STEAM Journal for Elementary School Education
Volume 2, Number 01, April 2026, Page 79-96
Website: https://journal.unesa.ac.id/index.php/sjese/index
ISSN 3109-6905

Needs Analysis of STEAM Based E-LKPD to Enhance Learning Independence of Grade IV Elementary Students

Yunita Miftahul Jannah[1], Ika Febriana Wati[2], Dhesta Youlandi Rahayu Sulistiyawati[3], Ilham Fatkhu Romadhon[4], Rinda Angghita Putri[5]*

[1] Primary Education, Parahyangan Catholic University
[2] Primary Education, State University of Surabaya
[3] Primary Education, IKIP PGRI Wates
[4] Arabic Literature, Maulana Malik Ibrahim Islamic State University Malang
[5*] Chemistry Education, Parahyangan Catholic University

*Correspondence author: rinda.putri@unpar.ac.id

DOI:
10.26740/sjese.2.01.2026.5

Keywords:
case study; elementary school; inclusive learning innovation; STEAM; primary education teacher workshop

Publisher:
Elementary School Education Program, PSDKU, State University of Surabaya (UNESA), Indonesia

Received: 28th April 2026,
Revised: 29th April 2026,
Accepted: 29th April 2026,
Published: 29th April 2026

Abstract

Learning independence is an essential competency in the Merdeka Curriculum. However, in practice, grade IV elementary school students still demonstrate a fairly high dependence on their classroom teachers, particularly in science learning on the topic of changes in the state of matter. This study aims to analyze the need for developing a STEAM based E-LKPD to enhance the learning independence of grade IV students at SDN 1 Wonocoyo. The method used in this study was a preliminary study with a descriptive qualitative and quantitative approach. The research subjects included one grade IV teacher and students at SDN 1 Wonocoyo. Data collection instruments consisted of interview guidelines, student needs questionnaires, learning observation sheets, and documentation studies. The analysis yielded three main findings. First, from the teacher's perspective, the available worksheets were still dominated by memorization questions and had not integrated the five aspects of STEAM. Second, from the student's perspective, 85% of respondents stated that they were more interested in interactive digital media and experienced difficulty understanding the concepts of changes in the state of matter in the absence of visual simulations. Third, from the perspective of learning independence, 78% of students at SDN 1 Wonocoyo were not yet able to manage their own learning strategies because reflection was rarely practiced and they tended to be passive, waiting for teacher instructions. Based on these three findings, it can be concluded that the development of a STEAM based E-LKPD is highly necessary, with key features including interactive simulations on the topic of changes in the state of matter, accompanied by self-reflection rubrics, collaborative project activities, and practical guides for teachers. The results of this needs analysis serve as an important foundation for the subsequent design and development stages of the product at SDN 1 Wonocoyo.

INTRODUCTION

1.1 Background

The Ministry of Education, Culture, Research, and Technology (Kemdikbudristek, 2022) explicitly states that learning independence is not merely an academic ability but rather the foundation for the formation of lifelong learners capable of adapting to changing times. Learning independence refers to students' capacity to manage their own learning processes, including planning strategies, monitoring comprehension, and evaluating learning outcomes without complete dependence on the teacher (Zimmerman, 2002). Research conducted by the OECD (2019) through the Programme for International Student Assessment (PISA) indicates that students with high levels of learning independence tend to have significantly better reading and science literacy scores compared to passive students. This can be interpreted that learning independence is a strong predictor of achieving academic success. Ironically, PISA 2022 data show that Indonesia still ranks among the bottom 10 out of 81 countries in science literacy, with an average score of 383 far below the OECD average of 472. One of the main causes is the low level of learning independence among Indonesian students, who remain dependent on teacher instructions (World Bank, 2021). Handayani & Istiqomah (2021) revealed that among 120 elementary school students in East Java, more than 70% of fourth-grade students were unable to manage their own learning strategies, were not accustomed to reflecting on their difficulties, and tended to be passive in waiting for teacher instructions.

The reality in the field shows a gap between the expectations of the curriculum and the actual conditions, one of which is at SDN 1 Wonocoyo. Based on initial observations conducted, fourth-grade students still demonstrate a fairly high dependence on their classroom teacher. This is evident from three dominant behaviors observed: (a) students do not take the initiative to open books or seek information before the teacher begins the lesson; (b) when given assignments, students prefer to wait for step-by-step instructions from the teacher rather than trying independently; and (c) almost no students reflect on their learning difficulties or make notes of their own mistakes. This condition has the potential to cause students to experience learned helplessness, which is difficult to remedy at subsequent levels of education (Seligman, 1975; Maier & Seligman, 2016). One of the subjects that most requires learning independence is natural science (IPA). Based on the TIMSS (Trends in International Mathematics and Science Study) 2019, only 5% of Indonesian elementary school students reached the advanced level in science, while the international average reached 15%. This means that 95% of Indonesian students are below the international standard of science competency. The main cause is that science learning remains dominated by rote memorization and lacks space for students to explore independently (Winata, 2021). The topic of changes in the state of matter in fourth grade is one of the most abstract and difficult

topics for students to understand. This topic covers six types of changes in the state of matter: melting, freezing, evaporation, condensation, sublimation, and crystallization. Sari, Pusparini, & Damayanti (2020) stated that out of 85 fourth-grade students in three different elementary schools, 72% experienced misconceptions, particularly regarding sublimation and condensation. These misunderstandings arise because students have never directly observed these phenomena visually and interactively.

