rather than a replacement for educators (Luo et al., 2024; Su & Yang, 2024), while broader educational research emphasizes complementary human–AI roles (Jeon & Lee, 2023). The contribution of the present study is therefore not to redefine AI as a rights-bearing audience, but to show how technological responsiveness can become pedagogically meaningful when it is interpreted, verified, and situated within human relationships.

Theme 3 suggests that AI-mediated dialogue can coexist with children's agency when the system provides possibilities without prescribing action. Children chose materials, rejected or adapted suggestions, tested designs, and revised solutions after failure. These behaviors resonate with recent AI-learning research showing that cooperative play can support self-regulation and social-cognitive processes, while structured guidance can strengthen other learning outcomes (Su et al., 2024). They also align with STEAM pedagogies that foreground

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inquiry, iteration, and design-based problem-solving (Kewalramani & Veresov, 2022; Su et al., 2025). Importantly, the evidence supports a bounded interpretation of agency: the children influenced task-level decisions within activities, but the study did not examine whether they influenced curriculum planning, institutional rules, or other higher-order decisions. Avoiding that overextension strengthens the conceptual link between observed behavior and claims about participation.

Theme 4 demonstrates that conversational AI did not necessarily individualize learning. Instead, its responses often became shared prompts around which children discussed, compared, and combined ideas. This finding is compatible with studies showing that AI-supported or robotic activities can create opportunities for collaborative inquiry and social interaction (Kewalramani & Veresov, 2022; Sung et al., 2023). It also reflects the relational character of children's participation: voice is not merely a sequence of isolated individual opinions but can be negotiated and co-constructed with peers (Heikka et al., 2022; Pascal & Bertram, 2021). From a STEAM perspective, the value of conversational AI may therefore lie partly in its capacity to seed collective reasoning, provided the classroom structure encourages children to discuss the response with one another rather than defer to it.

The fifth theme is critical because it identifies the conditions under which these affordances can fail. Children's difficulties with vocabulary, question formulation, response length, and comprehension indicate a mismatch that can occur between general-purpose conversational AI and the communicative capacities of 5–6-year-olds. Reviews of AI in ECE repeatedly identify developmentally appropriate design, teacher competence, and pedagogical guidance as unresolved challenges (Crescenzi-Lanna, 2023; Su et al., 2025). Teachers in recent ChatGPT studies likewise report concerns about reliability, age appropriateness, and the need for professional support (Su et al., 2024; Uğraş & Uğraş, 2025). Ethical frameworks further caution that AI-supported education must address autonomy, fairness, accountability, transparency, inclusion, and unintended consequences rather than assuming that engagement alone constitutes educational benefit (Holmes et al., 2022).

Accordingly, the findings support a human-guided model of AI-mediated children's voice in which technology complements the teacher–child and peer relationships rather than replacing them. The teacher's role becomes more interpretive and pedagogically consequential: teachers help children formulate questions, request shorter or simpler explanations, verify questionable outputs, redirect attention to material investigation, and sustain peer dialogue. AI-literacy scholarship in ECE similarly emphasizes the knowledge, skills, and attitudes needed to understand what AI can and cannot do (Su et al., 2024; Su & Zhong, 2022). For generative AI specifically, the risk of inaccurate or fabricated content and the tendency to anthropomorphize fluent systems make adult verification indispensable (Kasneci et al., 2023; Tlili et al., 2023). The evidence therefore does not show that AI independently produces participation; rather, it suggests that AI can serve as one interactional resource within a play-oriented, collaborative, and teacher-mediated STEAM ecology in which children's existing voices become more expressible and discussable.

3.3. Implications

Theoretically, the study suggests that Lundy's (2007) participation framework can be applied to AI-mediated learning only with a distinction between interactional responsiveness and accountable human listening. Conversational AI may help create space, elicit voice, and provide an immediate response, but influence remains a social and pedagogical process that must be enacted by teachers and educational institutions. This interpretation avoids attributing human agency or moral recognition to the technology.

Practically, AI-supported STEAM activities for young children should use short, concrete prompts; request concise, age-appropriate responses; prioritize hands-on experimentation over screen- or device-centered interaction; and build in teacher-led verification and peer discussion. Teachers should treat AI answers as propositions to examine rather than final authorities. AI-literacy frameworks that foreground safety, identity, attitudes, cognition, and capability can support this critical orientation (Luo et al., 2024), while Indonesian STEAM literature reinforces the importance of integrating problem-solving into meaningful early childhood projects (Motimona & Maryatun, 2023).

