Inovasi Kurikulum *- p-ISSN 1829-6750 & e-ISSN 2798-1363*
Volume 21 No 4 (2024) 2243-2262

Inovasi Kurikulum
https://ejournal.upi.edu/index.php/JIK

Developing STEM-based LKPD to improve student's critical thinking abilities

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ABSTRACT

Students' critical thinking skills in science learning remain low due to suboptimal teaching approaches. This study aims to develop and assess the feasibility, practicality, and effectiveness of STEM-based student worksheets (LKPD) on the life cycle topic for fourth-grade students at SDN 064027 Karang Sari. The research employed a Research and Development (R&D) approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. Data collection methods included observations, interviews, and tests, while data analysis was conducted through expert validation, practicality tests, and effectiveness evaluations. The results showed that the STEM-based LKPD is feasible, practical for classroom implementation, and effective in enhancing students' critical thinking skills. The LKPD supports active learning and fosters 21st-century skills such as critical thinking, creativity, collaboration, and communication. The STEM approach provides meaningful learning experiences by integrating science, technology, engineering, and mathematics, enabling students to relate learning concepts to real-life contexts. This study recommends the STEM-based LKPD as an innovative alternative for science education, particularly for the life cycle topic, to enhance students' critical thinking skills and conceptual understanding.

ARTICLE INFO

Article History:
Received: 22 Aug 2024
Revised: 20 Nov 2024
Accepted: 22 Nov 2024
Available online: 28 Nov 2024
Publish: 29 Nov 2024

Keyword:
critical thinking; LKPD; STEM

Open access
Inovasi Kurikulum is a peer-reviewed open-access journal.

ABSTRAK

Kemampuan berpikir kritis peserta didik dalam pembelajaran IPA masih rendah akibat pendekatan pembelajaran yang belum optimal. Penelitian ini bertujuan mengembangkan dan menguji kelayakan, kepraktisan, serta keefektifan Lembar Kerja Peserta Didik (LKPD) berbasis STEM pada materi daur hidup untuk peserta didik kelas IV di SDN 064027 Karang Sari. Penelitian menggunakan pendekatan Research and Development (R&D) dengan model ADDIE yang terdiri dari tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Teknik pengumpulan data meliputi observasi, wawancara, dan tes, sedangkan analisis data dilakukan melalui validasi ahli, uji kepraktisan, dan uji keefektifan. Hasil penelitian menunjukkan bahwa LKPD berbasis STEM layak digunakan dalam pembelajaran, praktis diterapkan, dan efektif meningkatkan kemampuan berpikir kritis peserta didik. LKPD ini dirancang untuk mendukung pembelajaran aktif, berorientasi pada pengembangan keterampilan abad ke-21, seperti berpikir kritis, kreativitas, kolaborasi, dan komunikasi. Pendekatan STEM memberikan pengalaman belajar yang bermakna melalui integrasi sains, teknologi, rekayasa, dan matematika, sehingga peserta didik dapat mengaitkan konsep pembelajaran dengan kehidupan sehari-hari. Penelitian ini merekomendasikan penggunaan LKPD berbasis STEM sebagai alternatif inovatif dalam pembelajaran IPA, khususnya pada materi daur hidup, untuk membantu peserta didik meningkatkan keterampilan berpikir kritis dan pemahaman konseptual.

Kata Kunci: Berpikir kritis; LKPD; STEM.

How to cite (APA 7)
Milala, K. N. B., Harahap, F., & Hasruddin, H. (2024). Developing STEM-based LKPD to improve student's critical thinking abilities. *Inovasi Kurikulum, 21*(4), 2243-2262.

Peer review
This article has been peer-reviewed through the journal's standard double-blind peer review, where both the reviewers and authors are anonymised during review.

https://doi.org/10.17509/jik.v21i4.74743

INTRODUCTION

The 21st century is a period of rapid development in science and technology. The development of the world in the era of globalisation today is marked by the widespread use of information and communication technology in various aspects of life. This development will also impact all aspects of life worldwide, particularly in the educational sector. Students need 21st-century skills, which are abbreviated as 4C, namely: critical thinking, collaboration, creativity, and communication (Sanjayanti et al., 2020). Preparing students in the 21st century is crucial for integrating 21st-century skills into an effective learning process (Trisnawati & Sari, 2019). The term learning embodies the essence of planning or designing as an effort to teach students. Learning is a method that involves acquiring information and understanding through conscious learning exercises, which positively impact a person, resulting in the emergence of new skills, abilities, and knowledge (Magrizos et al., 2021).