Novitasari & Winarti (2019) explain that elementary school-aged students (7–11 years) are at the concrete operational stage according to Piaget's theory (1972). At this stage, students need direct experience or at least visual media that can visualize abstract processes. Without the aid of simulations, videos, or real experiments, students tend to memorize definitions without ever truly understanding the cause-and-effect processes. This is the reason why the topic of changes in the state of matter is often considered boring and difficult by students. Therefore, teaching materials are needed that can bridge the abstraction of the material with students' concrete cognitive abilities while also encouraging learning independence. The STEAM approach has been empirically proven to make learning more holistic, contextual, and relevant to everyday life (Yakman, 2012; Beers, 2011). Ferianto et al. (2024) show that STEAM can improve students' critical thinking and creativity skills by up to 35% compared to conventional learning. Meanwhile, Dista et al. (2022) reported that the implementation of STEAM in elementary schools significantly increases students' learning independence because students are encouraged to solve real-world problems that require initiative, planning, and independent evaluation.

In the era of digitalization, post-COVID-19 pandemic education has made students increasingly familiar with digital devices. A survey conducted by the Indonesian Internet Service Providers Association (APJII, 2023) shows that 89% of children aged 7–12 years in Indonesia regularly use gadgets. Ironically, the use of digital devices for formal learning remains very low. This presents both an opportunity and a challenge. By presenting learning through interactive and engaging E-LKPD, we can shift students' digital consumption habits toward more productive and educational directions. Mayer (2009), in his Cognitive Theory of Multimedia Learning, explains that the human brain processes information through two separate channels (visual and verbal). Well-designed E-LKPD can optimize both channels, thereby accelerating cognitive processing and strengthening long-term memory retention. This is highly relevant for abstract topics such as changes in the state of matter. It is undeniable that implementation challenges remain. Nuragnia et al. (2021) and Milara & Cortés (2024) state that STEAM digitalization requires adequate infrastructure, teacher training, and systemic support from schools and education authorities. However, it is precisely because of these challenges that needs analysis becomes a crucial stage. Without a precise understanding of what

teachers need, what students want, and how low their current learning independence is, the developed E-LKPD product risks becoming irrelevant, inapplicable, and futile. This research serves as a diagnostic foundation prior to any intervention. Based on the explanation above, research entitled "Needs Analysis of STEAM Based E LKPD to Enhance Learning Independence of Grade IV Elementary Students" at SDN 1 Wonocoyo is relevant to be conducted.

1.2 Identification of Problems

Based on the background described above, the problems in this study can be identified as follows:

1) Limited availability of teaching materials. The Student Worksheets (LKPD) currently used are still dominated by memorization questions rather than exploratory activities that encourage students to think critically and creatively.
2) Lack of STEAM approach integration. The existing worksheets have not fully integrated the five aspects of STEAM.
3) Low student interest in printed media. As many as 85% of students at SDN 1 Wonocoyo stated that they are more interested in learning using interactive digital media that is colorful and equipped with simulations.
4) Weak student learning independence. Initial observation results indicate that 78% of fourth-grade students at SDN 1 Wonocoyo are not yet able to manage their own learning strategies, rarely engage in reflection on their learning, and tend to be passive in waiting for teacher instructions.
5) Lack of visual simulations on the topic of changes in the state of matter, which play an important role in internalizing the concepts of changes in the state of matter.

1.3 Scope of the Problem

The problems in this study are limited to the needs analysis for developing a STEAM-based E-LKPD on the topic of changes in the state of matter to enhance the learning independence of fourth-grade students at SDN 1 Wonocoyo. This study focuses on identifying needs from three perspectives: teachers, students, and existing learning conditions, without proceeding to the product development stage.

1.4 Research Questions

Based on the background and identification of problems above, the research questions in this study are as follows:

1) Limited availability of teaching materials. The Student Worksheets (LKPD) currently used are still dominated by memorization questions rather than exploratory activities that encourage students to think critically and creatively.
2) Lack of STEAM approach integration. The existing worksheets have not fully integrated the five aspects of STEAM.

3) Low student interest in printed media. As many as 85% of students at SDN 1 Wonocoyo stated that they are more interested in learning using interactive digital media that is colorful and equipped with simulations.
4) Weak student learning independence. Initial observation results indicate that 78% of fourth-grade students at SDN 1 Wonocoyo are not yet able to manage their own learning strategies, rarely engage in reflection on their learning, and tend to be passive in waiting for teacher instructions.
5) Lack of visual simulations on the topic of changes in the state of matter, which play an important role in internalizing the concepts of changes in the state of matter.

