

Observational Study Implementation of STEAM Activities to Stimulate 21st Century Skills in Early Childhood

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ABSTRAK

Learning with the STEAM approach has begun to be implemented in early childhood education settings. The STEAM approach provides significant opportunities to stimulate students' critical thinking skills. This phenomenon requires teachers to have a deep understanding of STEAM. Therefore, research is needed to reveal the extent to which STEAM activities are implemented in the classroom and how teachers are able to manage the learning environment to be more conducive in relation to the implementation of STEAM activities. This observational study aims to determine and analyze the extent to which teachers in early childhood education are able to carry out learning activities using the STEAM approach. It also aims to analyze how teachers are able to stimulate 21st-century skills through the implementation of the STEAM approach. The research data were collected through two main activities, namely observation and interviews. Observation and interviews were considered the most effective steps in gathering research data. The data obtained were analyzed using Miles and Huberman's qualitative data analysis model, which includes data reduction, data display, and conclusion drawing. The results show that teachers' understanding of STEAM is generally good; however, teachers still experience difficulties in providing contextual learning. Several misconceptions in science were also identified as important findings in this study. These results indicate that comprehensive and intensive mentoring is essential and deserves greater attention.

INTRODUCTION

Early childhood, also known as the Golden Age, is a prime age where cognitive, social-emotional, and motor development experience very rapid growth (Supiyardi et al., 2024). Cognitive, social-emotional, and motor development can be stimulated through learning activities at school (Early Childhood Education schools), where these learning activities must be capable of influencing students' abilities and skills, thinking power, attention, and also emotions (Salshabella et al., 2022).

To support cognitive, social-emotional, and motor development, students must be equipped with a strong foundation for thinking. A strong foundation for thinking is not limited to basic academic abilities, but also includes the development of 21st Century Skills. In the context of early childhood education, the 21st Century Skills that will be emphasized cover four aspects, often known as the '4C Skills', which include critical thinking, creativity, collaboration, and communication skills (Maulidah, 2021). Children who are highly engaged in learning processes that stimulate these four skills will tend to be more prepared to face future challenges (Ridhoni & Zen, 2023).

Some literature suggests that learning with the STEAM approach is relevant to be implemented to stimulate 21st Century Skills in early childhood (Wahyuningsih et al., 2020) and can provide meaningful direct experience (DeJarnette, 2018). The STEAM approach is capable of integrating five disciplines in a meaningful learning activity. Children will become increasingly proficient in critical thinking. Anak akan semakin terlatih dalam berfikir kritis (Wu, 2022), collaborate, communicate, and be creative in creating (Perignat & Katz-Buonincontro, 2019), while simultaneously fostering positive character traits such as self-confidence, responsibility, and

