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Analysis of PGSD students' perception of the implementation of STEAM in learning literacy and numeracy

Elok Fariha Sari [1*], Yl Sukestiyarno [1], Wiwi Isnaeni [1], Sarwi [1]

[1] Universitas Negeri Semarang, Semarang, Indonesia, 50229

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Abstract

The STEAM approach is closely related to 21st-century skills that accommodate innovation in thinking and skills so as to create superior learning outcomes. This study aims to present the results of a descriptive survey on the application of STEAM in numeracy literacy learning in PGSD students. The method in this study uses a quantitative descriptive method supported by a survey through a questionnaire on *Google Form* and a *WhatsApp Group*. The subjects of this study are 81 PGSD students. The results of the study showed a significant gap in students' perceptions of STEAM implementation, namely that 55.6% of students already understood the STEAM approach; on the other hand, only 34.6% of students in the category agreed to integrate numeracy concepts with STEAM components. Meanwhile, 66.3% of students believe that STEAM can help students develop problem-solving skills in numeracy. It is necessary to strengthen STEAM-based learning to encourage numeracy literacy skills.

* Corresponding Author.
E-mail address: elokfs@students.unnes.ac.id (Elok Fariha Sari)
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1. Introduction

Literacy is a crucial point to measure the competence of today's students who are carrying out learning that is dominated by project learning (Batool & Webber, 2019) Literacy in general is the ability of individuals to read, write, understand, and use information effectively to communicate and solve everyday problems (Moreno-Morilla et al., 2021) One of them is numeracy literacy which is related to understanding and analyzing numerical or quantitative data. Numerical literacy is one of the important components in the development of 21st century skills that emphasizes the ability of individuals to understand, interpret, and use numerical information in various life contexts (Karabulut & Abi, 2022) This ability is not only limited to basic mathematical understanding, but also involves data analysis, problem-solving, and numerical

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information-based decision-making (Claudia, 2022) Numeracy literacy plays a vital role in supporting academic success, career, and social life, especially in the digital era that is increasingly dependent on data and statistics (Simpson et al., 2022) Without adequate numeracy literacy, vulnerable individuals have difficulty managing finances, understanding risks, and adapting to rapid changes in modern society (Doshi et al., 2024)

Numeracy and Literacy in primary school also play an important role in building the foundation of children's cognitive and logical skills from an early age (Lynch et al., 2023)(Maharani & Suwandayani, 2025). These abilities not only help students understand basic mathematical concepts, but also improve the problem-solving and critical thinking skills necessary in daily life (Conica et al., 2023) Students easily analyze data, make simple calculations, and make rational decisions, such as managing time or pocket money (Richards & Islam, 2018) Numeracy skills also support academic achievement in other areas, such as science and technology (Azubuike et al., 2024) Effective numeracy literacy learning at the elementary level will help students grow into individuals who are ready to face future challenges. In line with this, numeracy literacy learning requires moderation and effective media in serving a weighty and quality learning process. An alternative that can be used as a moderation of numeracy literacy is the application of the STEAM approach.

The STEAM (*Science, Technology, Engineering, Arts, Mathematics*) approach is an educational method that combines five disciplines to provide an integrated and relevant learning experience in the real world. The goal is to develop critical and creative skills through interdisciplinary problem-solving and the application of knowledge in the context of daily life. This approach develops from the concept of STEM, with the addition of an element of the Arts that emphasizes creativity and innovation as key to learning (Rodrigues-Silva & Alsina, 2023). STEAM is a response to complex global challenges by combining STEM and the arts to develop interdisciplinary skills. This approach focuses on increasing intellectual curiosity and creative solutions that are socially just, especially in higher education (Carter et al., 2021). STEAM is a transdisciplinary learning process that allows for broad participation in the fields of science and engineering, as well as improving problem-solving skills through project-based inquiry and arts integration (Quigley et al., 2017)