For policy and school leadership, adoption decisions should include teacher professional learning, child-data and privacy safeguards, transparent communication with families, and procedures for checking developmental appropriateness and output quality. These requirements are consistent with contemporary calls for responsible, child-centered AI integration rather than technology-driven substitution of professional judgment (Holmes et al., 2022; Su et al., 2023).

3.4. Limitations

The findings should be interpreted within the study's qualitative and context-specific scope. Data were generated in a single early childhood education setting involving 20 children and two teachers between May and July 2026, through eight observation sessions across six AI-mediated STEAM activities. This context limits the transferability of the findings to other schools, age groups, linguistic settings, and AI configurations. The study

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did not include a comparison condition; therefore, the observed patterns cannot be interpreted as evidence that ChatGPT Voice directly caused changes in children's participation. Teacher interviews constituted the only adult interview source, and the study did not systematically document speech-recognition accuracy, complete AI interaction and prompt logs, or employ an independent second-coder procedure. Novelty effects, anthropomorphic interpretations of AI responses, and observer reactivity may also have influenced children's engagement and participation. Parent/guardian consent was obtained through the school's established consent procedure; however, separate formal child-assent documentation was not available. Future research should employ prospectively documented and developmentally appropriate consent and assent procedures, complete AI-interaction logs, longer-term and cross-context designs, and more systematic examination of speech recognition, teacher mediation, peer collaboration, and response design to determine how these factors shape equitable access to AI-mediated dialogue.

4. Conclusion

This study identifies five qualitative patterns through which ChatGPT Voice mediated children's voice during STEAM learning: expanded opportunities for expression, interactional responsiveness, task-level agency, collaborative meaning-making, and developmental barriers requiring teacher mediation. These patterns do not demonstrate that ChatGPT Voice directly increased children's participation. Rather, they indicate that conversational AI may complement STEAM pedagogy when its responses are connected to material exploration, peer dialogue, and accountable teacher scaffolding. The study contributes by distinguishing technological responsiveness from the human audience required for meaningful participation and by locating AI interaction within, rather than outside, teacher–child and peer relationships. Because the evidence derives from one ECE setting, the conclusions should not be generalized as causal or institution-wide effects. Further research requires stronger AI-interaction documentation, robust ethics and consent processes for research involving children, and cross-context designs examining how developmentally tailored prompts, language support, and safeguarding practices shape whose voices are amplified and whose may remain unheard.

Author Contributions

All authors contributed equally to this paper. All authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

The authors declare that they have no known financial, professional, or personal interests or relationships that could have influenced, or could reasonably be perceived to have influenced, the research reported in this manuscript.

Ethics and Consent Declarations

This study involved classroom observations of young children and semi-structured interviews with classroom teachers. Permission was obtained from the participating school and teachers prior to data collection. Parent/guardian consent for children's participation was obtained through the school's established consent procedure and documented using a school-provided consent form. Children's identities were anonymized, and no identifying information is reported. No formal institutional ethics committee approval number was issued for the study.

Data Availability

Primary qualitative data were generated through classroom observations, teacher interviews, and documentation. Participant identities are represented using codes C1–C20 and T1–T2 in the manuscript. Participant-level materials are not reproduced in full because they contain contextual information concerning young children and classroom activities. Additional de-identified information concerning the analytic process may be obtained from the corresponding author upon reasonable request, subject to appropriate confidentiality safeguards.

Declaration on AI Use

During the preparation of this manuscript, the authors used Quillbot and Grammarly as a supplementary tool for English-language editing and restructuring of author-provided text. The tool was not used to generate, modify, or analyze research data, fabricate references, produce participant quotations, or determine the reported findings and conclusions. All AI-assisted outputs and cited sources were independently reviewed, verified, and revised by the authors where necessary. The authors retain full responsibility for the accuracy, originality, integrity, interpretation, conclusions, and final content of the manuscript.

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References

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Correia, N., Aguiar, C., & Amaro, F. (2023). Children's participation in early childhood education: A theoretical overview. *Contemporary Issues in Early Childhood, 24*(3), 313–332. https://doi.org/10.1177/1463949120981789

Crescenzi-Lanna, L. (2023). Literature review of the reciprocal value of artificial and human intelligence in early childhood education. *Journal of Research on Technology in Education, 55*(1), 21–33. https://doi.org/10.1080/15391523.2022.2128480

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.

