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Designing Inclusive Early Childhood Experiences: Teacher Strategies with STEAM, Loose Parts, and PBL

Tanaya Qatrunada Rutriningtyas[1], Avanti Vera Risti Pramudyani[1*], Dewi Eko Wati[1], Dwi Hastuti[1], Risanti Dhaniaputri[1], Irma Sukarelawan[1]
[1]Universitas Ahmad Dahlan, Indonesia
✉ Author Corresponding: avanti.pramudyani@pgpaud.uad.ac.id*

ABSTRACT

The implementation of inclusive education in early childhood education settings requires innovative pedagogical strategies capable of accommodating children's diverse learning needs while supporting their cognitive, socio-emotional, and metacognitive development. Previous research on STEAM and Problem-Based Learning (PBL) has primarily focused on creativity and cognitive achievement, with limited attention to how inclusivity is implemented through adaptive pedagogical practices in heterogeneous early childhood classrooms. Furthermore, the use of loose parts as flexible learning materials in inclusive STEAM–PBL learning remains underexplored. Therefore, this study aims to examine how inclusive pedagogical principles are implemented through the integration of STEAM, Problem-Based Learning (PBL), and loose parts-based activities in early childhood education. This study employed a qualitative case study approach. Data were collected through classroom observations, interviews, and documentation involving teachers and children during the learning process. The instruments used in this study included interview guidelines, classroom observation sheets, and documentation notes focusing on inclusive STEAM–PBL implementation. Findings indicate that the integration of STEAM–PBL and flexible materials supports inclusive learning through contextual problem-solving activities, interest-based collaboration, responsive scaffolding, dialogic presentations, and reflective practices. Children demonstrated increased participation, communication skills, collaborative engagement, self-confidence, persistence in problem-solving, and emerging metacognitive awareness. The use of flexible materials enabled children with diverse abilities to explore, represent, and communicate ideas according to their individual capacities. This study highlights the uniqueness of inclusive STEAM–PBL implementation through adaptive scaffolding, flexible learning materials, and reflective participation practices that support meaningful and participatory learning experiences in early childhood classrooms.

Keywords: STEAM; Problem-Based Learning; Early Childhood; Inclusive Learning.

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1. INTRODUCTION

Inclusive education plays a crucial role in creating an educational system that is fair, welcoming, and supportive of every individual's development, as it promotes equitable access, active participation, and respect for diversity among all learners (Oji et al., 2025; Rončević & Rieckman, 2025). In Indonesia, this approach is not only a solution but also a response to the diversity of a heterogeneous society (UNESCO, 2020). Its implementation has been proven to have a holistic positive impact on children's development (Liu & Potmesil, 2025; Messiou et al., 2025),

as well as to promote the integration of cultural values and learning that is responsive to students' needs. Thus, inclusive education emphasizes not only access but also the quality and equity of the overall learning process (Dastyari & Jose, 2024; Florian, 2019).

Quality education acts as the fundamental basis of inclusivity by ensuring every child can achieve their maximum potential. Diversity in terms of gender, age, ability, and socio-cultural background forms the basis for creating an equitable and non-discriminatory learning environment (Jardinez & Natividad, 2024; Singh, 2024). Holistic learning is undeniably essential in inclusive education. The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach functions as a primary strategy for holistic learning in inclusive settings, as it combines the development of children's cognitive, social, emotional, and motor domains (Mullick et al., 2025; Veziroglu-Celik et al., 2025). Its integration with Problem-Based Learning (PBL) has demonstrated its effectiveness in improving both students' academic competencies and their personal growth (Wade et al., 2023).

The integration of STEAM and PBL encourages active, collaborative, and inclusive learning by positioning learners as the central focus of the educational process through solving real-life problems (Mullick et al., 2025; Smith et al., 2022; Veziroglu-Celik et al., 2025; Wised & Inthanon, 2024). Meanwhile, STEAM serves as an interdisciplinary framework that integrates science, technology, engineering, art, and mathematics into a unified project-based learning experience, while the inclusion of art enables students to express ideas creatively (J. Li, 2024; Perignat & Katz-Buonincontro, 2019; Sanz-Camarero et al., 2023; Wade et al., 2023). In the context of inclusive education, both approaches provide opportunities for all students to participate based on their individual abilities and preferred learning styles (Henley, 2025; Liu & Potmesil, 2025; Messiou et al., 2025; Randall, 2025b).