STEAM has distinctive characteristics in its implementation, including interdisciplinary and creative. STEAM emphasizes cross-disciplinary collaboration to encourage students to think holistically. The learning process is not only limited to mastering science or mathematical concepts, but also involves art and design to foster creativity and complex problem-solving abilities (Baek, 2023). Next is 21st Century Skills Development. Skills such as critical thinking, communication, and collaboration are the main focuses. STEAM not only prepares students academically but also to face the challenges of the increasingly complex world of work (Carter et al., 2021). Finally, there is Transdisciplinary vs. Interdisciplinary. The STEAM approach can be applied transdisciplinarily (combining multiple disciplines in an overarching context) or interdisciplinary (connecting two or more disciplines). This allows students to solve real problems with a broad and uncompartmentalized perspective in one particular discipline (Quigley et al., 2017) The STEAM approach is not only applied in primary schools but also in higher education and special education (Lage-Gómez & Ros, 2024) At the elementary school level, students are taught to understand basic concepts through problem-based projects, such as prototyping or simple experiments. At the higher education level, the focus shifts to developing skills relevant to the world of work and interdisciplinary research (Milara et al., 2020; Ramey & Stevens, 2023).

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However, the implementation of STEAM Learning among students is still dynamic and needs refreshment to support their numeracy literacy. The observation results show that students still show hesitation about their understanding of STEAM. They tend to master the process and impact of STEAM, but still do not support Numeracy literacy. Numeracy literacy learning through the STEAM approach is needed in preparing students to face the challenges of the world of work and daily life. Numerical literacy is the ability to understand and apply numerical concepts in real-life situations, which is essential for informed decision-making. When combined with the STEAM approach, this learning becomes more holistic and relevant to modern needs (Lechner et al., 2021).

The STEAM approach, with its interdisciplinary integration, provides an opportunity for students to look at the concept of numeracy not only from a purely mathematical point of view but also in relation to science, technology, art, and engineering (Bell et al., 2023). For example, in STEAM-based projects, students can apply numerical concepts in technical problem-solving or in design projects, which combine elements of creativity from art with a logical understanding of mathematics. This improves their critical and reflective skills. One of the reasons why it is important to apply STEAM in numeracy literacy learning is to help students master 21st-century skills, such as critical thinking, problem-solving, and collaboration (Getenet & Getnet, 2023). Through STEAM, students are also better prepared to face global challenges, where decision-making based on numerical data is indispensable in many modern professions, such as information technology, finance, and engineering (Hornburg et al., 2024).

Previous researches show that about STEAM learning in students, there are several examples of implementation that have been carried out by universities or LPTK. STEAM learning activities must be adjusted to the learning goals to be achieved, and adapting them to the characteristics of each student is a necessity. Several examples of implementation according to previous research, including (Sari et al., 2021), which applied the STEAM model to strengthen students' numeracy literacy. As a result, the application of the STEAM learning model can strengthen students' literacy and positive responses to learning. Furthermore, there is research conducted (Khaerani et al., 2023) on STEAM Learning innovations through AR-based traditional games to strengthen numeracy literacy, aiming to create and test the influence of STEAM-based learning innovations integrated with traditional Bugis-Makassar games and Augmented Reality in enhancing students' numeracy literacy. In line with this, research also presents a STEAM approach in supporting students' numeracy literacy. Students can be assisted in improving numeracy literacy through the use of the STEAM approach in mathematics learning. When STEAM-based learning is used, students' numeracy literacy increases dramatically because it is able to create projects that transform mathematics from a difficult subject to a fun topic.

In the context of numeracy literacy learning, the application of STEAM is very important because it helps students understand mathematical and numerical concepts in depth, as well as hone creativity and critical thinking skills (Alkhatatneh, 2024). A similar statement states that in addition to helping them understand mathematical concepts better, STEAM also hones vital thinking, creativity, and collaboration skills. Numeracy literacy supported by STEAM prepares students to face the challenges of the world of work and play an active role in a knowledge- and technology-based society. Students not only become more academically competent but are also able to contribute to creating innovative solutions to real-world problems (Montero-Izquierdo et al., 2024). While the effectiveness of STEAM has been documented, its success in the classroom depends heavily on teacher readiness and perceptions. To date, few studies have analyzed student teachers' perceptions of their readiness to implement STEAM, particularly in bridging their conceptual understanding with the practical integration of numeracy literacy in the

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classroom. Therefore, research analyzing the perceptions of PGSD students regarding the application of STEAM in numeracy literacy learning is crucial.