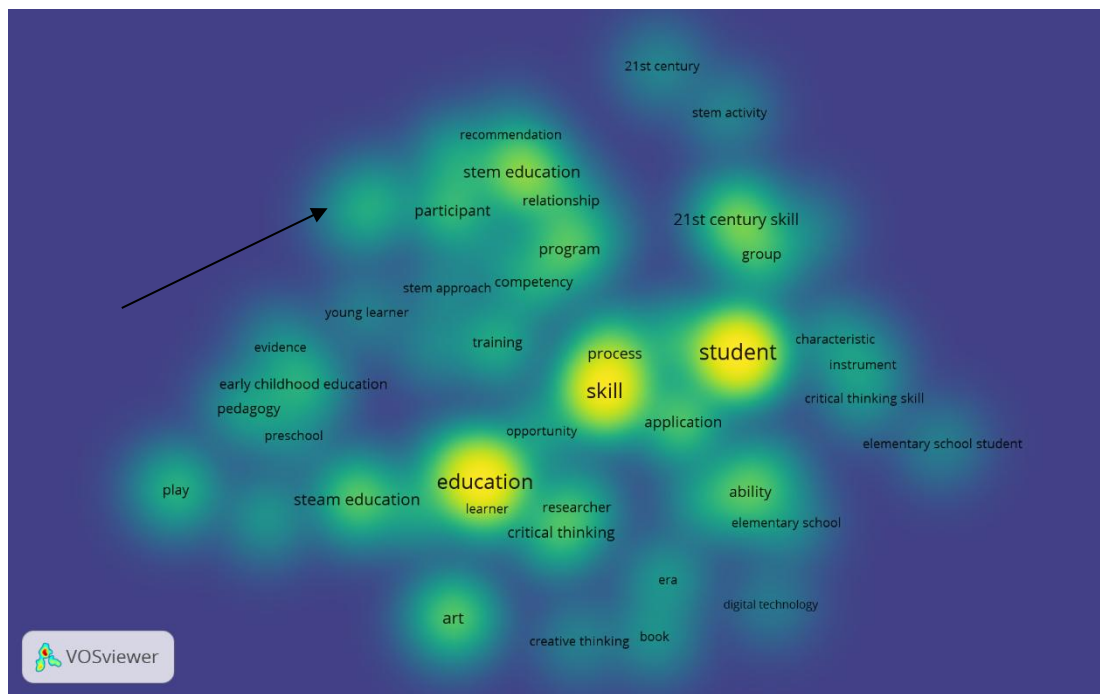


Figure 2. Density Visualization in VOS Viewer

Based on Figure 2, research analyzing teachers' understanding of STEAM implementation in early childhood education (the area indicated by the arrow) is still unclear (the area indicated by the arrow). This indicates that although this has been done, further development is still needed, especially in several different areas. In relation to 21st-century skills and learning activities using the STEAM approach, there is also still very little. Figure 3 shows that research connecting teachers in the field of early childhood education, STEAM learning activities, and 21st-century skills is still very much needed. The results of the bibliometric analysis indicate that research on the analysis of the implementation of the STEAM approach (STEAM activities) in learning is a novelty in this paper.

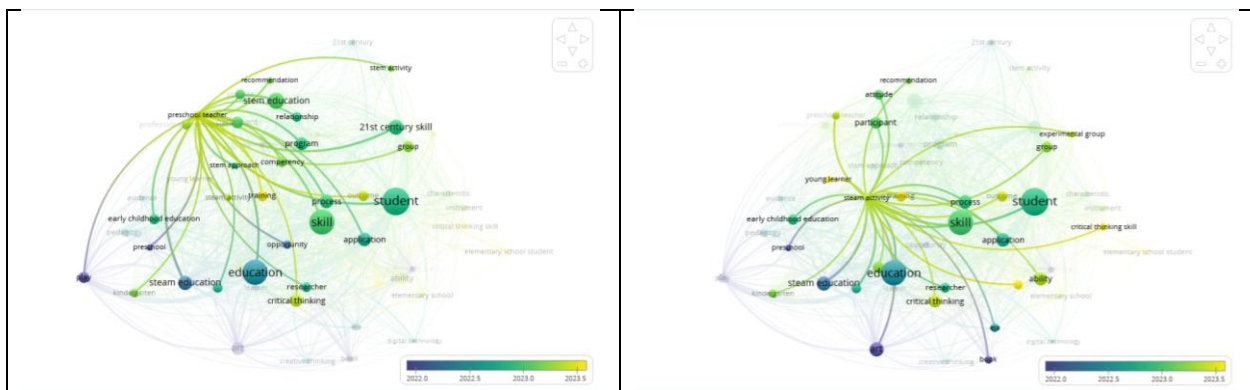


Figure 3. Overlay Visualization for STEAM Activity, Preschool Teacher, and 21st Century Skills

This research, which analyzes teachers' understanding of the implementation of the STEAM approach in learning and its relationship to 21st-century skills, aims to determine and analyze the extent to which teachers in early childhood education are able to implement learning activities using the STEAM approach. Furthermore, it also analyzes how teachers are able to stimulate 21st-century skills by implementing the STEAM approach. The findings at each stage of this study can serve as the basis for further research..

METHOD

This research is a descriptive exploratory study. Descriptive exploratory research describes a phenomenon in depth and comprehensively, especially on phenomena that have not been widely studied (Arikunto, 2010). This research was conducted over one semester. The population was teachers and students at partner schools. We selected six schools as research subjects in the Madiun Regency and City areas.

The approaches used in this study were qualitative and quantitative. The qualitative approach allows researchers to explore the meaning of data in depth. In the qualitative approach, researchers conducted interviews, in-depth observations, and documentation studies to explore the extent of understanding and implementation of STEAM activities in early childhood education schools. To support the data from the observations and interviews, quantitative data was also used in this study. The quantitative approach provides a broader picture of a phenomenon and is complemented by a survey. The data from the quantitative approach is in the form of numbers (Donatus, 2016). Data was collected through two main techniques, observation and interviews. Both were conducted to understand the process of implementing STEAM activities in the classroom and the 21st-century skills that emerged. Furthermore, they also explored teachers' understanding of STEAM activities in the classroom and the challenges in implementing them.

