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Exploring Teachers' Strategies for Integrating 21st Century Skills in STEAM

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ABSTRACT

Education has challenges in preparing students with the skills needed in the 21st Century, namely 4C. This ability can be developed with the STEAM approach, which can be implemented from the PAUD level by linking the real world to practical activities in the classroom. Teachers are facilitators in providing play activities, so they need a comprehensive understanding of STEAM. This study aims to see the understanding of teachers at the PAUD level in mastering the STEAM concept both theoretically and practically. This study uses case study research to gain an in-depth understanding of the 4Cs in STEAM Learning based on the teacher's perspective in integrating 21st Century skills. Four teachers participated as key informants with the criteria of alumni from the PGPAUD Study Program before 2000, working for more than 3 years in PAUD institutions, and participating in STEAM-related training. Data collection used research instruments of interviews, observations, and documentation, and was analyzed with thematic analysis using five themes. The study results showed diversity in understanding the STEAM approach to developing 4C skills, but all agreed that using loose parts and projects was easier to integrate. The study's findings found a discourse on the terminology of learning models and approaches. This study has implications for teacher professional development with the hope of increasing pedagogical literacy as a basis for learning.

Keywords: 4C, Steam Learning, Teacher Perspective, Teachers Strategies

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INTRODUCTION

Current education This face challenge big that is to form participant students who have 21st Century competencies, namely critical thinking, communication, collaboration, and creativity or known with the term 4 C. Maulidah (2021) explain ability think critical allow participant educate for analyze information in a way in depth, identify connection between concept, as well as find solution on problems faced. While ability communication covers skills in listen to in a way active, gaining as well as processing information, and putting forward ideas or opinions in an way effective to others, either in the context individual and group, respond information, and submitting questionss (Marfuah, 2017; Yoranika & Perdana, 2024; Istanto et al., 2022). For ability collaboration demand participant educate for capable work the same in a way productive, communicative in group, have not quite enough answer for finish project in group, weave synergy, adapt self in various roles and responsibilities answer, and value diversity (Hairida et al., 2021; Nopiani et al., 2023). Temporary that, creativity is the ability individual in utilise power imagination and optimization potential the developing self for generate ideas or innovative solutions (Foster & Schleicher, 2022; Gafour & Gafour, 2020). Through the fourth ability, the participant is educated capable overcome various challenges in life in a independent way in the future.

4C capabilities become the main pillar in creating participant educate who is not only intelligent in an academic way, but also adaptive, innovative, and capable Work The same in the face future challenges (Susanti et al., 2025). Challenges in the future, the increasingly bright front complex demands participants to educate themselves on their own 4C capability to be able to adapt to the environment as well as daily life in a competitive way (Maulidah, 2021). Mastery of 4C in participants becomes a foundation important in forming individuals For can adapt, innovate, and collaborate optimally in the face of future challenges. Development of 4C capability can be done through the STEAM approach (Science, Technology, Engineering, Arts, and Mathematics) (Angga, 2022; Wulandari, 2020). STEAM is an approach that integrates education educate For think in a wide about problems that exist in the real world, as well as participate active and exploring in activities a project that integrate knowledge of science, technology, engineering, arts, and mathematics (Angga, 2022). Learning process STEAM-based, participants are educated to think critical and creative in designing solutions, working The same with friends and peers, and communicating their ideas.

Ability thinking and skills in facing an increasingly global world complex, and dynamic global world can be built trough STEAM application in child education. STEAM in Early Childhood Education (PAUD) aims to push children to active explore and understand complex concepts through fun, interesting play, stimulate curiosity, and participant in the next student for the situations (Huda et al., 2024; Rachmadani et al., 2025). The STEAM approach creates an environment for fun and free learning for participants to feel free to explore, share new ideas that grow Creativity, be involved active in various activities, as well as develop communication and collaboration skills through a discussion group (Safitri, 2022).