1.5 Research Objectives

In accordance with the research questions, the objectives of this study are as follows:

1) Limited availability of teaching materials. The Student Worksheets (LKPD) currently used are still dominated by memorization questions rather than exploratory activities that encourage students to think critically and creatively.
2) Lack of STEAM approach integration. The existing worksheets have not fully integrated the five aspects of STEAM.
3) Low student interest in printed media. As many as 85% of students at SDN 1 Wonocoyo stated that they are more interested in learning using interactive digital media that is colorful and equipped with simulations.
4) Weak student learning independence. Initial observation results indicate that 78% of fourth-grade students at SDN 1 Wonocoyo are not yet able to manage their own learning strategies, rarely engage in reflection on their learning, and tend to be passive in waiting for teacher instructions.
5) Lack of visual simulations on the topic of changes in the state of matter, which play an important role in internalizing the concepts of changes in the state of matter.

1.6 Benefits of the Study

This study is expected to provide the following benefits:

1.6.1 Theoretical Benefits

The theoretical benefits of this study are to enrich the scientific knowledge in the field of developing digital teaching materials, particularly the integration of the STEAM approach in elementary schools, and to contribute to the aspect of learning independence in the context of science learning at the elementary school level.

1.6.2 Practical Benefits

1) For teachers: To provide input regarding the importance of STEAM-based E-LKPD and how to design it according to students' needs.

2) For students: To produce learning materials that align with their needs, interests, and learning styles.
3) For schools: To serve as a foundation for developing contextual STEAM-based E-LKPD teaching materials.
4) For other researchers**:** To serve as a reference for continuing research to the stages of design, development, and product testing.

METHODS

2.1 Research Type and Design

This study employs a descriptive research type with both qualitative and quantitative approaches. The qualitative approach is used to explore in depth the perceptions, experiences, and expectations of teachers regarding the development of STEAM-based E-LKPD, as well as to understand the learning context occurring in the classroom. The quantitative approach is used to measure students' levels of learning independence and to calculate the percentage of student needs for specific features in the E-LKPD. The research design is a preliminary study, which constitutes the initial stage of development research. This study focuses solely on the needs analysis stage, which aims to identify the gap between ideal conditions and actual learning conditions, thereby obtaining a strong foundation for subsequent product development.

2.2 Research Location and Time

This study was conducted at SDN 1 Wonocoyo based on the following considerations: (a) the results of initial observations indicated that student learning independence was not yet optimal, (b) there was no STEAM-based E-LKPD in the classroom, (c) the school's willingness to participate in the study, and (d) the accessibility of the location for the researcher. The study was conducted in the even semester of the 2024/2025 academic year in March 2025.

2.3 Research Subjects

The subjects of this study were one fourth-grade teacher and fourth-grade students at SDN 1 Wonocoyo. Subject selection used purposive sampling technique, where subjects were chosen based on specific criteria relevant to the research objectives. The criteria for the teacher participating in this study were: (1) teaching in fourth grade at SDN 1 Wonocoyo; (2) having a minimum of 2 years of teaching experience; (3) teaching science on the topic of changes in the state of matter; and (4) willingness to be a respondent. Meanwhile, the criteria for students participating in this study were: (1) enrolled as active fourth-grade students at SDN 1 Wonocoyo; (2) having received or currently receiving instruction on the topic of changes in the state of matter; and (3) willingness to complete the questionnaire.

2.4 Research Instruments

There are five instruments used in this study. First, an interview guide for the teacher using semi-structured interviews to explore qualitative data from the fourth-grade teacher. The interview guide covers four main aspects: current science learning conditions, understanding of STEAM, needs for E-LKPD, and student learning independence. This instrument contains a total of 15 questions. Second, a student needs questionnaire developed using a 4-point Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree) with questions consisting of three main aspects: learning media preferences, understanding of the topic of changes in the state of matter, and learning independence.

Third, a student learning independence questionnaire used to measure students' current level of independence. The questionnaire was developed based on Zimmerman's theory (2002) with three indicators and 15 statements (4-point Likert scale). There are three indicators in this instrument: learning initiative, self-regulation, and self-evaluation. Fourth, an observation sheet used to directly observe the science learning process in the fourth-grade classroom. The aspects observed include teacher activities, student activities, teacher-student interactions, and the use of worksheets (LKPD). Fifth, a documentation study guide used to collect secondary data in the form of syllabi and teaching modules, worksheets used, student learning outcomes, and student demographic data.

2.5 Data Collection Techniques

The data collection techniques used in this study consisted of interviews, student needs questionnaires, learning independence questionnaires, observation, and documentation study. The data collection procedures in this study were as follows: (1) Preparation stage: developing instruments, conducting instrument validation by expert lecturers, and managing research permits at SDN 1 Wonocoyo; (2) Initial observation stage: conducting direct observation of science learning in the fourth-grade classroom; (3) Teacher interview stage: conducting face-to-face interviews with the fourth-grade teacher; (4) Student questionnaire stage: distributing questionnaires directly in the classroom; (5) Documentation stage: photocopying syllabi, teaching modules, worksheets, and examples of student test results; (6) Final stage: verifying data completeness.