The learning process is carried out actively by both teachers and students, and it is creative in developing learning activities that can lead to positive change and provide meaningful learning experiences. A meaningful learning experience occurs when students actively participate in learning activities (Marliani et al., 2021). Incorporating active learning will help students develop the 4C competencies and skills necessary in the 21st century. In the 21st century, critical thinking is one of the most important aspects for students. Critical thinking is an intellectual process that involves formulating concepts, synthesising information, and assessing data obtained from research results, experience, reflection, and communication, as a basis for acting (Dolapcioglu & Doğanay, 2022).

Critical thinking skills can be built through learning that actively involves students (Putri et al., 2020). Critical thinking skills can be developed through school learning, particularly in science or natural science classes. Science subjects are generally considered interesting, supported by the rapid development of science and technology today, which increasingly positions science as one of the most important subjects (Adhiati et al., 2023). The skills students need in science learning include problem-solving, enabling them to think critically and creatively when solving problems. Science learning should be carried out naturally to foster the ability to think, work, and behave scientifically, and communicate these skills effectively (Fithri et al., 2021). Process skills for applying science in everyday life are also one of the two main components in science learning in the Kurikulum Merdeka.

The results of observations and interviews before the study of students and teachers in the learning process at SDN 064027 Karang Sari, it was seen that students had low critical thinking skills, the discussion process regarding problem solving still seemed passive, the results of observations also showed that at SDN 064027 Karang Sari the results of students' critical thinking skills were less than 70 by 73%, getting a score of 70 by 19.23%, and getting a score above 70 was only two students with a percentage of 7.69%. The low critical thinking skills were caused by the learning process focusing only on material memorisation of concepts, and students did not participate optimally in practicums. As a result, students were not allowed to analyse problems, identify issues, draw conclusions, or devise new ideas or actions to address them. The results of interviews with teachers at SD 064027 Karang Sari also showed that the learning process, especially in science, did not encourage students to think critically. This was evident during the learning process, as teaching materials were not used. Student worksheets, in Indonesian, are called Lembar Kerja Peserta Didik (LKPD) and are used exclusively in the textbooks used by the school.

Applying Science, Technology, Engineering, and Mathematics (STEM) through experimental or project activities can improve cognitive learning outcomes and shape attitudes and scientific process skills, as students are trained in 4C activities—namely, creativity, critical thinking, collaboration, and communication. STEM-based learning encompasses multidisciplinary sciences and involves various skills,

https://doi.org/10.17509/jik.v21i4.74743

including reading, writing, mathematics, and building knowledge concepts (Harahap et al., 2023). The application of STEM can enhance students' skills and cooperation in problem-solving and product development, as students are accustomed to the steps of the engineering design process, which include defining the problem, researching, imagining, planning, creating, testing, evaluating, redesigning, and communicating (Owens & Hite, 2022). Thus, STEM-based LKPD is suitable for improving students' critical thinking skills, especially in science subjects. This finding is supported by several previous studies that support this study, namely, the use of STEM-based LKPD can effectively improve students' critical thinking skills. STEM-based LKPD has received good student responses and can be used in learning. STEM-based LKPD has received positive student responses and can be effectively integrated into learning (Aristo & Tampubolon, 2019). Integrated STEM learning improves students' scientific thinking skills (Agustina et al., 2020).

Based on the problems that occurred at SDN 064027 Karang Sari, it is necessary to develop teaching materials in the form of LKPD that can enhance students' critical thinking skills to describe the results of their understanding and solve problems that arise during the learning process, thereby making learning more meaningful. Therefore, this study aimed to develop LKPD and determine its feasibility, practicality, and effectiveness for students.

LITERATURE REVIEW

Science, Technology, Engineering, and Mathematics (STEM)

STEM is a model of cross-disciplinary integration so that students can understand more deeply the importance and application of integrated disciplines during classroom learning (Nuryadin, 2024). The applied teaching becomes more meaningful in understanding the material concept and exploring through project activities to solve problems based on STEM components and scientific literacy competencies (Alifiyah et al., 2020). STEM learning encourages students to have knowledge and technological literacy as seen from reading, writing, observing, and conducting scientific research (Retnowati & Subanti, 2020; Surahman, 2024).