Qualitative data were analyzed using the Miles and Huberman interactive analysis model, which includes three stages: data reduction to focus and simplify the interview and observation data. Meanwhile, quantitative data were analyzed descriptively using statistics, displaying percentages regarding the level of understanding of teachers' implementation of STEAM activities. The data collection and analysis process carried out in this study is summarized in Figure 4.

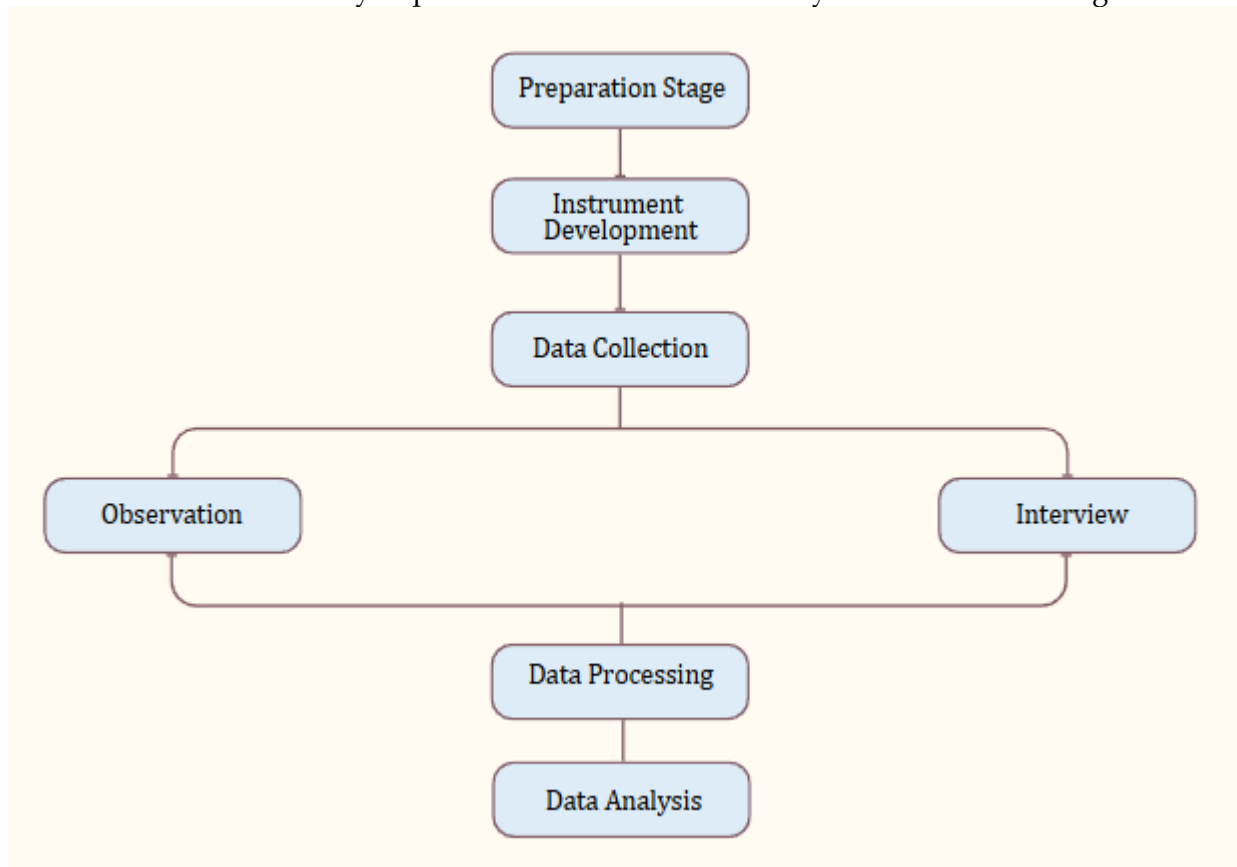


Figure 4. Research Flow Stages

RESULT AND DISCUSSION

Result

Interview

The initial data collection process involved in-depth interviews with teachers. There were 24 teachers involved, with details of 12 main teachers and 12 assistant teachers. Interview questions were structured in line with the learning activities being conducted. In-depth interviews are essential to support observational activities. Both methods are used to gather diverse stories from individuals or groups who are able to explain, describe, and explain the subject being investigated (Mowat, 2022). Interviews were conducted in person with each teacher involved. Interview components focused on seven key areas: understanding STEAM, lesson planning, classroom implementation, stimulating questions, evaluation, teacher reflection, and analysis of supporting aspects related to STEAM activities in learning. The interview results are summarized in Table 1.