2. Method

This study uses a descriptive method with a quantitative approach, which aims to obtain an overview of the perception of PGSD students regarding the implementation of STEAM in numeracy literacy learning in the Elementary School Mathematics Learning Development course. The population in this study was taken from all students of the PGSD Study Program of Semarang State University who had taken classes with STEAM content. This research method uses a survey that takes data through *Google Forms* and *WhatsApp groups*. The research sample consisted of 81 respondents using purposive sampling. The reason for this sampling was that the research focused on analyzing perceptions of STEAM implementation in the context of numeracy learning, so respondents were selected who truly understood this context. The results of data analysis are described quantitatively based on the data obtained. The steps of this research are shown in Figure 1.

Figure 1. Research steps

The results of the data analysis are interpreted with the categories of Very Good, Good, Enough, Less, and Very Less, which are visualized in Table 1.

Table 1. Range of percentage of student perception of STEAM implementation

Interval percentage	Information
85% - 100%	Excellent
75 – 84%	Good
60 – 74%	Enough
40 – 59%	Less
0 – 39%	Very Less

This research instrument consisted of 35 statements using a 5-point Likert scale. Content validation was conducted through assessments by three experts in the fields of elementary education, numeracy literacy, and STEAM learning to assess aspects of relevance, clarity, and construct representation. After revisions based on expert input, the instrument was piloted on 30 PGSD students. The results of the empirical validity test with Pearson Product-Moment correlation showed that 24 items had a calculated r between 0.412 and 0.782, higher than the table r of 0.361 ($\alpha = 0.05$), so that only 24 statement items were declared valid. Furthermore, the reliability test with Cronbach's Alpha produced $\alpha = 0.902$, indicating very high internal consistency. Thus, this instrument was declared valid and reliable for measuring PGSD students' perceptions of STEAM implementation in numeracy literacy learning.

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3. Results

The results of this study were obtained based on questionnaires that had been filled out by respondents who had met the criteria. The respondent criteria are presented in Table 2.

Table 2. Respondent criteria

Class	Learning Experience	Level	Number of students
2022 G		S1	38
2022 J	STEAM Content Course	S1	24
2022 L		S1	19
Total			81

The following is a data analysis of each STEAM indicator from 24 question items that have been validated by STEAM experts and are worthy of being provided to respondents. Furthermore, the level of student perception of STEAM learning is presented in Table 3.

Table 3. Results of analysis of perception of steam learning students on numeracy and literacy learning

STEAM Indicator	Excellent	Good	Enough	Less	Very Less
Understanding STEAM Learning	21%	55.6%	23.5%	0%	0%
Components of the STEAM Approach	13.6%	51.9%	30.9%	3.7%	0%
Relevance of STEAM in Primary Education	28.7%	57.5%	12.5%	1.2%	0%
STEAM improves numeracy literacy	24.7%	63%	12.3%	0%	0%
STEAM involves student activity in numeracy learning	25.9%	60.5%	13.6%	0%	0%
Integration of Numeracy Concepts with STEAM Components	9.9%	34.6%	46.9%	8.6%	0%
PGSD Curriculum Supports STEAM Development	16%	56.8%	25.9%	1.2%	0%

Table 3 above shows that the perceptions of Elementary School Teacher Education (PGSD) students regarding the implementation of the STEAM approach in numeracy literacy learning are positive across most indicators. In general, students demonstrated a good understanding of the concepts and relevance of STEAM to numeracy learning in elementary schools. For the STEAM learning comprehension indicator, 55.6% of respondents were in the Good category, indicating that the majority of students understood the basic concepts and objectives of the STEAM approach. For the STEAM approach component indicators, 51.9% of respondents were in the Good category, 13.6% were in the Very Good category, 30.9% were in the Fair category, and only 3.7% were in the Poor category. Students were able to connect components of science, technology, engineering, art, and mathematics with elementary school subjects.