STEM is also useful for realizing students who care about technological developments, can solve problems, find solutions, are innovators, logical and realistic thinkers, are independent, liaisons between culture and history with the education they are studying, and become a liaison between STEM education and the world of work in everyday life later STEM can develop students' thinking patterns such as thinking scientifically in solving problems in their lives (Mufidah, 2019). Learning with a technological and design context, such as using STEM, has excellent potential to train scientific literacy (Pratiwi & Rachmadiarti, 2022).

Based on several opinions of the experts above, it can be concluded that the STEM-based approach can create integrated, active learning and become an alternative to overcome problems in learning, which is expected to increase intelligence, creativity, design skills, student learning outcomes, and improve critical thinking skills of students. STEM education aims to enhance students' understanding of learning materials by applying STEM. Besides that, the most important thing is that students can use this knowledge to solve complex problems by developing high-level thinking skills; prepare for the needs of 21st-century human resources and develop competencies in the STEM field (Septiani et al., 2020). Bybee describes the definition of STEM literacy in **Table 1** below (Septiani et al., 2020).

https://doi.org/10.17509/jik.v21i4.74743

Table 1. Definition of STEM Literacy

STEM Subject	STEM Literacy
Science	Scientific Literacy: The ability to use scientific knowledge and processes to understand the natural world and participate in decision-making to influence it.
Technology	Technological Literacy: Knowledge of how to use new technologies, understanding how new technologies are developed, and having the ability to analyse how new technologies affect individuals and society.
Engineering	Design Literacy: Application of science and technology through design processes using project-based learning themes by integrating several different subjects (interdisciplinary).
Mathematics	Mathematical Literacy: The ability to analyse, reason, and communicate ideas effectively and understand how to behave, formulate, solve, and interpret solutions to mathematical problems in their application.

Source: Septiani et al*. (2020)*

Critical Thinking Skills

Critical thinking skills are one of the high-level thinking skills needed to solve problems. They are important to develop in the learning process, where students must be active in learning and teachers are only facilitators. Thinking is a cognitive process, a mental activation to acquire knowledge (Rahma & Isralidin, 2022). Critical thinking involves recognizing and avoiding bias, collecting and evaluating evidence, and identifying and assessing arguments (Sitompul & Bunawan, 2021).

Critical thinking also allows one to overcome emotions and prejudices, producing more objective and rational thinking. The complex critical thinking process is known as a high-level thinking process. It is categorised into problem solving, decision making, critical thinking, and creative thinking. Critical thinking skills are important skills that allow a person to actively analyse, evaluate, and deeply understand the information obtained (Rahma & Isralidin, 2022).

Critical thinking can be defined as rational and reflective thinking that focuses on deciding what to believe. Critical thinking has two significant aspects: disposition and abilities (Simanjuntak et al., 2019). Critical thinking skills can be developed through continuous practice and awareness. By having good critical thinking skills, individuals can make better decisions, face challenges with stronger thinking, and better understand the world around them.

Based on this opinion, it can be stated that the thinking process is a high-level thinking process with problem solving, decision making, and creative thinking. Critical thinking skills are important for analysing, evaluating, and understanding in-depth information. It benefits academic and everyday life contexts, helping individuals understand concepts better, make good decisions, and solve problems with logical and innovative solutions. Indicators of critical thinking skills can be seen in **Table 2** below.

Table 2. Critical Thinking Skills Indicators

Critical Thinking Skills	Sub Critical Thinking Skills
Elementary Clarification (Providing Simple Explanations)	1. Focusing questions 2. Analysing arguments 3. Asking and answering clarifying and challenging questions
Basic Support (Building Basic Skills)	1. Considering credibility (criteria of a source) 2. Observing and considering observation results
Inference	1. Making deductions and considering deduction results 2. Making inductions and considering induction results

https://doi.org/10.17509/jik.v21i4.74743

Critical Thinking Skills	Sub Critical Thinking Skills
(Concluding)	3. Making and considering decision values
Advance Clarification (Creating Further Explanations)	1. Identifying terms, considering definitions 2. Identifying assumptions
Strategic And Tactics	1. Deciding on something 2. Interacting with others