No	Aspect	Summary of Findings
1.	STEAM Understanding	The majority of teachers defined STEAM as Science, Technology, Engineering, Arts, and Mathematics. However, some teachers were still unable to explain examples of STEAM implementation in early childhood education schools.
2.	Planning	Some teachers have been able to develop lesson plans that involve STEAM activities. However, the exploration of STEAM concepts in the PLTA & PLTS KIT is still limited to specific themes and does not provide contextual examples. Nevertheless, teachers have been able to apply relevant methods to stimulate students' critical thinking skills.
3.	Implementation	Teachers have utilized the hydroelectric and solar power plant (PLTS) kits to their full potential. They facilitate and provide ample learning space for children, enabling optimal stimulation of critical thinking skills. However, teachers still struggle to contextually explore the STEAM concept in relation to renewable energy. All teachers focused on the hydroelectric and solar power plant (PLTS) kits, failing to provide other relevant examples that are familiar to the children. Furthermore, several misconceptions about science concepts were still found.
4.	Trigger Questions	Teachers have been able to provide open questions to stimulate children's critical thinking skills.
5.	Evaluation	Evaluation has been directed at critical thinking skills, however, spontaneous evaluation still dominates, so it has not been documented well and systematically.
6.	Reflection	Reflection is still done informally. Teachers have not yet provided the results of the reflection in a structured document that could later be used as evaluation material.
7.	Support	Teachers are enthusiastic about the new media in schools, but they still need extensive training to truly utilize it optimally in contextual exploration. Furthermore, teachers' scientific literacy needs significant attention to avoid misconceptions in learning.

The interview phase was followed by field observations involving six early childhood education (PAUD) schools, with one school in Madiun Regency and five schools in Madiun City. These schools also served as teaching locations for the teachers involved in the interviews. Previous research indicated that two schools had implemented STEAM-led learning activities (Prastyaningrum et al., 2025). The study then continued to observe the extent to which learning in these schools involved STEAM activities to stimulate 21st-century skills in early childhood. This

study focused on stimulating one skill, critical thinking. This observation was crucial for corroborating the results of the previous interviews.

Observation activities in the research was supported by hydroelectric and solar power generation kits. Both kits serve as learning media that teachers can use to stimulate and explore students' critical thinking skills. Based on field observations, the data obtained are as shown in Table 2.

Table 2. Assessment Results in Field Observation Activities

No	Main Aspect	Observed Items	Score	Category
1.	Planning	Teachers' ability to understand STEAM (Science, Technology, Engineering, Arts, and Mathematics) concepts	78%	Good
		Teachers' ability to design integrated learning activities using a STEAM approach.	75%	Good
		Selection of appropriate learning methods to stimulate critical thinking.	80%	Good
2.	Implementation	The appropriateness of using hydroelectric power plants (PLTA) and solar power plants (PLTS) in lesson plans.	75%	Good
		Teacher creativity in linking material to real-world contexts (renewable energy).	60%	Good Enough
		Teachers' methods of facilitating children's experiments with hydroelectric power plants (PLTA) and solar power plants (PLTS).	84%	Very Good
		Teachers' ability to provide triggering questions (stimulating critical thinking).	82%	Very Good
		Variation of learning activities (discussion, practice, exploration, reflection).	73%	Good
		Classroom management during project-based/experimental activities.	84%	Very Good
		Teachers' ability to use renewable energy-based media/teaching aids.	79%	Good
3.	Evaluation and Reflection	How teachers assess children's critical thinking skills.	84%	Very Good
		Teachers' ability to reflect on learning and identify obstacles.	82%	Very Good
		Using evaluation results to improve future learning.	81%	Very Good

Discussion

Interviews

In-depth interviews were conducted with each teacher teaching in the classroom. The interviews took place before the teachers began teaching activities. The interview results were supported by classroom observations. The purpose of these observations was to provide insights and validate the interviews.