Furthermore, the STEAM indicator for improving numeracy literacy received the highest scores, with 63% in the Good category and 24.7% in the Very Good category, indicating that students considered STEAM effective in strengthening their numeracy literacy skills. For the STEAM relevance indicator in elementary education, 57.5% were categorized as Good and 28.7% as Very Good, indicating strong confidence in the implementation of STEAM in elementary schools. The indicator of student engagement in numeracy learning through STEAM also received positive responses, with 60.5% categorized as Good and 25.9% as Very Good, reflecting the perception that this approach encourages active and interactive student participation. For the

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indicator of the integration of numeracy concepts with STEAM components, student perceptions were more varied: 9.9% categorized as Very Good, 34.6% as Good, 46.9% as Fair, and 8.6% as Poor, indicating that some students still need further understanding of how to integrate numeracy elements with STEAM dimensions effectively.

Finally, the indicator of support for the Elementary School Teacher Education curriculum for STEAM development showed positive results, with 56.8% of respondents categorizing it as Good and 16% as Very Good. However, 25.9% still rated it Sufficient and 1.2% Poor, indicating that curriculum support still needs to be strengthened, particularly through training and integration of relevant courses. Overall, the study results indicate that elementary school teacher education students have a positive perception of the STEAM approach as a learning strategy capable of developing numeracy literacy skills in elementary schools, although strengthening the integration of numeracy concepts and curriculum support is still needed for optimal implementation.

4. Discussion

The data of the research results revealed the unique and diverse perceptions of students in responding to the application of STEAM to numeracy literacy learning. Students start their understanding of STEAM with a good predicate, because they have the foundation of knowledge obtained from STEAM content courses, such as Curriculum Development, Research Design and Data Analysis to Elementary Education Research. For students to understand and master STEAM learning, they need to follow several effective strategies (Baek et al., 2022). STEAM focuses not only on theory, but also on hands-on involvement and practical application of concepts.

The STEAM approach component indicators show that students relate each component to subjects in elementary school. For example, in the material on getting to know simple fractions, students integrate STEAM components well. Students train themselves with a combination of basic teaching skills and the application of STEAM. Science in STEAM focuses on understanding natural phenomena and the scientific principles that underlie various aspects of life. Students are invited to develop critical and evidence-based thinking skills. This component teaches students how to find answers to questions or problems with scientific methods, such as observation, hypothesis, and data analysis (Singh et al., 2024). Technology involves using digital tools, software, and platforms to solve problems or come up with innovative solutions. Technology helps students understand how science is applied to produce innovations that benefit society (Jeong et al., 2023). The engineering component in STEAM teaches students how to design, build, and test practical solutions to a variety of problems. This engineering process involves creativity, analytical skills, and collaborative work. Engineering learning also emphasizes the importance of iteration, which is the process of trying, evaluating, and improving solutions iteratively (Liu et al., 2024). The addition of the arts in STEM is a key differentiating factor that makes this approach more inclusive and creative. Art in STEAM involves elements of design, aesthetics, and creative expression to encourage innovation. In STEAM learning, mathematics is not only taught as an abstract theory, but it is also applied to understanding patterns, calculating probabilities, and predicting outcomes. A strong understanding of mathematics allows students to more easily work with data, create models, and validate solutions they find in engineering or technology projects (Zhan et al., 2024)

In the STEAM Indicator of increasing numeracy literacy, the facts obtained from student perceptions show that STEAM dominance maintains numeracy literacy with a combination of teaching style, media acquisition, and numeracy evaluation. Previous research has shown an improvement in children's reading and numeracy literacy skills as well as an increase in the

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capacity and skills of partners in providing learning assistance when combined with STEAM (Musa Azhari et al., 2022). Furthermore, there is a study through STEAM learning using Loose Parts material to have a significant influence on the numeracy ability of children aged 5-6 years in group B (Ayu Raniah et al., 2023). Furthermore, research on Literacy and numeracy Assistance through STEAM-based comic worksheets shows that this activity can help improve students' literacy and numeracy skills. This can be seen from the results of the student pre-test, which is in the very poor category (22.00), and the post-test results are in the good category (82.50). The quality of the implementation of activities is also very good because it has an average of 4,765.