In STEAM–PBL learning in early childhood education, the learning process unfolds through five interconnected steps (Bustami et al., 2018; Temiz & Çevik, 2024). First, children are introduced to simple problems through media such as pictures, stories, or videos to foster interest and understanding (Lee, 2020; Sari et al., 2023). Second, teachers organize learning activities through discussions, observations, or simple information gathering (Randall, 2025; Sari et al., 2023). Third, during the investigation stage, children are guided to identify the causes of problems by experimenting, observing, asking questions, and making hypotheses (Lile Diamond, 2018; Simanjuntak & Purwaningsih, 2024). Fourth, students develop and present their results through projects, drawings, or simple presentations (Bustami et al., 2018; Santos et al., 2018). Finally, teachers and students conduct an evaluation by reflecting on the process, results, and improvements, thereby helping students re-examine their thinking process in an enjoyable way (Bustami et al., 2018; Kanoknitanunt et al., 2021).

The teacher's role in the STEAM approach is that of a facilitator, mediator, and motivator in learning. In PBL, teachers do not merely deliver content but guide students to think critically and find solutions on their own (Nguyen, 2025; Sun, 2023). In inclusive learning, teachers need to adapt activities, create a non-discriminatory atmosphere, and encourage collaboration (Pinky, 2023; Ranbir, 2024). Additionally, teachers need to engage in continuous professional development to gain a deep understanding of PBL methods and the STEAM approach (Pant et al., 2020; Sun, 2023). Collaboration with support teachers, parents, and school administrators is also key to creating inclusive and sustainable learning (Bridges, 2025). Thus, the adaptive integration of PBL and STEAM facilitated by teachers can build a creative, collaborative, and equitable learning environment for all students (Nguyen, 2025; Sonu et al., 2025).

Limitations in teachers' knowledge and skills regarding the Technology and Mathematics components of the STEAM approach, as well as in designing inclusive learning, indicate that some teachers are not yet able to accommodate all students' needs, including those of students with special needs (Daniel et al., 2024; Thi, 2022). In addition, limited resources such as adaptive media, assistive devices, and educational technology also hinder the implementation of inclusive learning (Boiliu & Messakh, 2024). Teachers also face challenges in understanding the STEAM-PBL methodology, designing adaptive learning (Ramey & Stevens, 2023; Teixeira et al., 2025), and difficulties in managing inclusive classrooms with students of diverse characteristics (Larios & Zetlin, 2023; Sharma, 2023). On the other hand, insufficient policy support, collaboration among stakeholders (Spyropoulou et al., 2025; Teixeira et al., 2025), and suboptimal curriculum flexibility also hinder the implementation of inclusive learning (Mahali, 2024). Therefore, continuous training, the development of adaptive curricula, enhanced collaboration, and classroom management responsive to children's diversity are required (Florian & Camedda, 2020; Gaewen, 2025).

The demands of inclusive early childhood education have not yet aligned with the availability of ongoing professional development for teachers, so the lack of relevant training has resulted in suboptimal inclusive learning (Silva, 2023; Siwik, 2025). This situation aligns with findings from previous research highlighting the scarcity of training and supporting resources for early childhood education (PAUD) teachers (Casimiro et al., 2025). However, systematic and practice-based training has proven effective in enhancing teachers' inclusive competencies (Donath et al., 2023; Hawthorne et al., 2025).

Consistent training can enhance teachers' knowledge and skills while strengthening the implementation of inclusive learning (Cruz et al., 2024; Florian & Camedda, 2020). The Integrated 'Aisyiyah Nur'aini Early Childhood Education Center in Yogyakarta has implemented project-based learning with a STEAM approach as an innovation to holistically develop children's potential (Ichlas et al., 2023). Through this approach, learning becomes more collaborative, creative, and capable of accommodating the needs of every child.