Source: Syanas et al*., 2019*

Lembar Kerja Peserta Didik (Student Worksheets)

Lembar Kerja Peserta Didik (LKPD) is a learning medium used to support student activity in the learning process, which can help foster student interest in participating in learning, and make learning activities more focused and effective. Student Worksheets are a learning medium that can support students' learning process, individually and in groups, to build their knowledge with various existing learning resources (Nua et al., 2019). The teacher only acts as a facilitator and prepares Student Worksheets in accordance with the curriculum. Student Worksheets are teaching materials in the form of sheets containing assignments to be done by students, containing instructions, steps to complete a task in the form of theory or practice that have been adjusted to the fundamental competencies that must be achieved (Yani & Mulia, 2023).

LKPD are work instructions that contain steps for students to make observations or experiments to carry out tasks related to the material being studied (Puspita et al., 2021). LKPD can be developed by teachers with a teacher's creativity so that students are invited to be active in the learning process (Omanda et al., 2023). In this case, project-based LKPD is needed to encourage student activity. Based on this description, researchers can conclude that LKPD is an activity sheet containing steps and instructions that ask students to solve problems from assignments that have been given. LKPD is used in the learning process to make it easier for students to understand the teaching material and increase student activity and skills by completing the assignment.

The benefits of using LKPD in learning activities are numerous. Using LKPD can allow students to be actively involved in the discussed material. The use of LKPD and learning processes that have not fostered science process skills and scientific attitudes results in students not playing an active role in learning (Hanim et al., 2019). This results in low motivation and a lack of seriousness in students following the lesson. The benefits that can be obtained by using LKPD in learning activities, namely: 1) Can provide convenience for teachers when managing the learning process which was previously teacher oriented to student oriented; 2) Can make it easier for teachers to guide and direct students in getting concepts when doing activities individually or in groups; 3) Can be used to develop process skills and arouse students' interest in their surroundings; and 4) Can help teachers in observing student progress in order to achieve a learning goal (Hasanah, 2021).

Life Cycle Science Learning Materials

Every living thing must experience a life cycle. The life cycle encompasses all the stages of change that living things experience during their lifetime. Each animal has distinct stages in its life cycle. Metamorphosis is the distinct stages of change in shape that animals undergo from hatching to adulthood. Based on changes in body shape, the life cycle of animals is divided into two categories: life cycles without metamorphosis and life cycles with metamorphosis (Alibardi, 2024). There are two types of metamorphosis: Incomplete metamorphosis and complete metamorphosis.

https://doi.org/10.17509/jik.v21i4.74743

Incomplete metamorphosis is the process of changing the shape of an animal that at birth is no different from when the animal is an adult. Animals that undergo incomplete metamorphosis have a young animal shape similar to its parent's, but certain body parts, such as wings, have not yet formed. Incomplete metamorphosis occurs in insects such as cockroaches, dragonflies, crickets, grasshoppers, ants, and dragonflies. Animals that undergo incomplete metamorphosis do not experience the larval and pupal stages. The stages of imperfect metamorphosis are Egg → Nymph → Adult (Santos-Ortega & Killiny, 2020). According to Amalia et al. In her book "Buku Peserta Didik IPAS SD Kelas IV", the perfect metamorphosis is how an animal's body changes from larval to adult. Insects that undergo perfect metamorphosis experience four life cycle stages: egg → larva → pupa (cocoon) → adult (imago)—for example, butterflies, mosquitoes, flies, frogs, and ants.