Learning with the STEAM approach stimulates participants to educate by connecting the real world through activity practice, so that child No only understand concepts, but also are invited For involved direct as subjects in creative, active in play, discover, and live experience new useful for development they (Motimona & Maryatun, 2023). Focus on Study children through daily life experience will have a positive impact ability to child For think critically, innovative, and creative in breaking down future problems (Astuti et al., 2013; Romli, 2022). According to Della et al, implementing the STEAM approach in PAUD is appropriate with characteristics think children early age, that is, holistic or comprehensive (Huda et al., 2024; N. Novitasari et al., 2022). Children can connect various draft discipline knowledge with a more complicated real situation. However, not all implementations STEAM approach are carried out in a holistic way. Fun cooking, collage leaves, mixing colors are activities that result in STEAM implementations are numerous and provided by teachers at the PAUD (Agusniatih & R, 2022; Ngili & Yudha, 2024; Utami & Azmi, 2024). The results of the analysis of every activity said that children will do something in accordance with STEAM elements, for example, science is carried out with observation, technology with providing tools technology use child, child art requires decorating, engineering requires children requested make something, and math requires counting. Separately, every element is not enough in accordance with the method that thinks holistic, a connected child between aspects cognitive, social emotional and spiritual, so that it is expected that teachers can provide mutual STEAM learning related one with another (Oktaviana et al., 2025; Amalia et al., 2023).

The teacher has a crucial role in providing appropriate play activities with principal development of STEAM learning so that the goal can be achieved (Yestiani & Zahwa, 2020). Efforts made by teachers to be able to provide appropriate play activities, STEAM principles, with understand with correct the concept. Good understanding will influence practice learning carried out by teachers, but I have not met the teacher yet and understand the STEAM concept if implemented in learning Early Childhood Education (PAUD) (Fatimah et al., 2022; Nursyahida & Nurhaliza, 2024; Olyffia & Jauhari, 2024; Pramudyani & Indratno, 2022). The lack of teacher understanding in control the STEAM concept will impact classroom learning, starting from determination objective learning, preparation play activities, determination assessment, and assisting (Metafisika et al., 2022). Research This aims to describe the understanding of

teachers at the PAUD level in mastery good the STEAM concept in both theoretical and practical especially in provision holistic play activities.

METHOD

This study uses qualitative research with a case study approach. The case study approach was chosen with the aim of gaining an in-depth understanding of the 4Cs in STEAM Learning based on Teachers' Perspectives in integrating 21st-century skills. The use of the case study method allows researchers to explore data in more detail and comprehensively regarding the STEAM concept, which examines theoretically and practically in preparing the main activities for early childhood. This research was conducted in Yogyakarta City with 4 teachers as informants in the study. The research informants were selected based on the criteria of alums of the UAD PGPAUD Study Program who graduated before 2020, worked at the PAUD level in Yogyakarta City, and had a minimum of 3 years of experience.

Data collection was obtained using interviews, observation, and documentation techniques. The researcher conducted interviews with 4 teachers who teach at Kindergartens in Yogyakarta City. Before conducting the interview, the researcher created interview questions related to the research topic. The purpose of creating interview guidelines is to provide guidelines and an overview of the research topic, as well as to facilitate researchers in collecting research data. The researcher used a triangulation technique credibility test to ensure the validity of the data from interviews, observations, and documentation. The data obtained by the author through the interview process, observation, and documentation were then analyzed using thematic analysis so that the data obtained could be explored in depth (Creswell, 2013). The analysis themes are understanding STEAM (W1), implementation (W2), 4 C (W3), challenges (W4), and support (W5).The interview question grid can be seen in Table 1.

Table 1 Grid interview study

Indicator	Grid Question
Teachers' Understanding of STEAM	1. Whether You know or familiar with STEAM Education? What is your understanding of STEAM learning in PAUD?
Implementation of STEAM learning	1. Whether There examples of STEAM activities that encourage children to ask, analyze, or solve problems? 2. How does learning with your STEAM implement in class? 3. In STEAM activities, how do you provide room for children to be creative? 4. Are there activities that encourage children to produce solutions different or unique?
Benefits of STEAM	1. What are the benefits of using STEAM in learning?
Development 4C Capabilities	1. What do you know? about ability 21st century , especially 4C? 2. According to you, are you can STEAM develop 4C ability in children? *If possible, how does it look in children 3. How do you grow your ability to think critical in learning?