Previous studies on STEAM–PBL in early childhood education have primarily focused on improving children's critical thinking, creativity, and collaboration skills. However, limited studies have specifically examined how loose parts are adaptively utilized within STEAM–PBL learning to support inclusivity in early childhood settings, particularly for children with diverse learning needs. Existing studies also tend to emphasize learning outcomes rather than exploring teachers' pedagogical strategies in integrating scaffolding, differentiation, and reflective practices during the implementation process. Furthermore, in-depth case studies investigating the use of loose parts as exploratory media in inclusive STEAM–PBL classrooms remain scarce.

Based on these gaps, this study offers a novel contribution by analyzing teachers' strategies in implementing inclusive STEAM-based learning through the Problem-Based Learning (PBL) approach using loose parts media in early childhood education. This study not only discusses implementation but also explores the integration of scaffolding, differentiation, and reflection in inclusive classrooms. Thus, this research is expected to provide conceptual and practical contributions to the development of the STEAM–PBL model and to examine its application at the 'Aisyiyah Nur'aini Integrated Early Childhood Education Center in Yogyakarta.

2. METHODS

This research adopts a descriptive qualitative approach through a case study to investigate teachers' strategies in implementing STEAM–PBL-based inclusive learning in early childhood education. This method enables a comprehensive exploration of learning phenomena, including challenges, solutions, and instructional innovations (Daněk & Urgošíková, 2024). The research framework encompasses the determination of case units, the focus of inquiry, and data triangulation conducted through observations, interviews, and documentation to ensure the credibility of the findings (Meydan & Akkaş, 2024). Through this approach, researchers examined teachers' strategies in planning, implementing, and evaluating inclusive learning while emphasizing contextual factors, challenges encountered, and adaptive practices utilized in early childhood education settings.

This research took place at the Nur'aini Integrated Early Childhood Education Center in Yogyakarta. The process of data collection was carried out through classroom observations, in-depth interviews, transcript analysis, and documentation review. Participants were selected using purposive sampling based on criteria such as active involvement in STEAM–PBL implementation, consisting of two B4-grade teachers and one principal. The inclusive classroom involved children with varying learning needs and developmental abilities, allowing teachers to apply flexible scaffolding, differentiated instruction, and collaborative learning strategies during STEAM–PBL activities.

Data collection was conducted over approximately two to three months using three techniques: semi-structured interviews with classroom teachers to explore STEAM–PBL implementation strategies, participatory observations to capture authentic classroom interactions without disrupting learning activities and documentation in the form of photographs, videos, modules, and field notes. Observations also emphasized the use of loose parts in STEAM learning, with classroom teachers serving as the main data sources. The research instrument framework is presented in Table 1, while data validity was ensured through triangulation of sources and techniques.

Table 1. Framework for Interviews, Observations, and Research Documentation Regarding the Steam Approach through Inclusive Learning.

Indicators	Interview Guidelines	Observation Guidelines
Students' orientation toward STEAM problems	How does the teacher guide students in defining the problems to be solved?	The teacher presents context-based STEAM problems through real-life stories using videos or other media
Organizing students for learning	How does the teacher manage to ensure students can plan solutions to problems in groups?	How do teachers encourage children to gather information, explanations, and solutions to problems?
Guiding Individual or Group Investigations	How do teachers encourage children to gather information, explanations, and solutions to problems?	Teachers accompany and ask probing questions so that children can gather information related to the problem
Developing and Presenting Results	How do teachers provide opportunities for children to showcase their work?	Teachers provide opportunities for children to present their work

Indicators	Interview Guidelines	Observation Guidelines
Analyzing and evaluating the problem-solving process	How do teachers guide children to engage in joint reflection and provide feedback during the children's activities?	Teachers guide children to reflect on their learning outcomes, reinforce key concepts, and together with the children summarize the activities that have been carried out