METHODS

This study employs a research and development (R&D) approach. This method aims to produce a product that is then tested for its effectiveness. The research and development model used is the ADDIE model. The ADDIE model, according to Sugiyono in "Quantitative, Qualitative Research Methods," consists of five stages: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and 5) Evaluation. The research was conducted during the even semester, specifically from May to July 2024. The population of this study consisted of students in Class IV of SD 064027 Karang Sari. The sampling used a purposive sampling technique. The sample obtained was Class IV A, comprising 24 students. The sampling considerations included analyzing semester 1 PTS scores and teacher recommendations based on student activity. Data collection techniques were employed in interviews, questionnaires, and descriptive tests. The interview technique was conducted openly, where researchers gathered initial information in the form of problems that existed within the organization. The questionnaire contains several questions that respondents submit to provide information on answers related to the problem. This research questionnaire consists of an expert validation questionnaire, a student response questionnaire, and a pretest-posttest. The validity questionnaire instrument was completed by nine validators, comprising three teachers and six lecturers, with two lecturers validating material experts, two validating language, and two validating learning design experts. The practicality questionnaire is reviewed based on the results of student and teacher responses to the developed LKPD. The practicality questionnaire is calculated using the percentage score obtained from student and teacher responses. The essay test aims to see the effectiveness of the product being developed. The effectiveness test was implemented through a one-group pretest-posttest research design. The experimental class was class IV A with 24 students. The data obtained from interviews and observations were used to prepare the introduction and background of the study. The analysis stage consists of 1) a normality test, using the Kolmogorov-Smirnov test assisted by SPSS 26.0; 2) a homogeneity test, using the Levene test with SPSS 25.0; 3) a one-sample t-test using the SPSS 26.0 application; 4) an N-gain test using the Hake formula with the help of Microsoft Excel.

RESULTS AND DISCUSSION

Result

This development results in a STEM-based LKPD for the life cycle material, utilising the ADDIE model. The First Stage of this research began with conducting a needs analysis in science lessons at SDN 064027 Karang Sari, involving grade IV teachers and students. The results found that the independent curriculum, the books used in the learning process, are also books for grade IV science published by Kemendikbud (Ministry of Education and Culture). However, LKPD is not yet based on critical thinking, as it is only used by science textbooks in elementary schools. So that it does not encourage students to think critically,

https://doi.org/10.17509/jik.v21i4.74743

making it difficult for them to achieve optimal learning outcomes. However, as agents of change, teachers must be able to direct themselves and their students to think critically (Hasruddin, 2022; Hasruddin et al., 2024).

The results of the questionnaire require analysis. 92% of grade IV teachers at SDN 064027 Karang Sari expressed interest in using STEM-based LKPD in their learning. In addition, fourth-grade teachers rarely create LKPD that can improve students' critical thinking skills; instead, they use LKPD listed in student textbooks during the learning process, and rely solely on school books. Most teachers do not utilise LKPD to support learning and apply it in the classroom (Novitasari et al., 2022). The needs analysis also indicates that 82% of teachers require additional learning resources beyond textbooks.

Based on the student needs analysis questionnaire that 24 respondents have conducted, it can be seen that 59% of students consider the life cycle material difficult to understand, 60% of students find it challenging to understand the life cycle material through LKPD that students have used, and 89% of students need an investigation of science teaching materials, especially life cycle material that is packaged better and simpler so that it is easier to understand and can improve students' critical thinking skills than textbooks or LKPD that students have used. Students also feel bored if learning is only done with conventional methods. Hence, they need innovation in the learning process by implementing a STEM approach that can make students more enthusiastic when learning. One of the science materials in grade IV is about the life cycle.

The second stage involves designing STEM-based LKPD, which includes preparing the LKPD design, life cycle materials, supporting materials, learning activities, and evaluation questions. The material presented in the STEM-based LKPD consists of the life cycles of animals undergoing perfect metamorphosis and imperfect metamorphosis. This STEM-based LKPD also supports evaluation questions that can improve critical thinking skills. The STEM-based LKPD also features interesting visual images, utilises the latest technology, and incorporates active learning projects. STEM-based LKPD combines four disciplines: science, technology, engineering, and mathematics. This combination enables STEM to create student-centred thinking activities, fostering the development of students' critical thinking skills, which are characterised by the ability to conduct investigations, solve problems, and make informed decisions (Davidi et al., 2021). The following is **Table 3**, the design for developing STEM-based LKPD.