Overall, the STEAM Relevance Indicators in Elementary Education show that STEAM is relevant to be implemented in elementary schools in demonstrating numeracy literacy. Each component facilitates every planning and process for students to understand data and facts. STEAM helps elementary school students see the connections between different disciplines. For example, when learning about ecosystems, students can realize scientific aspects (science), create diagrams (art), calculate animal populations (mathematics), and use technology to present their learning outcomes (Duban et al., n.d.) Education in primary school plays an important role in developing problem-solving and critical thinking skills. STEAM offers a variety of project activities that encourage students to seek creative solutions to real problems (Chen & Ding, 2023)

Student perceptions in the STEAM Indicator section involving student activeness in numeracy learning show that the STEAM component encourages and makes it easier for students to control themselves, easily express opinions, and be good at exploring learning information. STEAM learning is responsible for increasing students' learning activity because this approach combines a variety of disciplines that are relevant to real life. STEAM learning often uses project-based learning (PBL), where students are directly involved in projects that require exploration and problem-solving. Students are invited to design solutions from real-world problems, such as creating prototypes of tools or creating interactive artwork (Michael et al., 2023). Because students are given the freedom to explore, they feel more responsible for the learning process and are motivated to be actively involved. STEAM emphasizes the importance of collaboration between students with different backgrounds and interests. Students learn to work in teams to achieve common goals, which encourages them to be more active in communicating and sharing ideas. These collaborations also help them develop social skills, such as leadership and conflict-solving abilities (Khamhaengpol et al., 2024).

The integration indicator for numeracy concepts with STEAM components shows diverse perceptions among PGSD students. Most respondents rated the idea as Sufficient (46.9%) and Good (34.6%), indicating that students still face challenges in integrating numeracy concepts with elements of science, technology, engineering, art, and mathematics. This finding suggests that students' conceptual understanding of cross-disciplinary integration still needs to be strengthened through more applied learning experiences. This is in line with the views of (Rohmah et al., 2025) and (Pelamonia et al., 2025) who emphasize that the implementation of STEAM requires systemic and creative thinking skills to link concepts across fields contextually. In the context of PGSD learning, students need guidance and practice in designing numeracy projects that contain real-life STEAM elements. Therefore, project-based learning strategies and reflection on teaching practices are needed so that prospective teachers are more skilled at integrating numeracy into STEAM activities holistically.

Several courses that support STEAM Development include Curriculum Development courses. This course profile contains. This course discusses the essence and theory, curriculum, principles and foundations of curriculum development, curriculum concept models, curriculum

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design, components in the curriculum development process, curriculum development models, school curriculum development developers and strategies. The substance of the material is contained in STEAM, which supports the pillars of curriculum development in elementary schools. In addition, there is an Elementary Education Research course. The description of the Elementary Education Research course has the content of the material on the essence of educational research, the objectives, scope, characteristics and types of academic research, and the difference between qualitative and quantitative research.

5. Conclusion and implications

This study concludes that PGSD students hold a generally positive perception of the concepts, relevance, and benefits of the STEAM approach in developing numeracy literacy**.** They recognize STEAM as an engaging and effective framework for improving students' mathematical thinking and problem-solving skills in elementary education. However, the findings also reveal a notable gap in students' perceived practical ability to integrate numeracy concepts within STEAM components, particularly in designing interdisciplinary and contextualized learning activities. This discrepancy indicates that students' conceptual understanding of STEAM has not been fully translated into pedagogical competence. Therefore, teacher education institutions must move beyond theoretical exposure to STEAM and focus on project-based, practice-oriented training that directly targets the integration of numeracy within STEAM disciplines. Curriculum developers should embed structured practicum experiences, design-based learning modules, and reflective assessments to bridge the identified gap between understanding and implementation. By doing so, PGSD programs can produce future elementary teachers who are not only conceptually aware of STEAM but also pedagogically ready to apply it effectively in real classroom contexts**.**

Credit authorship contribution statement

First Author: Conceptualization, Methodology, Data Curation, Formal Analysis, Writing – Original Draft. **Second Author:** Supervision, Validation, Methodology, Writing – Review & Editing. **Third Author:** Resources, Project Administration, Writing – Review & Editing. **Last Author:** Funding Acquisition, Supervision, Formal Analysis, Writing – Review & Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical Declaration

All participants provided informed consent prior to their involvement in the study. They were informed about the study's purpose, procedures, and their right to withdraw at any time without consequence.

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