Data analysis in this study employed thematic analysis, a method used to identify patterns or themes within qualitative data (Braun et al., 2025). The initial stage involved repeatedly reading and reviewing interview data, observations, and documentation to gain a comprehensive understanding of the phenomena and identify important points relevant to the research focus. Next, initial coding was conducted by labeling meaningful and relevant data segments. To ensure coding validity and consistency, the coding process was continuously reviewed through comparisons across interview, observation, and documentation data, as well as discussions with peers and supervisors. The resulting codes were then grouped into categories based on similarities in meaning and context (codes B1, B2, B3). The determination of themes was carried out inductively by identifying recurring patterns and relationships among categories. From these categories, provisional themes were formulated and subsequently reviewed, refined, and reorganized to ensure coherence and alignment with the research objectives and context. The themes were repeatedly compared with the raw data to ensure that they accurately represented participants' experiences and the implementation of inclusive STEAM–PBL learning.

The final stage involved determining the main themes, namely: (1) contextual STEAM problem orientation, (2) organizing collaborative learning, (3) scaffolding in inquiry, (4) representation of work products, and (5) reflection on the problem-solving process. These themes were systematically organized as the basis for presenting the findings, leading to relevant and comprehensive interpretations. To maintain data credibility, this study also applied member checking, prolonged engagement, persistent observation, and audit trails to strengthen the trustworthiness and transparency of the findings beyond triangulation techniques. The instrument validation process involved expert judgment from two lecturers specializing in early childhood education and inclusive pedagogy. Feedback from the experts was used to revise the clarity, relevance, and suitability of the interview and observation indicators prior to data collection.

3. RESULT AND DISCUSSION

The conceptual model resulting from this study indicates that the STEAM–PBL learning strategy in an inclusive context unfolds through five main stages, namely: (1) orienting students toward contextual STEAM problems, (2) organizing collaborative learning, (3) teacher scaffolding during STEAM investigations, (4) representation and presentation of students' STEAM work, and (5) students' reflection on the problem-solving process. These five stages are interconnected within a continuous learning cycle and supported by the teacher's role as an adaptive facilitator. This model emphasizes that inclusive learning is determined not only by differentiation strategies but also by the integration of meaningful, participatory, and reflective learning experiences.

These findings indicate that inclusivity in STEAM–PBL is reflected not only through differentiated instruction but also through the creation of contextual, participatory, collaborative, and reflective learning experiences that enable every child to engage meaningfully in the learning

process. At all stages, teachers continuously facilitate opportunities for participation, communication, and problem-solving, thereby enabling children with diverse developmental characteristics to learn in the same classroom environment.

3.1 Student-Centered Approach to Contextual STEAM Problems

Observations indicate that problem-based learning in STEAM–PBL is conducted through a contextual approach rooted in students' real-life experiences. Teachers do not present problems in an abstract manner but rather through topics closely tied to daily life, enabling students to gradually build foundational understanding in alignment with their developmental stages. This approach provides an equitable entry point for all students, including those with communication, social, or cognitive challenges, as meaning-making is grounded in sensorimotor experiences. This aligns with the principles of inclusive education, which emphasize access to meaningful learning experiences (UNESCO, 2020).

Two-way dialogic interaction created opportunities for children to express experiences, negotiate meaning, and participate more confidently during collaborative learning. The results of interviews with the three informants indicate that teachers explore children's experiences before determining the direction of learning, as stated by one teacher: "Teachers must first explore what the child is actually experiencing, rather than making assumptions right away" (B3). Observational findings reinforce this, showing that teachers facilitate a circular discussion that enables two-way interaction. In addition, Visual representations supported children's meaning-making processes by helping them connect concrete experiences with abstract concepts, particularly for children requiring additional cognitive and communication support, as shown in Figure 1.