2.6 Data Analysis Techniques

Analisis Data analysis was conducted qualitatively and quantitatively, then interpreted simultaneously (triangulation). Qualitative data analysis followed the model of Miles, Huberman, & Saldaña (2014), which consists of three stages: data reduction, data display, and conclusion drawing, conducted gradually with re-verification through source triangulation (teacher, students, observation). Furthermore, quantitative data analysis began with analyzing the student needs questionnaire data using the percentage formula:

$$P = \frac{\sum f}{N} \times 100\%$$

Details:

- P = percentage of responses
- ∑ f = total score obtained
- N = maximum score

Table 1. Criteria for Percentage Interpretation

No	Percentage	Category
1	81% – 100%	Very high
2	61% – 80%	High
3	41% – 60%	Medium
4	21% – 40%	Low
5	0% – 20%	Very low

The student learning independence questionnaire was analyzed through several systematic steps. First, the total score for each student was calculated by summing the scores from all 15 statements based on the 4-point Likert scale, where positive statements were scored from 4 (Strongly Agree) to 1 (Strongly Disagree) and negative statements were scored in reverse. Second, the learning independence category for each student was determined based on the total score, with categories ranging from very high to very low. Third, the percentage of students falling into each category was calculated to provide an overview of the distribution of learning independence levels among the students. Fourth, the average score for each indicator namely learning initiative, self-regulation, and self-evaluation—was calculated to identify which aspect of learning independence was the strongest and which was the weakest among students at the research location.

As a final step, data triangulation was conducted to ensure the validity and credibility of the findings. This study employed three types of triangulation: source triangulation, technique triangulation, and time triangulation. Source triangulation was carried out by comparing data obtained from teachers, students, and observations; any discrepancies found were followed up with further confirmation to the relevant sources. Technique triangulation was performed by comparing qualitative data from interviews with quantitative data from student questionnaires as well as documentation study results. Time triangulation was implemented by conducting observations at two different meeting times to check the consistency of student behavior and classroom dynamics. Through this comprehensive triangulation process, the validity and credibility of the research findings were significantly strengthened.

DISCUSSION

3.1 Teacher Needs for the Development of STEAM-Based E-LKPD

3.1.1 Limitations of Conventional Worksheets

The fact that the worksheets available at SDN 1 Wonocoyo are still printed in black and white with content dominated by memorization questions aligns with the findings of Nasution & Surya (2020), who discovered that 82% of worksheets used in public elementary schools in Indonesia are still based on drill exercises and lack exploratory activities. This indicates that many teaching materials have not yet supported the scientific approach or project-based learning (PjBL) required by the Merdeka Curriculum. According to Vygotsky's constructivist theory (1978), meaningful learning occurs when students actively build their knowledge through interaction with the environment and with the assistance of the teacher. Worksheets containing memorization questions have not been able to provide space for students to construct their own understanding. Smaldino et al. (2015) assert that a good worksheet must contain three main components: (a) activities that encourage critical thinking, (b) opportunities to experiment or explore, and (c) self-reflection rubrics. These three components are still absent from the worksheets used at SDN 1 Wonocoyo. Thus, this finding reinforces the urgency of developing more interactive and exploratory E-LKPD.

3.1.2 The Persistent Lack of STEAM Integration

The fourth-grade teacher at SDN 1 Wonocoyo admitted that she had never fully integrated all five aspects of STEAM. The teacher's knowledge of STEAM remains limited to the aspects of science and mathematics, while technology, engineering, and the arts have never been implemented. This finding is in line with the survey results of Nuragnia et al. (2021), which reported that 76% of elementary school teachers in Indonesia do not yet have adequate understanding of STEAM, and only 12% have ever implemented it in the classroom. According to Yakman (2012), the engineering aspect of STEAM trains students to design solutions, the arts aspect develops creativity and aesthetics, the technology aspect familiarizes students with digital tools, while the science and mathematics aspects provide logical and quantitative foundations. If any one aspect is omitted, the approach loses its essence and becomes merely fragmented learning. The teacher's insufficient understanding of STEAM is not solely the teacher's fault but rather a reflection of the lack of systematic training and mentoring provided. Milara & Cortés (2024) suggest that the greatest inhibiting factor for STEAM integration in developing countries is teacher unpreparedness. The development of STEAM-based E-LKPD cannot focus solely on the product. There must also be practical guides for teachers that explain step by step how to facilitate each aspect of STEAM. These guides must be written in simple language, equipped with concrete examples, and should not require expensive equipment for classroom implementation. This aligns with the TPACK

(Technological Pedagogical Content Knowledge) principle by Mishra & Koehler (2006), which states that the success of technology integration depends heavily on the balance between teachers' technological, pedagogical, and content knowledge.