Table 3. Design of STEM-based LKPD development

LKPD Cover	Achievements, Learning Objectives	Materials
		
Supporting Materials	**Student Activities**	**Test Questions**

https://doi.org/10.17509/jik.v21i4.74743

Source: Research 2024

The third stage is development, where the researcher's product is then consulted or validated with experts. The selected experts are recognised as leaders in their respective fields. Based on this, there are three types of experts: media experts, language experts, and material experts. The validation results obtained are quantitative data, specifically from the Likert scale questionnaire sheet, and qualitative data, including criticisms and suggestions provided by the validator in the questionnaire. Based on the validation results of media, learning design, and language experts, STEM-based LKPD on animal life cycle material is categorised as "feasible" for application in the learning process. Similar research states that using STEM-based teaching materials can increase students' interest in mathematics learning and improve learning outcomes (Febriyanti et al., 2020). STEM-based LKPD is feasible for implementation in schools. The development product in the form of STEM-based LKPD falls into a valid category because its preparation meets the requirements, namely didactic, constructional, and technical (Aprilianti et al., 2020). The following are the average results of the validation of STEM-based LKPD products, as validated by lecturers, including validation by material experts, validation by learning design experts, and validation by language experts, as shown in **Figure 1**.

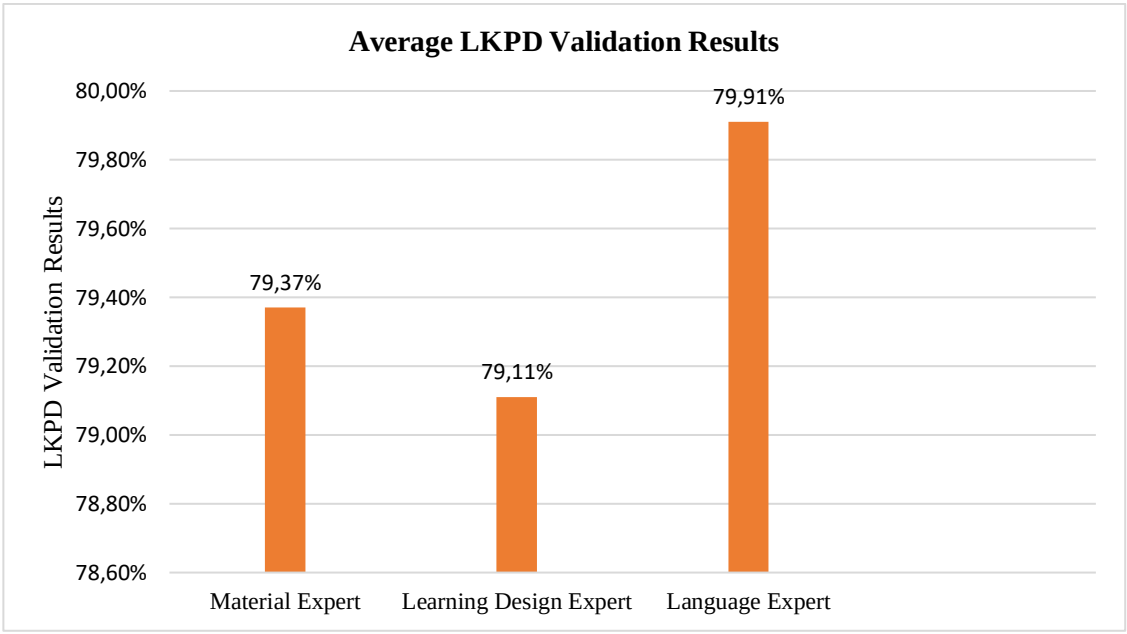

Figure 1. Recapitulation Diagram of LKPD Validation Results
Source: 2024 Research

https://doi.org/10.17509/jik.v21i4.74743

Based on the results of **Figure 1**, it can be seen that the results of the validation of material experts are in the range of 79.37 with a feasible category, the results of the validation of learning design experts on STEM-based LKPD were 79.11% with a feasible category and the results of the validation of language experts on STEM-based LKPD were 79.91 with a viable category. With the results of the feasibility test obtained from the experts, it can be stated that STEM-based LKPD can be used to improve critical thinking skills. The fourth stage is implementation. At this stage, the design and LKPD that have been developed are implemented in real situations, namely in the classroom. STEM-based LKPD will be implemented at SDN 064027 Karang Sari and distributed to 24 students. At this implementation stage, how practical and effective STEM-based LKPD with life cycle material improves students' critical thinking skills will be seen. At the practicality analysis stage, the researcher will conduct three stages of field tests: individual trials, small group trials, large group trials, and trials on students. Additional assessments from grade IV teachers are also carried out. The analysis results show that the practicality of STEM-based LKPD with life cycle material is efficient. The results of the practicality test can be seen in **Table 4**, as well as individual tests, small group tests, extensive group tests, and the results of the STEM-based LKPD assessment from teachers.