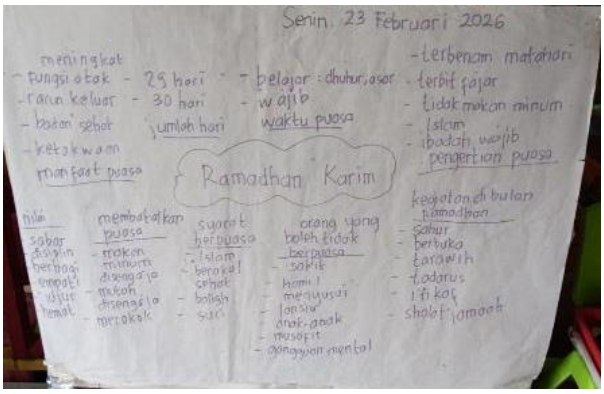

Figure 1. Documentation of the topic list

Contextual orientation strategies appear to enhance children's active participation during the early stages of learning. Observational data indicate that some children who were initially passive began to respond verbally, point to visual materials, and connect classroom topics to their own experiences. These findings suggest that contextual STEAM problems serve not only as cognitive stimuli but also as social entry points that allow children with varying communication abilities to participate meaningfully in classroom interactions.

In several learning sessions, children demonstrated emerging competencies in asking questions, taking turns in conversation, and sharing personal experiences during group discussions. This suggests that a contextual problem-based approach supports the development of early communication and social interaction skills, particularly among children who previously showed limited classroom participation. Reflective dialogue in early childhood education plays a

crucial role in deepening thinking processes (Hamel et al., 2021), as it encourages children to reflect on their experiences (Chen, 2023), develop metacognition (Chen et al., 2025), and open-ended questions in STEAM enhance the quality of children's participation and exploration of ideas (Chen & Tippett, 2022).

The use of concrete learning resources such as direct experiences, visual media, and the surrounding environment has been shown to strengthen children's curiosity and engagement. Children demonstrate active participation through observing, asking questions, and discussing with peers, confirming that contextual problems serve as catalysts for inquiry and social interaction (Ramey & Stevens, 2023), and support diverse learning readiness (Messiou, 2025). Thus, the problem-oriented approach in STEAM–PBL serves as a foundation for learning that activates prior experiences while fostering cognitive (Chiu et al., 2025), social (Wijnia et al., 2024), and emotional engagement (Meulenbroeks et al., 2024).

3.2 Organizing Collaborative Learning

Observations show that once children understand the context of a problem, teachers organize learning by giving children the opportunity to participate in planning activities. Children are given the freedom to choose play ideas, which naturally leads to the formation of groups based on interests rather than abilities. This approach reflects the principle of child-centered learning, which positions children as active agents in shaping their own learning experiences, while providing equal opportunities for participation for all children without early labeling based on ability. It emphasizes active engagement, learning choices, and recognition of children's voices and experiences within the learning process (Barblett et al., 2024; Cade et al., 2022). The results of interviews with the three informants indicate that children independently determine the play activities they will engage in, as stated: "The children decide for themselves what they want to play; that means they also form their own groups." (B1). This finding is supported by observation results showing group formation based on interests and collaborative play activities, as shown in Figure 2.

Figure 2. Observation data of children playing in group

The observations in Figure 2 that collaborative interactions emerged through idea sharing, role negotiation, and joint problem-solving, indicating that children actively constructed social participation within peer groups. These interactions indicate that collaboration arose naturally from the children's need to bring their shared ideas to life, rather than from direct instructions by the teacher. The teacher's strategy of allowing children to form groups based on shared interests appears to reduce the participation barriers typically experienced in ability-based grouping. Interest-based grouping appeared to reduce social participation barriers, particularly for children who initially demonstrated limited peer engagement. Children demonstrated increased social engagement and collaborative responsiveness during peer interaction activities.

Pedagogically, practices such as discussion (Ansari & Naseer, 2024), negotiation (Zhou & Colomer, 2024), and class agreements (Neri Tejada et al., 2024) are integral components of organizing collaborative learning. Children are encouraged to verbally express problems to peers and teachers, thereby fostering empathy (Meza et al., 2025) and conflict resolution simultaneously (Ibarrola-García, 2024). Peer interaction within interest-based groups reinforces inclusive learning practices (Azmat ullah & Samad, 2025; Neri Tejada et al., 2024). Children share ideas, help one another according to their respective abilities, and build shared understanding without the pressure of competition. This confirms that interest-based collaboration not only enhances engagement but also creates a supportive and inclusive learning environment (Zhou & Colomer, 2024). Thus, organizing collaborative learning through interest-based grouping and class consensus serves as an effective strategy for integrating children's social (Adl-Amini et al., 2024) and emotional aspects (Pollak et al., 2024).