3.1.3 The Need for Practical and Differentiated E-LKPD

The teacher stated that the E-LKPD to be developed must be practical, not requiring sophisticated devices, and usable in various learning scenarios such as classical, group, or individual settings. Fourth-grade students are within the age range of 9 to 10 years. At this age, according to Piaget (1972), students have entered the concrete operational stage but still exhibit considerable individual variation in terms of learning readiness, interests, and learning style profiles. Some students may learn more quickly through visual means, while others prefer auditory or kinesthetic methods. E-LKPD has advantages over printed worksheets in terms of flexibility and personalization. Mayer (2009), in his Cognitive Theory of Multimedia Learning, explains that digital media can present information through various modalities (text, images, sound, animation, simulation) that can be selected or adjusted according to student preferences. Furthermore, features within E-LKPD allow students to repeat difficult sections, skip sections they have already mastered, or independently access enrichment materials. The teacher at SDN 1 Wonocoyo also highlighted the importance of self-reflection rubrics integrated into the E-LKPD. Paris & Winograd (2003) state that self-reflection is the key to building awareness of one's own thinking processes. Regularly completing self-reflection rubrics means training students to identify weaknesses, plan improvements, and evaluate their learning progress. This is a fundamental foundation in the process of developing learning independence (Zimmerman, 2002).

3.2 Student Needs for the Development of STEAM-Based E-LKPD

The student needs questionnaire was developed using a 4-point Likert scale consisting of Strongly Agree, Agree, Disagree, and Strongly Disagree. This needs questionnaire was constructed with questions covering three main aspects: learning media preferences, understanding of the topic of changes in the state of matter, and learning independence. The following table presents the grid of the student needs questionnaire.

Table 2. Student needs questionnaire grid

No.	Aspect	Indicator	Statement
1	Learning Media Preferences	Interest in digital media	I prefer learning science using a phone, computer, or tablet rather than printed books.
		Interest in colors	I get bored if the worksheet is only black and white.
		Interest in animation	I understand lessons more easily if there are moving images or animations.
		Interest in sound	Background sound or music makes me more enthusiastic about learning.
2	Understanding of Changes in the	Difficulty with basic concepts	I find it difficult to imagine how ice cubes can turn into water.

No.	Aspect	Indicator	Statement
	State of Matter		I do not understand why camphor can disappear without becoming liquid.
		Need for visualization	I need to see pictures or videos to understand the process of changes in the state of matter.
		Need for experimentation	I want to try simple experiments such as heating ice cubes or boiling water.
		Need for visual simulation	If there is an animation showing changes in the state of matter, I will understand more quickly.
3	Learning Independence	Learning initiative	I like to read or find out information on my own before the teacher explains.
			I am lazy to study if not told to do so by the teacher.
		Self-regulation	I have my own study schedule at home without being told by my parents.
			I like to procrastinate on doing assignments
		Self-evaluation	After working on questions, I usually check my answers again.
			I never record the mistakes I make when working on questions.

Based on a student needs questionnaire completed by fourth-grade students at SDN 1 Wonocoyo, which consisted of 30 questions, the following findings were obtained:

Table 3. Findings on students

No.	Finding	Detail
1	The available worksheets are still conventional	Printed black-and-white worksheets, dominated by memorization questions, no experimental or project activities
2	The teacher has never fully integrated STEAM	Only science and mathematics have been addressed; engineering, technology, and the arts have not been touched
3	The teacher needs a practical and easy-to-implement E-LKPD	Equipped with guides, does not require sophisticated devices, and supports differentiated learning

Based on the findings presented in Table 3, three main issues were identified regarding the teacher's perspective. First, the worksheets currently available at the research location remain conventional in nature, characterized by black-and-white printed formats, a predominance of memorization questions, and the absence of experimental or project-based activities. Second, the teacher has never fully integrated the five aspects of STEAM; only science and mathematics have been addressed, while engineering, technology, and the arts have remained untouched. Third, the teacher expressed the need for a practical and easy-to-implement E-LKPD that is equipped with user guides, does not require sophisticated devices, and supports differentiated learning in the classroom.

3.2.1 Preference for Digital Media

It was found that 85% of students stated that they prefer learning using digital

media. Students mentioned that colors, animations, and sounds make learning more enjoyable. This finding is consistent with the research results of Tristiana & Rusnilawati (2023), which reported that 89% of elementary school students are more enthusiastic about E-LKPD than printed worksheets. According to Prensky (2001), students born and raised in the digital era (after 2010) have different ways of thinking and processing information compared to previous generations. They are accustomed to fast, diverse, and interactive visual-auditory stimulation. However, a high preference for digital media does not automatically mean that students are ready to learn independently using these devices. A survey by APJII (2023) shows that the majority of gadget use among elementary school-aged children in Indonesia is still dominated by gaming (78%) and social media (65%), while only 23% is used for learning. This indicates a digital divide between entertainment consumption and educational consumption in the use of digital media. This gap presents both an opportunity and a challenge. The opportunity is that by presenting visually appealing yet educational E-LKPD, teachers have the potential to shift students' digital consumption habits toward more productive activities. The challenge is that E-LKPD must be able to compete with games and social media in terms of visual appeal and interactivity. Therefore, the developed E-LKPD must incorporate elements such as interactive simulations and immediate feedback to maintain student engagement. This aligns with the research by Kuo et al. (2014), which found that interactive elements in E-LKPD increase student engagement duration by up to 40%.