RESULT AND DISCUSSION

A. Understanding STEAM in PAUD

The study's results showed that all informants in this study had never received STEAM material during their undergraduate studies but had received material related to the Scientific Approach through Mathematics and Science Learning Courses. Knowledge of STEAM was

obtained by participating in workshops, training, seminars, and other professional development activities organized by the institution where they work or the PGPAUD Study Program, FKIP UAD. Based on the study's results, it was found that most teachers had understood the concept of STEAM as an integrated approach between elements and aimed at broadly developing children's potential. As in the results of an interview with Teacher LZ:

"*STEAM prepares children to face future technological developments... very different from centers, making teachers want to improve.*"

Teachers understand that STEAM learning developed at the PAUD level uses an integrated approach between elements. Another teacher's understanding is that STEAM learning aims to prepare children to face future conditions that require 4C abilities. Teachers also believe that STEAM is beneficial for children and themselves because they can improve their competence with various developments. Through STEAM, children can develop creativity, problem-solving, critical thinking, and collaboration. Improvement in teacher competence can be seen during play activities. Namely, teachers inviting children to discuss developing projects during play activities, as seen in Figure 1

Figure 1. Discussion activities between teachers and children during learning

B. Implementation of STEAM in the Classroom

STEAM learning implemented at the PAUD level uses the Independent Curriculum as a reference for learning with Loose-part media. Based on the results of observations and documentation, all teachers have the same opinion: STEAM is currently collaborating with the Independent Curriculum by creating projects according to the topics discussed with students, such as building hospitals, making medical equipment, and creating zoos with loose parts as the media. Developing projects is carried out for several days to weeks, starting with literacy activities, exploring story books and videos, discussing concept maps as the basis for project activities, and delivering student work projects. Children's presentations at the end of the project aim to see exploratory abilities and idea creation or creativity through STEAM learning. Exploration and creativity are some of the final abilities developed through STEAM.

One form of project produced by students with STEAM can be seen in Figure 2, the beginning of the project to make a hospital, and in Figure 3, the end of the hospital project made by students presented.

Figure 2 Project Start

Figure 3 End of project

Based on the results of the interview with the QA teacher below:

"*... Children build a hospital from loose parts in the form of cardboard, blocks and other accessories, they will try various materials until they find a sturdy material to be used as a hospital building. At the end of the project, the children present the results of the project by conveying the*

materials used, how to assemble them, the parts of the building, the function of the parts of the building, and so on.."

C. 4C Ability

4C ability is described as thinking critically, being creative, communicating, and collaborating. The study's results revealed that children's critical thinking skills emerged when they were free to explore tools and materials and faced project challenges. The teacher used trigger questions and open discussions to encourage children to analyze situations and make decisions. Research data shows that most teachers understand that critical thinking skills can be seen during the process of children thinking about developing their projects. In an interview, GL said:

"*Children build ideas from videos, then make doctor's tools. The thinking process can be seen from ideas to works.*"

Based on the interview results, the teacher said critical thinking is carried out since children watch videos as part of literacy, develop ideas, and produce works resulting from the project. The systematic thinking described shows critical thinking skills, especially systematic thinking. Children build ideas and analytical thinking skills when they build ideas to make doctors' tools. It can be seen from picture 4 of the video used as the basis for building ideas and picture 5 of the results of the doctor's tool work as a form of analytical thinking.