The majority of teachers understood the concept of STEAM. However, some teachers were unable to explain examples of STEAM implementation in early childhood education (PAUD) schools. The challenges faced were primarily related to exploring science, engineering, and art concepts. A lack of understanding among teachers regarding science concepts can lead to misconceptions. Misconceptions significantly impact children's future understanding, therefore, minimizing misconceptions in learning is crucial (Kowalski & Taylor, 2017; Sobah Ch et al., 2019).

The teachers involved in the interviews were also able to develop a STEAM-integrated learning activity plan. They also included discussions about hydroelectric power plants (PLTA) and solar power plants (PLTS) in their activity plans. However, we found that in exploring material related to hydroelectric power plants (PLTA) and solar power plants (PLTS), the teachers were still limited to specific themes. For example, the discussion was limited to water and sunlight as alternative sources of electrical energy. Despite this, the methods used were geared towards stimulating critical thinking skills.

In terms of implementation, the majority of teachers remained focused on the hydroelectric power plants (PLTA) and solar power plants (PLTS) KIT. They failed to provide other relevant examples, especially those familiar to the children. We also found several misconceptions related to the concept of energy. The teachers struggled to explore other examples. This demonstrates that providing scientific knowledge (literacy) to early childhood teachers is an area that requires greater attention. A deep understanding of scientific concepts will foster effective science learning (McConnell et al., 2013).

Regarding critical thinking skills, teachers are inherently equipped to stimulate these skills. Some of the questions they develop are geared toward stimulating these skills. They also understand how the simple projects they give students foster critical thinking skills. They also experienced no significant difficulties utilizing the hydroelectric power plant (PLTA) and solar power plant (PLTS) Kits as learning media for critical thinking skills, and they also experienced no difficulties in providing evaluations, although these were still conducted spontaneously and not yet well documented.

Observations

Based on Table 2, it appears that STEAM activities have begun to be integrated into the learning process. The development of lesson plans has also been integrated with the STEAM approach. Teachers have also been able to utilize the hydroelectric power plant (PLTA) and solar power plant (PLTS) Kits as learning media. Observations revealed that essentially all schools involved in the research had implemented learning activities using the STEAM approach. However, the schools still encountered challenges related to the comprehensive implementation of STEAM, particularly in relation to various contextual issues related to STEAM.

These findings indicate the need for organized and intensive mentoring. This mentoring focused on developing a lesson plan that fully integrates the STEAM approach. Each aspect of STEAM was clearly outlined, complete with contextual examples. This is crucial, given that contextual learning is an effective way to stimulate 21st-century skills (Aydin, 2021) particularly critical thinking skills (Djoehaeni, 2016; Tari & Rosana, 2019).

In addition to contextualization, the preparation of learning activity plans also needs to be supplemented with real-life examples that are familiar to children. This is crucial, as children tend to understand something more easily when it's concrete (Baroody, 2017). Children will more easily understand something they can see, touch, and even experience directly.

Judging from the various findings in this study, it can be concluded that intensive guidance is currently needed in exploring STEAM activities in learning activities that involve contextual phenomena close to children's world. Science guidance is also needed, given the misconceptions about several scientific concepts, which are crucial to eliminate. Guidance in developing more structured evaluation materials also deserves attention. This is intended to ensure that teachers implement a complete package of learning activities with a STEAM approach in each learning activity. This begins with developing a learning activity plan, using contextual yet relevant STEAM-based learning, and providing evaluation materials that can more accurately measure students' abilities and skills.

CONCLUSION

This study concludes that it is crucial to equip early childhood education teachers with a deep understanding of the STEAM approach. Teachers must not only understand the concept but also be able to provide contextual learning, providing other examples that are still relevant but close to the world of children. Furthermore, equipping teachers with an understanding of basic scientific concepts is also crucial to avoid misconceptions in scientific understanding. In this regard, intensive training and mentoring are needed regarding the implementation of learning involving STEAM activities, from preparation, implementation, to the evaluation stage. This study still has several limitations, including the use of renewable energy media, which is still limited to hydropower and solar power. In the future, it can be further developed towards wind power. Furthermore, the number of samples is still very possible to be increased, by expanding the area to several districts around Madiun.

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