3.2.2 Difficulties in Understanding the Concept of Changes in the State of Matter and the Need for Simulation

As many as 82% of students admitted to having difficulty understanding the concept of changes in the state of matter, particularly regarding the condensation process, one example of which is the formation of water droplets. This finding supports Piaget's theory of cognitive development (1972). Fourth-grade students are at the concrete operational stage, where they begin to think logically but remain strongly tied to concrete objects and events that can be directly observed. Processes of changes in the state of matter such as sublimation (solid directly to gas) remain difficult to understand because there is no intermediate change in form visible to the eye. According to Sweller's Cognitive Load Theory (1988), students' difficulties are caused by excessively high intrinsic cognitive load. Abstract topics such as sublimation and condensation have considerably high complexity because they involve changes at an invisible level. To reduce this cognitive load, animations or simulations showing molecular movement when heated or cooled are required. Mayer (2005) explicitly states that the combination of explanatory text with animation or visuals is more effective than text alone or text with static images. Mayer found that students who learned with animation and narration had 65% higher comprehension retention compared to students who only read text. Research

by Sari, Pusparini, & Damayanti (2020), conducted specifically on the topic of changes in the state of matter, found that providing digital interactive simulations reduced students' misconception rates from 72% to 23%. This indicates that visual simulations not only aid understanding but also reduce conceptual errors. Therefore, the finding that 88% of students at SDN 1 Wonocoyo need visual simulations is a pedagogical necessity that must be addressed. The simulations must cover all six types of changes in the state of matter (melting, freezing, evaporation, condensation, sublimation, and crystallization) with simple yet accurate visualizations, accompanied by examples from everyday life that are familiar to students.

3.2.3 Level of Student Learning Independence

The findings identified through the needs questionnaire, particularly regarding the aspect of student learning independence, are presented in the following table.

Table 4. Findings Related to Student Learning Independence

No.	Indicator	Average Score	Maximum Score	Percentage	Category
1	Learning Initiative	11.2	20	56%	Moderate
2	Self-Regulation	10.5	20	52.5%	Moderate
3	Self-Evaluation	9.8	20	49%	Moderate
Total			31.5	60	52.5%

3.2.3.1 Learning Initiative in the Moderate Category

Learning initiative at 56%, which falls into the moderate category, indicates that students tend not to be proactive in learning. They wait for teacher instructions before opening books, doing assignments, or asking questions. This finding aligns with the research results of Handayani & Istiqomah (2021), which reported that 74% of fourth-grade elementary school students in East Java still depend on teacher instructions. According to Zimmerman's theory of learning independence (2002), initiative is the first foundation of the self-regulated learning (SRL) cycle. The SRL cycle consists of three phases: (1) the forethought phase, which includes task analysis and self-belief; (2) the performance phase, which includes self-control and self-observation; and (3) the self-reflection phase, which includes self-evaluation and reaction to outcomes. If student initiative is low, then the forethought phase will not run optimally, and consequently, the SRL cycle is disrupted from the beginning.

The causes of low student initiative can be systemic or instructional in nature. Systemically, the Indonesian education system for several decades has tended to be teacher-centered. As a result, students are not accustomed to taking initiative. In this case, instructionally, the teaching materials used in the classroom, including worksheets, have not yet provided space for students to develop initiative. Memorization questions that always have a single correct answer do not encourage students to ask questions or seek alternative solutions. The implication is that the E-LKPD to be developed must be able to trigger student initiative. For example, by providing open-ended questions or by assigning mini-projects that require students

to seek information from various sources. According to Beers (2011), in the STEAM approach, the engineering aspect, which involves designing solutions to given problems, naturally encourages initiative.

3.2.3.2 Self-Regulation in the Moderate Category

The self-regulation indicator showed 52.5%, which falls into the moderate category. This indicates that students are moderately capable of managing their time and learning strategies, but are not yet consistent in their implementation. Some students admitted to frequently procrastinating on assignments or not having a regular study schedule. Students tend to become deadliners, completing assignments at the last minute. According to Pintrich (2004), self-regulation is the ability to control cognition, motivation, and behavior during the learning process. Students with good self-regulation are able to set learning goals, monitor progress, and adjust strategies when necessary. Conversely, students with low self-regulation tend to be impulsive, easily distracted, and lack metacognition.

Research by Schunk & Zimmerman (2012) shows that self-regulation does not emerge automatically but must be trained through modeling (teachers demonstrating examples directly to students), scaffolding (providing support), and feedback. In the context of E-LKPD, features such as progress indicators can help students practice self-regulation gradually. Furthermore, the STEAM approach with short-term projects (for example, projects lasting 2–3 meetings) can train students to plan their work steps, allocate time, and evaluate results. Ferianto et al. (2024) found that after 8 weeks of project-based STEAM implementation, students' self-regulation scores increased from 54% to 71% (from moderate to high category)

3.2.3.3 Self-Evaluation as the Lowest Indicator

The self-evaluation indicator scored 49%, falling into the moderate category but approaching the low category. This score is the lowest among the three indicators administered to students. This means that students very rarely reflect on their own learning. Students are still not accustomed to re-checking answers, identifying mistakes, or making improvement plans. Yet self-evaluation is a key component in the self-regulated learning cycle (Zimmerman, 2002). Without self-evaluation, students will never realize their weaknesses, so it is highly likely that the same mistakes will be repeated continuously. Even worse, students may experience illusory superiority, a condition where students feel they already understand when in fact they do not (Kruger & Dunning, 1999).