Figure 4 Literacy Video as a base idea builder

Figure 5 Thinking results critical

Creativity in early childhood is defined as the ability to see things in a new way, think outside the box, create something unique, combine unrelated things into something new, and go beyond limits. The results of the GA interview research data explain that creativity ability is defined as children being able to create something new by combining various unusual materials, namely loose parts. The results of the GA interview are below:

"*Children create their own version of a zoo. They make animal houses from unusual materials.*"

This opinion was also conveyed by all informants in this study, who believe that creativity is defined as the ability to create works according to the child's thoughts. If loose parts are used, then the ability to combine various elements becomes part of creativity. Creativity is considered to be the most prominent ability. Children's work as a form of creativity using loose parts can be seen in Figure 6 below:

Figure 6 Process and results of children's creativity

Communication is also an indicator of the 4C abilities that need to grow during the learning process with STEAM. STEAM learning developed with loose parts can develop communication skills in early childhood through conveying ideas, discussions, and explaining the work results. Research data shows that all informants have the same opinion regarding STEAM learning being able to develop children's communication skills, especially when explaining the projects they build. One example of an interview with teacher GL is below:

"*When children present, they tell stories about what they make. That's part of communication.*"

The presentations made by students at the end of the project were not developed by themselves. The observation results found that teachers actively asked open questions and encouraged children to explain their answers in detail and systematically. Open questions will help children develop communication skills, as we know that the vocabulary of early childhood is still limited. One way to help children explain something is through open questions.

Developing skills in making presentations or communication can be done through literacy activities. The results of the overall observation showed that all informants had accustomed children to communicating through literacy activities and reading in the morning for GA and GR. While GA and GQ were at the beginning of the project, usually on Monday for 1 day of learning, they still gave open questions to children every day through daily activities.

All informants also agreed upon collaboration as a 4C ability as one of the goals of Learning using the STEAM approach. Although GQ notes that the level of collaboration children can do is adjusted to their developmental age, For example, children aged 2-3 years with egocentric characteristics still need help and guidance from teachers in dividing tasks, giving examples of collaboration, and organizing each child's tasks. The results of the GQ interview are below:

"*Collaboration does not seem strong for children aged TAA (2-3 years), but we get used to dividing roles and tasks in one activity.*"

These 4C skills have been proven to be developed through learning with the STEAM approach. However, loose parts are not the only media that can be used to implement STEAM in the classroom.

DISCUSSION

STEAM learning at the PAUD level has been implemented since 2017 as a development of Permendikbud 137 of 2014 concerning National PAUD Standards and Permendikbud Number 146 2014 concerning PAUD Curriculum. This policy developed a scientific approach for the PAUD level, introducing science specifically and then continuing with the STEAM approach (Angkur, 2019; Marwiyati & Istiningsih, 2020). STEAM learning at the PAUD level can be carried out while still paying attention to the characteristics of early childhood learning, namely holistic or comprehensive. So teachers need to understand the concept of STEAM, which consists of various elements of Science, Technology, Engineering, Arts, and Mathematics and how to relate one to another. Especially now that STEAM is one of the learning approach efforts that can develop 4C abilities.

A. Understanding STEAM in PAUD

Teachers understand that STEAM learning developed at the PAUD level uses an integrated approach between elements. When viewed from the characteristics of early childhood thinking, integration is interpreted as interrelated between STEAM elements or holistic principles so that teachers do not need to prepare every activity that leads to elements. With principles that are by the characteristics of children, STEAM learning can be used for early childhood (Oktaviana et al., 2025). This also indicates that teachers should no longer provide separate activities between STEAM elements in learning in PAUD. If teachers have the same perception, it can be concluded that the understanding of STEAM that is mastered is more towards the STEAM approach (Motimona & Maryatun, 2023; Sativa et al., 2024). Teachers' understanding of STEAM learning aims to prepare children to face future conditions that require 4C abilities. This is the opinion of Prameswari et al., Putra, who emphasized that future

skills are in the form of creativity, communication, collaboration, and critical thinking (4C) (Prameswari & Lestariningrum, 2020; Putra & Murniati, 2023). Current learning is expected to be able to develop a curriculum that provides provisions so that students have critical and analytical thinking skills, problem-solving, innovation, and communication so that their standard of living will be better in the future (Indarta et al., 2021; Rawung et al., 2021; Wahyuni, 2020).