3.3 Teacher Scaffolding in STEAM Inquiry

The results of the observations show that during the inquiry phase, teachers apply scaffolding (support) gradually without compromising the students' independence. Teachers do not immediately provide solutions but first observe to identify the types of difficulties students face, whether technical or conceptual. All three informants agreed with this and stated, "We observe first for 5–10 minutes to see if the student's difficulty lies with the equipment or their way of thinking, so the assistance can be targeted." (B2). This approach reflects the principle of contingent scaffolding, which involves providing responsive support tailored to the child's needs and gradually reducing it as their abilities improve (Bohm et al., 2025; Mannion et al., 2021). In addition, the primary form of scaffolding provided by teachers involves open-ended questions that encourage exploration and reflection. Questions such as "What will you add for tomorrow?" or "What will you do next?" help students evaluate their work and plan their next steps, as shown in Figure 3.

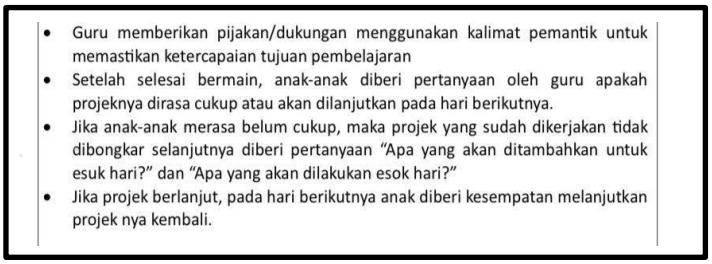
- Guru memberikan pijakan/dukungan menggunakan kalimat pemantik untuk memastikan ketercapaian tujuan pembelajaran
- Setelah selesai bermain, anak-anak diberi pertanyaan oleh guru apakah projeknya dirasa cukup atau akan dilanjutkan pada hari berikutnya.
- Jika anak-anak merasa belum cukup, maka projek yang sudah dikerjakan tidak dibongkar selanjutnya diberi pertanyaan "Apa yang akan ditambahkan untuk esuk hari?" dan "Apa yang akan dilakukan esok hari?"
- Jika projek berlanjut, pada hari berikutnya anak diberi kesempatan melanjutkan projek nya kembali.

Figure 3. Documentation of scaffolding forms in the instructional module

A gradual scaffolding strategy allows children to maintain autonomy while still receiving adaptive support tailored to their individual needs. During observations, children increasingly demonstrated independent problem-solving behaviors, such as retrying failed constructions, modifying materials, and seeking help from peers before seeking direct intervention from the teacher. These findings suggest that responsive scaffolding contributes not only to task completion but also to the development of perseverance, decision-making, and early critical thinking skills. In inclusive settings, these practices are particularly important because they allow children with diverse developmental characteristics to participate in the same learning environment without experiencing exclusion or excessive dependence on the teacher.

Within the framework of inclusive education, the scaffolding practices employed by the teacher demonstrate adaptive instructional differentiation (Ranbir, 2024; Vantieghem et al.,

2020). Teachers provide support based on individual needs without separating students by ability, but rather within the same group work context. Effective implementation of scaffolding in heterogeneous classrooms also requires teachers' pedagogical competence. Therefore, strengthening teachers' capacity through continuous professional development is a critical factor in supporting high-quality inclusive learning practices (Cruz et al., 2024; Tuerah, 2025).

Inquiry activities encouraged children to actively construct understanding through exploration, experimentation, and peer interaction, thereby supporting autonomous and participatory learning processes. Children's ideas were positioned as meaningful contributions within the learning process, reinforcing agency, participation, and confidence during project development. Thus, scaffolding in STEAM–PBL inquiry serves as a pedagogical mechanism that bridges independence, differentiation, and inclusivity. Therefore, flexible and contextual scaffolding becomes a crucial foundation for creating adaptive (Hussein et al., 2025), participatory (Zhou & Colomer, 2024), and responsive STEAM–PBL learning that addresses the diversity of early childhood students (Perignat & Katz-Buonincontro, 2019).