Table 4. Practicality Test Results

No	Practicality Test	Average Results	Category
1	Individual test	90,37%	Very practical
2	Small group test	95,11%	Very practical
3	Large group test	91,39%	Very practical
4	Teacher assessment	87,37%	Very practical

Source: 2024 Research

Based on the results of **Table 4** above, individual tests, small group tests, large group tests, and teacher assessments get the category result of "very practical." Thus, it is noted that STEM-based LKPD with life cycle material is said to be practical for improving critical thinking skills in elementary schools.

The implementation stage also aims to assess the effectiveness of STEM-based LKPD. To achieve this, trials were conducted on individual groups, small group tests, extensive group tests, normality tests, homogeneity tests, one-sample t-tests, and n-gain tests. This effectiveness test uses pretest and posttest questions on life cycle material distributed to grade IV elementary school students at SDN 064027 Karang Sari. The pretest and posttest questions have passed the validity test, namely that 10 out of 15 questions were declared valid, with an r-table of 0.4227. After the valid questions were tested for reliability using the IMB SPSS Statistic 26 Software and obtained a Cronbach alpha of 0.715 which was categorized as high, at the difficulty level test stage, three questions were categorized as difficult, six questions were categorized as medium and 1 question was categorized as easy, at the difference power test stage, six questions were categorized as sufficient and four questions were categorized as very good with 0, so the questions were suitable for use with students. The results of the individual group test analysis consisting of 3 people with one high cognitive level, one person with a medium cognitive level and one person with a low cognitive level, after that a small group test was carried out consisting of 9 people, namely three people with a high cognitive group, three people with a medium cognitive level and three people with a low cognitive level, a significant group test was carried out on 24 students in grade IV of SDN 064027 Karang Sari.

The individual test, the small group test, and the large group trial aim to determine students' responses to the product being developed. This small group consists of students with varying knowledge, aiming to

https://doi.org/10.17509/jik.v21i4.74743

ensure that the assessment for the product is evenly distributed among students in the upper, middle, and final ranks. The trial results show that the students' response to the product in the small group trial achieved a very high category. This indicates that the media product is suitable for use in learning. The individual test, small group test, and large group trial demonstrate that the beginning reading and writing textbook is highly engaging for learning, as indicated in the third group test (Suttrisno et al., 2021). **Table 5** shows the results of the effectiveness test of individual tests, small group tests, and extensive group tests.

Table 5 Results of the Effectiveness Test: Individual Test, Small Group Test, Large Group Test

No	Effectiveness Test	Pre-test		Post-test	
		Average	Category	Average	Category
1	Individual test	56,33%	Low	71,00%	High
2	Small group test	62,00%	Low	77,11%	High
3	Large group test	61,00%	Low	91,75%	High

Source: 2024 Research

Based on the results of **Table 5**, it was obtained that the results of the individual test of critical thinking skills before using STEM-based LKPD analyzed through the pretest stage with an average value of 56.33% with the criteria of "Low" meaning that the value achieved by students needs to be improved again. In comparison, the results of critical thinking skills after using STEM-based LKPD were analyzed through the pretest stage with an average value of 71.00% "Medium". Notably, the use of STEM-based LKPD has increased significantly. At the small group test stage, a pretest value of 62.00% was obtained with a low category that requires improvement in students' critical thinking skills, while in the posttest test in small groups, an average pretest result of 77.11% was obtained with a moderate category, so it can be seen that critical thinking skills experience critical thinking skills after using STEM-based LKPD in students. The extensive group test analysis results indicated that students' pretest results fell into the low category, with 61.00% of students, and the average pretest score was 91.75% in the high category. Thus, STEM-based LKPD was effective in improving students' critical thinking skills.

The difference in pretest and posttest data results in the individual test was 12.667, the small group test was 15.875, and the significant group test was 8.50. The difference in normal posttest results between the experimental and control classes was 7.816, indicating an increase in the collaboration ability of students in the experimental class (Adhiati et al., 2023). STEM LKPD can enhance learning motivation by examining the relationship between motivation, pedagogy, and students' gender identity. This is evident from the increase in pretest and posttest results in each test, small group trial, and large group (Stolk et al., 2020).