Teachers also believe that STEAM is beneficial for children and themselves because they can improve their competence with various developments. Through STEAM, children can develop creativity, problem-solving, critical thinking, and collaboration (Wahyudi et al., 2024). To foster these abilities, teachers must first create a play environment that supports exploration. Teachers also provide guidance while children are playing so that without realizing it, the teacher's abilities can also develop (Jumarniati & Fitriani A, 2023; Rachmadani et al., 2025).

Discussion activities are not just about asking questions between two or more people. According to Amrain et al. (2024), discussions help students develop analytical and reflective skills and even face other academic challenges. Even in science learning, discussions not only develop cognitive skills but also affective and social skills (Dwikoranto, 2011).

B. Implications of STEAM in the Classroom

In principle, STEAM learning can be done through various activities. The project method is one way that STEAM can be implemented and can develop 21st Century skills in the form of 4C (Andhianto et al., 2024; Mulyani et al., 2023; Sulastri & Cahyani, 2021).

In addition to teachers, parents can also be companions for children when learning with project-based STEAM. For example, in Turkey, they have started developing STEM Education for Early Childhood projects using activities such as Bee dance, design a slide, cook stem, play dough ship, space shuttle, and others. The role of the teacher in the project ensures that each child does their job, helps children ask questions or find solutions, and designs the system. Parents play a role in preparing all the equipment and materials for each project, providing information related to the project during the activity, and sending documentation of all children's activities to the teacher for assessment (Donmes & Idil, 2021). Likewise, in Bulgaria, parents and children carry out project-based STEM activities with standards provided and designed by teachers at school (Aleksieva & Mirtschewa, 2021). This shows that implementing STEAM with projects is not difficult and can be a means for parents to fully involve children's learning, as in the concept of parent involvement. Parent involvement significantly impacts children's learning efficiency (Ramasamy et al., 2023).

The implications of STEAM learning with projects begin with literacy activities and reading story books. The storybooks read at the beginning of STEAM learning provide children with visual images that stimulate creative analogical expressions and scientific knowledge. With both of these things, there is a significant difference in the level of self-efficacy and better project results (Mou, 2024). This shows that literacy activities can be an alternative to connecting STEAM learning with projects.

Projects collaborated with STEAM are assisted by media in the form of Loose parts. The choice of media in the form of Loose Parts is based on the consideration that it has a goal in line with STEAM, namely developing 4C skills. Children can develop 4C while playing because there are three game elements: sensorimotor, role play, and constructive. The results of interviews, observations, and documentation when children choose the loose part materials used and when presenting the results of their projects (Sukardjo et al., 2023). Loose parts also positively impact the learning atmosphere, increasing children's curiosity and enthusiasm for learning (Ratna et al., 2023).

D. 4C Ability

4C ability is a learning outcome that must be developed starting from the PAUD level. In the future, these abilities will develop into skills so that when they are adults and in a larger community environment, students can solve problems (Nurhayati et al., 2024). 4C ability is described as thinking critically, being creative, communicating, and collaborating.

Critical thinking skills can be observed when children are able to analyze a problem and explore something in detail and systematically (Imamah & Muqowim, 2020). In early childhood,

systematic thinking skills are built through analytical thinking, planning and anticipating, and interconnections in life, as well as holistic understanding (Casnan et al., 2023)(Casnan et al., 2023).

Creativity in children can be seen when children play, explore, and generate ideas or new things that are effective, imaginative, and original (Arsil et al., 2025; Imamah & Muqowim, 2020). However, creativity can also be interpreted as the ability to see something in a new way, think outside the box, create something unique, combine unrelated things into something new, and go beyond limits. Creativity can be developed in early childhood by preparing a play environment that allows children to think and experiment with creative ideas freely (Fox & Schirrmacher, 2009). Since STEAM learning uses Loose parts, all informants have stated that children's creativity is more developed than using Worksheets (LKPD) (Apriyansyah & Kurniawaty, 2022; Lismayani et al., 2023; Nurjanah & Muthmainah, 2023; Sukardjo et al., 2023). Creativity in early childhood emphasizes the process rather than the product. According to Fox & Schirrmacher (2009), creativity emphasizes more on ongoing activities than creativity is measured by the products produced. Assessing creativity not only focuses on the products produced but, no less importantly, the process of students producing these products shows true creativity.