Hasibuan, R., Fitri, R., & Dewi, U. (2022). STEAM-based learning media: Assisting in developing children's skills. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 6*(6), 6863–6876. https://doi.org/10.31004/obsesi.v6i6.3560

Hayes, N. (2024). 'It's not fair': Hearing the voices of young children. *Education 3-13, 52*(6), 830–842. https://doi.org/10.1080/03004279.2024.2332862

Heikka, J., Kettukangas, T., Turja, L., & Heiskanen, N. (2022). How educators commit to enhancing children's participation in early childhood education pedagogical plans. *South African Journal of Childhood Education, 12*(1), Article a1170. https://doi.org/10.4102/sajce.v12i1.1170

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education, 32*(3), 504–526. https://doi.org/10.1007/s40593-021-00239-1

Jeon, J., & Lee, S. (2023). Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. *Education and Information Technologies, 28*(12), 15873–15892. https://doi.org/10.1007/s10639-023-11834-1

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., … Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, Article 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kewalramani, S., & Veresov, N. (2022). Multimodal creative inquiry: Theorising a new approach for children's science meaning-making in early childhood education. *Research in Science Education, 52*(3), 927–947. https://doi.org/10.1007/s11165-021-10029-3

Knauf, H., & Lepold, M. (2021). The children's voice—How do children participate in analog and digital portfolios? *European Early Childhood Education Research Journal, 29*(5), 669–682. https://doi.org/10.1080/1350293X.2021.1906291

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE Publications.

Lundy, L. (2007). 'Voice' is not enough: Conceptualising Article 12 of the United Nations Convention on the Rights of the Child. *British Educational Research Journal, 33*(6), 927–942. https://doi.org/10.1080/01411920701657033

Luo, W., He, H., Liu, J., Berson, I. R., Berson, M. J., Zhou, Y., & Li, H. (2024). Aladdin's genie or Pandora's box for early childhood education? Experts chat on the roles, challenges, and developments of ChatGPT. *Early Education and Development, 35*(1), 96–113. https://doi.org/10.1080/10409289.2023.2214181

Motimona, P. D., & Maryatun, I. B. (2023). Implementasi metode pembelajaran STEAM pada Kurikulum Merdeka pada PAUD. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 7*(6), 6493–6504. https://doi.org/10.31004/obsesi.v7i6.4682

Pascal, C., & Bertram, T. (2021). What do young children have to say? Recognising their voices, wisdom, agency and need for companionship during the COVID pandemic. *European Early Childhood Education Research Journal, 29*(1), 21–34. https://doi.org/10.1080/1350293X.2021.1872676

Su, J., & Yang, W. (2022). Artificial intelligence in early childhood education: A scoping review. *Computers and Education: Artificial Intelligence, 3*, Article 100049. https://doi.org/10.1016/j.caeai.2022.100049

Su, J., & Yang, W. (2024). Powerful or mediocre? Kindergarten teachers' perspectives on using ChatGPT in early childhood education. *Interactive Learning Environments, 32*(10), 6496–6508. https://doi.org/10.1080/10494820.2023.2266490

Su, J., & Zhong, Y. (2022). Artificial intelligence (AI) in early childhood education: Curriculum design and future directions. *Computers and Education: Artificial Intelligence, 3*, Article 100072. https://doi.org/10.1016/j.caeai.2022.100072

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ISSN: 2797-3174

Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial intelligence (AI) literacy in early childhood education: The challenges and opportunities. *Computers and Education: Artificial Intelligence, 4*, Article 100124. https://doi.org/10.1016/j.caeai.2023.100124

Su, J., Yang, W., Yim, I. H. Y., Li, H., & Hu, X. (2024). Early artificial intelligence education: Effects of cooperative play and direct instruction on kindergarteners' computational thinking, sequencing, self-regulation and theory of mind skills. *Journal of Computer Assisted Learning, 40*(6), 2917–2925. https://doi.org/10.1111/jcal.13040

Su, J., Yim, I. H. Y., Wegerif, R., & Chu, S. K. W. (2025). STEAM in early childhood education: A scoping review. *Research in Science & Technological Education, 43*(2), 495–511. https://doi.org/10.1080/02635143.2023.2296445

Sung, J., Lee, J. Y., & Chun, H. Y. (2023). Short-term effects of a classroom-based STEAM program using robotic kits on children in South Korea. *International Journal of STEM Education, 10*, Article 26. https://doi.org/10.1186/s40594-023-00417-8

Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel? ChatGPT as a case study of using chatbots in education. *Smart Learning Environments, 10*, Article 15. https://doi.org/10.1186/s40561-023-00237-x

Uğraş, H., & Uğraş, M. (2025). ChatGPT in early childhood STEM education: Can it be an innovative tool to overcome challenges? *Education and Information Technologies, 30*(4), 4277–4305. https://doi.org/10.1007/s10639-024-12960-0

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