3.4 Representation and Presentation of Children's STEAM Projects

Observations show that during the development and presentation stages of their projects, children represented ideas through flexible and open-ended materials, enabling diverse forms of expression and participation during project development. The project outcomes reflected collaborative meaning-making processes in which children negotiated and transformed shared ideas into tangible representations. In the STEAM context, the integration of artistic elements enhances children's creativity, flexibility of thought, and communication skills in transforming ideas into tangible forms (Minces & Akshay, 2022; Sanz-Camarero et al., 2023).

The presentation stage serves as a crucial reflective phase, as it provides children with the opportunity to explain the process, strategies, and reasoning behind their work (Chan & Lee, 2021). The results of interviews with the three informants consistently indicate that children are given the opportunity to present their work in front of the class, as reinforced by the statement: "When children are given the chance to share their stories, their self-confidence visibly increases, especially with the praise given by the teacher." (B3). Repeated presentation opportunities appeared to strengthen children's confidence and willingness to communicate ideas publicly within peer interactions. Children gradually become more confident speaking in front of their peers, explaining the project process, and answering simple questions from teachers and classmates. This activity helps children develop the ability to convey ideas (Veldman et al., 2020).

The teacher's role in this stage is evident through the provision of positive reinforcement, whether in the form of verbal praise or symbolic rewards. Positive reinforcement plays a role in enhancing children's motivation, interest, and engagement in learning (Hardy & McLeod, 2020). The form of reinforcement, such as praise, is specific to the process for instance, highlighting the child's strategies or efforts thereby helping the child understand the factors contributing to the success of their work. When a child struggles to explain their work, the teacher poses prompting questions to help the child organize their explanation coherently. This strategy demonstrates that presentations serve not only as a communication activity but also as an ongoing scaffolding process in developing children's reflective and critical thinking skills (Chan & Lee, 2021). Pedagogically, the combination of presentation opportunities and positive reinforcement contributes to enhancing children's self-confidence and sense of competence (Sarkar, 2025; Trecy Rosefine et al., 2024). Children become more confident in expressing their ideas in front of their

peers in a psychologically safe environment, which is a key indicator of inclusive learning (Henley, 2025; Paul Mary, 2023).

3.5 Children's Reflection on the Problem-Solving Process

Observation results indicate that the reflection stage serves as an essential concluding element in the STEAM–PBL learning sequence, functioning to integrate children's learning experiences. Group-based reflective discussions created an inclusive interactional space that supported open communication and shared participation among children and teachers (Martinková et al., 2020), which facilitates open communication (Baptista et al., 2018) and visual contact (Sybing, 2021) between teachers and children. All three informants stated that teachers help children reflect on the process they have gone through by asking reflective questions about their work, the difficulties they faced, and their problem-solving strategies. As emphasized: "From the children's reflections, the teacher can identify which areas need improvement in the future." (B3). Children demonstrated emerging metacognitive awareness by recognizing challenges, evaluating unfinished work, and proposing ideas for future improvement. This behavior indicates the emergence of early metacognitive awareness, particularly in recognizing personal strategies, challenges, and learning progress, as shown in Figure 4.