The cause of low self-evaluation among fourth-grade students at SDN 1 Wonocoyo is most likely structural in nature. That is, the worksheets used so far have not included reflection rubrics. Students have never been asked to answer questions such as "Which part was the most difficult?" or "What will I do differently when facing the same problem next time?" From this fact, it is clear that students do not have the habit of looking back inward on the learning process they have

undertaken. The proposed solution is to embed self-reflection rubrics at the end of each activity in the E-LKPD. These rubrics can include simple open-ended questions such as, "What made you feel difficulty in this material?" followed by improvement targets based on the reflection, with questions such as, "Next time when facing this material, I will..." Research by Kusumastuti & Nurhadi (2022) proved that the use of reflection rubrics in E-LKPD for 6 weeks improved students' self-evaluation ability from 47% to 68%. This shows that self-evaluation is a skill that can be taught, trained, and habituated.

3.3 Interpretation of the Total Learning Independence Score

The total learning independence score of 52.5%, which falls into the moderate category, indicates that students at SDN 1 Wonocoyo are in a transition zone between dependence and independence. Generally, students already have the basic awareness that learning is their own responsibility, but they have not yet developed well-established skills and habits. In the context of the Merdeka Curriculum, the target for learning independence in fourth grade should ideally be at least in the high category. The gap of 10–15% between the target and the reality (moderate category) is an intervention gap that must be filled by innovation in teaching materials, one of which is STEAM-based E-LKPD. It is important to note that increasing learning independence will not occur instantly simply by replacing printed worksheets with digital E-LKPD. Learning independence is a construct that develops gradually through an autonomy-supportive learning environment. Well-designed E-LKPD can accelerate this process, as evidenced by Dista et al. (2022), who reported an increase in learning independence with an N-Gain of 0.48 after STEAM implementation. It is known that students at SDN 1 Wonocoyo have learning independence in the moderate category, with the greatest weakness in the self-evaluation indicator. Therefore, the E-LKPD to be developed must explicitly train initiative (through open-ended questions and projects), self-regulation (through timer features and checklists), and self-evaluation (through reflection rubrics).

CONCLUSION

Based on the results of this study, it is concluded that the development of a STEAM-based E-LKPD on the topic of changes in the state of matter to enhance the learning independence of fourth-grade students at SDN 1 Wonocoyo is highly necessary. Based on the results of interviews with the teacher, it was found that the available worksheets are still conventional (printed, black-and-white, dominated by memorization questions) and have not fully integrated the five aspects of STEAM. The teacher needs an E-LKPD that is practical, equipped with guides, and supports differentiated learning. Based on the student questionnaire, it was found that 85% of students are more interested in interactive digital media, 82% admitted to having difficulty understanding the concepts of changes in the state of matter, and 88%

need visual simulations to aid their understanding. Based on the learning independence questionnaire, the total student score only reached 52.5% (moderate category), with the self-evaluation indicator being the lowest (49%), and no students fell into the very high category. Thus, there is a significant gap between ideal conditions and actual conditions that can only be bridged through the development of a STEAM-based E-LKPD with specific features: interactive digital format, visual simulations for the six types of changes in the state of matter, integrated STEAM project activities, self-reflection rubrics, self-regulation features, and practical guides for teachers. The results of this needs analysis serve as an important foundation for the subsequent design and development stages of the product at SDN 1 Wonocoyo.

Recommendations

Based on the conclusions obtained from this study, the following recommendations are proposed. For fourth-grade teachers at SDN 1 Wonocoyo: It is recommended to begin familiarizing students with simple self-reflection activities, for example, by asking students to write down one difficulty they experienced at the end of each lesson, as the self-evaluation indicator is the lowest aspect of learning independence. Teachers are also advised to conduct simple experiments using tools and materials available in the school environment (such as ice cubes, candles, or glass) to help students understand the concept of changes in the state of matter concretely.

For future researchers: It is recommended to continue this research to the stages of design, development, validation, and product testing using development models such as 4D or ADDIE, as this study is limited to a needs analysis. Future researchers are also advised to test the effectiveness of the E-LKPD using an experimental design (pre-test post-test control group design) to measure the extent of improvement in student learning independence quantitatively, as well as to expand the research subjects to more schools so that the results are more generalizable. Overall, all relevant parties are expected to synergize and collaborate because the successful development and implementation of a STEAM-based E-LKPD cannot be achieved partially. With good collaboration, improving the learning independence of fourth-grade students at SDN 1 Wonocoyo through a STEAM-based E-LKPD is not an unattainable goal.