Communication for children functions to convey needs clearly and understand the desires of others. During the learning process, good communication can help children acquire and perfect knowledge and even develop social skills through interaction (Early Childhood Australia, n.d.). Communication skills in children can be developed through activities to convey ideas and discussions and explain the results of work. Suppose it still does not help children communicate something. In that case, teachers can expand and provide inquiry-based games and carry out play activities by repeatedly asking open questions so that children's skills continue to develop (Early Childhood Australia, n.d.).

According to Duc Hoi (2018) developing skills in making presentations in front of many people is better if the children are trained to pay attention to the teacher's instructions so that they understand what to do and can collect various information. Teachers can train children to communicate through the habit of involving children in various activities so that they are accustomed to understanding other people's thoughts, gathering information, and learning to respect others when communicating.

The most typical characteristic of two-year-old children is egocentrism, which is one of the domains of cognitive aspects. Egocentrism is interpreted as the inability to distinguish between one's perspective and the perspective of others (Y. Novitasari & Prastyo, 2020). This inability affects the way they socialize, especially when collaborating. Meanwhile, to collaborate, the ability to actively contribute to a group, work in a group, communicate with group members, and be responsible for completing tasks in a group is needed (Hairida et al., 2021).

Collaboration is part of social development, especially the ability of specific social interaction and the learning process to solve problems involving group members effectively and constructively(Lee et al., 2015; Ridwan et al., 2023). This ability can only develop when children enter the age of 4 to 5 ½ years when children enter the cooperative play stage. The cooperative play type of game has elements of ability that lead to collaboration, namely communication, sharing teamwork skills, being organized, and each group member has respective roles (Gowrie NSW, n.d.).

All 4C skills have been proven to be developed through learning with the STEAM approach (STEAM Education LTD, 2024). Teachers can combine STEAM with loose parts as part of the learning media to develop 4C early childhood (Jupriyanto et al., 2025; Prameswari & Lestariningrum, 2020). Loose parts are not the only media that can implement STEAM in the classroom with an online system (Jovanka et al., 2021).

D. Challenges in Implementing STEAM

Teachers' confusion in implementing STEAM is found because they assume that STEAM is implemented like the Sentra learning model teachers used when using the 2013 Curriculum. This GR condition is common in education because everything describes the teaching and

learning situation (Reksiana, 2018). To overcome this, teachers should completely understand STEAM because many teachers still think that STEAM is limited to activities with separate elements. Even teachers implement STEAM only at the surface level; for example, the element of technology is interpreted as using a laptop, LCD, or video (Pramudyani & Indratno, 2022). However, not all understanding is a determining factor for teachers facing challenges. If teachers have high self-efficacy, it can be the basis for implementing a new concept, for example, the STEAM approach (Damayanti & Lanawati, 2024).

Participating in training as part of teacher professional development can help overcome challenges in terms of increasing understanding. Training can effectively provide changes in knowledge from not knowing to knowing or knowing to understanding various topics, one of which is STEAM.

E. Support needed

It is undeniable that facilities and infrastructure influence; if the school uses loose parts as a learning medium, then the elements that need to be provided are four loose-part elements, namely seeds, natural materials, used materials, and artificial materials (Ikhsan, 2022). If you look at the function of loose-part media, it has the principle of developing 4C abilities in children (Sukardjo et al., 2023). Combining loose parts with STEAM, which has the same goal, will make it easier for teachers to develop 4C during the learning process (Muawanah & Harjani, 2024; Purwaningsih et al., 2022; Ratna et al., 2023).