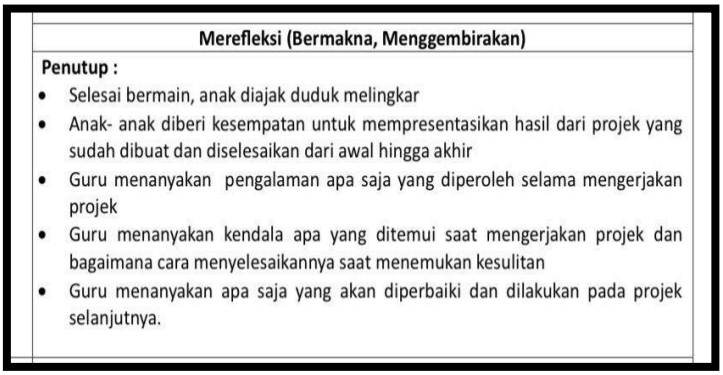

Figure 4. Documentation of the reflection guide in the teaching module

Conceptually, reflective activities conducted through open discussions and probing questions indicate the development of metacognitive awareness in children that is, an initial awareness of the thinking processes, actions, and strategies they have employed (Ma et al., 2025; Mickelburgh, 2022). Children begin to understand what they have done, how they did it, and what can be improved. Within the Problem-Based Learning framework, reflection also serves as part of a continuous improvement cycle that connects prior experiences with future learning planning (Li et al., 2023). In the context of STEAM–PBL, reflection expands the meaning of learning from merely producing an outcome to a process of understanding experiences, facing challenges, and finding solutions (Nguyen, 2025). In inclusive learning, non-competitive reflection practices provide space for every child to share their experiences without the pressure of comparison, thereby fostering an equitable learning environment that values diversity (Mahali, 2024; Stanichenko, 2025).

In addition to impacting children's development, reflection also serves as a pedagogical evaluation for teachers. This practice demonstrates the presence of an adaptive and continuous reflective cycle in learning, which is a key characteristic of inclusive education (Donath et al., 2023; Hawthorne et al., 2025). Thus, the reflection stage in STEAM –PBL is not merely a closing activity but acts as a bridge between past learning experiences and the improvement of learning quality

in the next cycle, thereby supporting the creation of adaptive (Metsäpelto et al., 2022), participatory (Kärner et al., 2026), and inclusive (Landry & Malena, 2025) learning.

Based on the overall research findings, these results indicate that the implementation of STEAM–PBL within an inclusive education context is not only effective in enhancing children's engagement and holistic development but also contributes to the development of communication skills, collaborative participation, self-confidence, perseverance in problem-solving, and reflective thinking. These developmental outcomes are closely linked to the adaptive pedagogical strategies teachers employ at each stage of learning. Beyond the main findings, this study reveals that the success of inclusive learning is significantly influenced by teachers' ability to create a contextual, collaborative, and reflective learning environment supported by responsive scaffolding practices tailored to the individual needs of each child. Therefore, strengthening teachers' competencies through continuous training, developing flexible curricula, and providing institutional support are crucial to ensuring the sustainability of inclusive practices.

The novelty of this study lies in a demonstration of how the principles of inclusive pedagogy are concretely applied at every stage of STEAM–PBL learning in early childhood education. Inclusive education that emphasizes access, participation, and adaptive support for every child without discrimination (Pradhan & Naik, 2024; UNESCO, 2020), In this study, these approaches were implemented through contextual problem-based learning, interest-based collaborative grouping, responsive scaffolding, dialogic presentation practices, and non-competitive reflective activities throughout the STEAM–PBL cycle.

Unlike previous studies, which have largely focused on creativity or cognitive outcomes, this study provides a comprehensive analysis of how teachers foster inclusivity through active student engagement, a non-discriminatory collaborative environment, and adaptive scaffolding and differentiated instruction that responds to the individual needs of each child (Dulfer et al., 2025; Pozas et al., 2021) Empirical findings indicate that this pedagogical strategy contributes to children's communication skills, collaborative engagement, emotional self-confidence, perseverance in problem-solving, and the development of metacognitive awareness in heterogeneous classrooms. Thus, inclusivity in STEAM–PBL is not merely positioned as a normative principle, but as a pedagogical practice that is systematically embedded throughout the learning process.

4. CONCLUSION

These findings demonstrate that STEAM–PBL supports inclusive early childhood learning through contextual problem-based learning, interest-based collaboration, responsive scaffolding, dialogic instruction, and reflective activities. These pedagogical practices enhance children's communication skills, collaborative participation, self-confidence, perseverance in problem-solving, and emerging metacognitive awareness while enabling all children to participate according to their individual abilities. Practically, inclusive early childhood teachers are encouraged to utilize open-ended materials as flexible learning media and apply responsive scaffolding and reflective dialogue to support active participation in heterogeneous classrooms. Further research is recommended to examine the implementation of STEAM–PBL across broader educational contexts and subject areas using longitudinal or mixed-methods approaches.

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