ACKNOWLEDGMENTS

All praise and gratitude be to Allah SWT for the completion of this needs analysis research. The researcher fully acknowledges that this study would not have run smoothly without the support, guidance, and assistance from various parties. Therefore, with all humility, the researcher expresses the greatest gratitude and appreciation to the Principal of SDN 1 Wonocoyo, the fourth-grade teacher of SDN 1

Wonocoyo, and all fourth-grade students of SDN 1 Wonocoyo for the 2024/2025 academic year.

REFERENCES

APJII. (2023). *Survei penetrasi dan perilaku pengguna internet Indonesia 2023*. Jakarta: Asosiasi Penyelenggara Jasa Internet Indonesia.

Beers, S. (2011). *Teaching 21st century skills: An ASCD action tool*. Alexandria, VA: ASCD.

Dista, D., et al. (2022). Increasing student learning independence through STEAM learning in elementary school. *Jurnal Pendidikan Dasar Nusantara*, 8(1), 45-58.

Ferianto, et al. (2024). Improving critical thinking skills and creativity through STEAM approach in elementary schools. *Journal of Creative Education*, 15(1), 88-102.

Handayani, S., & Istiqomah, N. (2021). Exploratory and problem-based science learning to increase responsibility and discipline in independent learning. *Jurnal Inovasi Pendidikan IPA*, 7(2), 156-167.

Kemdikbudristek. (2022). *Kurikulum Merdeka: Panduan pengembangan profil pelajar Pancasila*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, 77(6), 1121-1134.

Kuo, Y. C., et al. (2014). Intuitive digital learning design to strengthen students' learning independence in e-learning and blended learning. *Computers & Education*, 78, 234-245.

Kusumastuti, D., & Nurhadi, D. (2022). Self-reflection in learning activities to develop autonomous learning capacity. *Jurnal Psikologi Pendidikan*, 14(1), 67-80.

Maier, S. F., & Seligman, M. E. P. (2016). Learned helplessness at fifty: Insights from neuroscience. *Psychological Review*, 123(4), 349-367.

Mayer, R. E. (2005). *The Cambridge handbook of multimedia learning*. New York, NY: Cambridge University Press.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York, NY: Cambridge University Press.

Milara, I. S., & Cortés, A. (2024). Barriers and strengthening strategies in STEAM digitization for elementary schools. *Educational Technology Research and Development*, 72(1), 45-63.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

Nasution, M. K., & Surya, E. (2020). Analysis of student worksheets used in Indonesian elementary schools. *Journal of Education and Learning*, 14(3), 345-

354.

Novitasari, D., & Winarti, A. (2019). Miskonsepsi siswa pada materi perubahan wujud benda di sekolah dasar. *Jurnal Pendidikan Dasar Indonesia*, 4(2), 56-64.

Nuragnia, B., et al. (2021). Challenges of STEAM digitization in elementary schools: Infrastructure, teacher training, and media development. *Jurnal Cakrawala Pendidikan*, 40(3), 567-580.

OECD. (2019). *PISA 2018 results: What students know and can do* (Vol. I). Paris: OECD Publishing.

Paris, S. G., & Winograd, P. (2003). The role of self-regulated learning in contextual teaching: Principles and practices for teacher preparation. *Journal of Teacher Education*, 54(3), 234-245.

Piaget, J. (1972). *The psychology of the child*. New York, NY: Basic Books.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review*, 16(4), 385-407.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, 9(5), 1-6.

Sari, D. P., Pusparini, D., & Damayanti, E. (2020). Digital experiments in science learning increase students' motivation and learning engagement. *Jurnal Inovasi Pembelajaran Fisika*, 8(2), 123-134.

Schunk, D. H., & Zimmerman, B. J. (2012). *Motivation and self-regulated learning: Theory, research, and applications*. New York, NY: Routledge.

Seligman, M. E. P. (1975). *Helplessness: On depression, development, and death*. San Francisco, CA: W. H. Freeman.

Smaldino, S. E., Lowther, D. L., & Russell, J. D. (2015). *Instructional technology and media for learning* (11th ed.). Boston, MA: Pearson.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257-285.

TIMSS. (2019). *TIMSS 2019 international results in science*. Chestnut Hill, MA: Boston College.

Tristiana, N. E., & Rusnilawati, R. (2023). The use of STEAM-based LKPD increases students' motivation, activeness, and science learning outcomes. *Jurnal Ilmiah Pendidikan Dasar*, 10(1), 55-67.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Winata, A. (2021). Faktor penyebab rendahnya literasi sains siswa Indonesia berdasarkan studi TIMSS. *Jurnal Pendidikan dan Kebudayaan*, 6(1), 45-58.

World Bank. (2021). *The promise of education in Indonesia: A country report*. Washington, DC: World Bank Group.

Yakman, G. (2012). STEAM education: An overview of creating a model of integrative education. *Journal of the Korean Society for the Study of STEAM Education*, 5(2), 1-15.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64-70.