The study results showed a comprehensive understanding of all informants regarding the STEAM approach in developing 4C abilities in the 21st century. Although all informants have a positive perception in theory, it is necessary to continue to pay attention when implementing STEAM for 4C abilities in the classroom so that the pedagogical structure, including models, approaches, and learning methods, remains visible. This is because there is still a mismatch in concepts related to models, approaches, and methods, as believed by several informants. Although it is common to find that the positive perceptions of built-in teachers about learning do not significantly affect implementation, there is still a significant difference when teachers carry out the learning process (Reksiana, 2018). It is also necessary to note that teacher competence and willingness affect the implementation of STEAM in the classroom (Bui et al., 2023).

The novelty of this study is that it focuses on the teacher's perspective regarding STEAM as a learning approach for developing 4C skills more deeply, especially in terms of readiness, perspective, and practicality at the PAUD level. All informants have the same perspective on 4C skills that can be developed with the help of loose parts and projects more easily than partially by implementing each element with the same activity (Amri, 2024). The use of loose parts combined with STEAM can be a form of learning innovation (Haque & Purwoko, 2024) and utilization of the surrounding environment (Jazariyah, 2023) or contextual learning (Ismaniar et al., 2023; Muhu et al., 2024). Loose parts as a learning medium are also beneficial for language development (Maulina et al., 2025), cognitive and art (Isnariyati et al., 2025), and motoric (Nawanti et al., 2025) in early childhood.

This study has limitations in the small number of informants and does not represent all teachers at the PAUD level in a region. In addition, the study is limited to the perspective of teachers who obtain the concept of the STEAM approach from training activities, workshops, or seminars. When taking the PG PAUD undergraduate level, informants only gained an understanding that science learning was not focused on STEAM. Further studies are also needed regarding STEAM learning outcomes for more specific 4C abilities, especially regarding gender. This is based on the research results showing significant differences in 4C abilities between boys and girls (Saad et al., 2024).

The findings in this study are that there are still teachers who experience discourse on the terminology of learning models and approaches that indicate conceptual challenges in implementing STEAM at the PAUD level (Santos et al., 2025). The implications of the research results show that teachers need to improve pedagogical literacy related to the STEAM approach and specifically on the concept of learning models and approaches (Chappell et al., 2025). Meanwhile, in learning, the study's results can be applied; 4c skills do not have to be carried out

separately but are interrelated by first mastering the indicators of each ability by teachers. Mastering these abilities will make it easier for teachers to develop play activities and not be fixated on project learning.

It is expected that with the results of this study, teachers can improve pedagogical literacy, specifically in STEAM learning at the PAUD level. Likewise, organizers of training, seminars, workshops, or PAUD PG Study Programs, especially FKIP UAD, can provide programs or courses that provide conceptual and practical understanding in developing play activities that support 4C capabilities in an integrated manner, especially with STEAM (Santos et al., 2025) and collaborate with currently developing technology, namely AI (Artificial Intelligence) (Guan et al., 2025) or the use of digital materials so that children's literacy and numeracy also develop (Hidayanthi et al., 2024).

CONCLUSION

This study describes teachers' understanding of the STEAM approach and integration of 21st Century skills, namely 4C, which are still diverse. Some teachers have their own understanding draft with comprehensive and able to hook with practice learning using loose parts and projects. However, there are still those who experience confusion in the framework of conceptual pedagogical with terminology of models and approaches to learning. Research results in a way that the general public sees teacher perspective in developing 4C will be more effective when done in an integrated way compared to an implemented way. It is expected that with existence results study this , teachers can increase literacy pedagogical in a way specifically for STEAM learning at the PAUD level . Likewise, for organizer training, seminars, workshops, or the PG PAUD Study Program, especially the UAD FKIP, can provide programs or eye lectures that provide an understanding of conceptual and practical in developing supportive play activities 4C capabilities in general, integrated especially with STEAM.

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AUTHOR CONTRIBUTION STATEMENT

AVRP compiled the research concept and design, collected data, presented tables, and compiled the discussion. SJ checked the data and discussion results. RD collected data and compiled the discussion. MWL collected data and compiled research data. TQR collected research data.

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