The normality test is the next stage to see the effectiveness of STEM-based LKPD in improving students' critical thinking skills. The Lilliefors test is used to assess normality. The Shapiro-Wilk test determines whether the results of pretest and posttest data obtained from students are normally distributed, with a significance level of 5%. The data are determined to be generally distributed in this normality test using the Lilliefors test. If L_0<L_t is obtained or the sig.> 0.05, then the data is usually distributed. Conversely, the sig. A < 0.05 test value means the data is not normally distributed. The normality test results, calculated using the Lilliefors formula, are presented in **Table 6** below.

Table 6. Normality Test Results

Normality Test

https://doi.org/10.17509/jik.v21i4.74743

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	.174	24	.060	.939	24	.155
Post-test	.117	24	.200*	.928	24	.090
a. Lilliefors' significance correction						
*. This is the limit of the true meaning.						

Source: 2024 Research

The significant value of the Liliefors test on the pretest data was obtained at 0.155, indicating a significance value of 0.155 > 0.05. Thus, it can be stated that the pretest data on students' critical thinking skills are normally distributed. And in the posttest data, the significance value is 0.090 > 0.05. Thus, the posttest data on students' critical thinking skills are normally distributed. The validity of the normality data is also supported by previous research. The results of the normality tests on the pretest and posttest data from the control class and the experimental class obtained a p-value of 0.05, indicating that the data are normally distributed and accurate, and thus continued to the next prerequisite test stage (Prika, 2022). The experimental and control classes have L0 < Lt, indicating that the results of the self-efficacy questionnaire analysis for students in both sample classes are normally distributed (Kurniawati & Dayu, 2022). Thus, the data can be continued to the following statistical test, a one-sample posttest.

After the normality test is conducted, a one-sample t-test is performed to evaluate the hypothesis. The one-sample t-test is a statistical testing procedure for a single sample, comparing the average of a variable to a specific constant value. In other words, in this one-sample t-test, the average data of the students' post-test scores is compared to the minimum value of 70. **Table 7** presents the results of the one-sample t-test calculation using SPSS version 26.

Table 7. One Sample Test Calculation Results

One-Sample Test										
KKM=70										
	N	**Rata-Rata**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed)**	**Mean Differenced**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Postest Critical Thinking Skills	24	90.29	6.321	1.290	15.727	23	.005	20.292	17.62	22.96

Source: 2024 Research

Based on the calculation of SPSS version 26, it was found that the average (mean) of the posttest was 90.29 with a t_{count} of 15.727 with as many as 24 students. The decision-making hypothesis is that H0 is accepted when $t_{count}<t_{table}$. Conversely, H0 is rejected when $t_{count}>t_{table}$. The t_{table} value is taken from the t table. T table is obtained by calculating dk = n-1 (n = number of respondents), then dk = n-1 = 24, then t table = 1.713. Thus, the results of the one-sample t-test calculation show $t_{count}>t_{table}$, which is 15.727> 1.713, so H_0 is rejected and H_a is accepted. This means that the value of students' critical thinking skills on the life cycle material is greater than the hypothesized 70 after learning using STEM-based LKPD in class IV SDN 064027 Karang Sari.

https://doi.org/10.17509/jik.v21i4.74743

The n-gain test aims to analyze students' critical thinking skills by increasing their cognitive abilities after receiving learning treatment using STEM-based Science LKPD on life cycle material. Pretest and posttest score data were analyzed both descriptively and quantitatively by calculating the n-gain score <g> against students' critical thinking skills.

$$\text{N-Gain} = \frac{post\text{-}test\ score - pre\text{-}test\ score}{100 - pre\text{-}test\ score}$$

$$= \frac{91{,}75 - 61{,}00}{100 - 61{,}00}$$

$$= \frac{30{,}75}{39{,}00}$$

$$\text{N-Gain} = 0{,}7$$

According to the gain test, the fourth-grade students of SD Negeri 064027 Karang Sari scored 0.79 in the "High" category, indicating that STEM-based LKPD can improve critical thinking skills. The increase in critical thinking skills is also evident in the improvement of students' critical thinking skills, as indicated by the results of their pretest and posttest, which show an increase in the five essential thinking indicators. The following is shown in **Figure 2**, illustrating the average increase in students' critical thinking skills as indicated by the data.

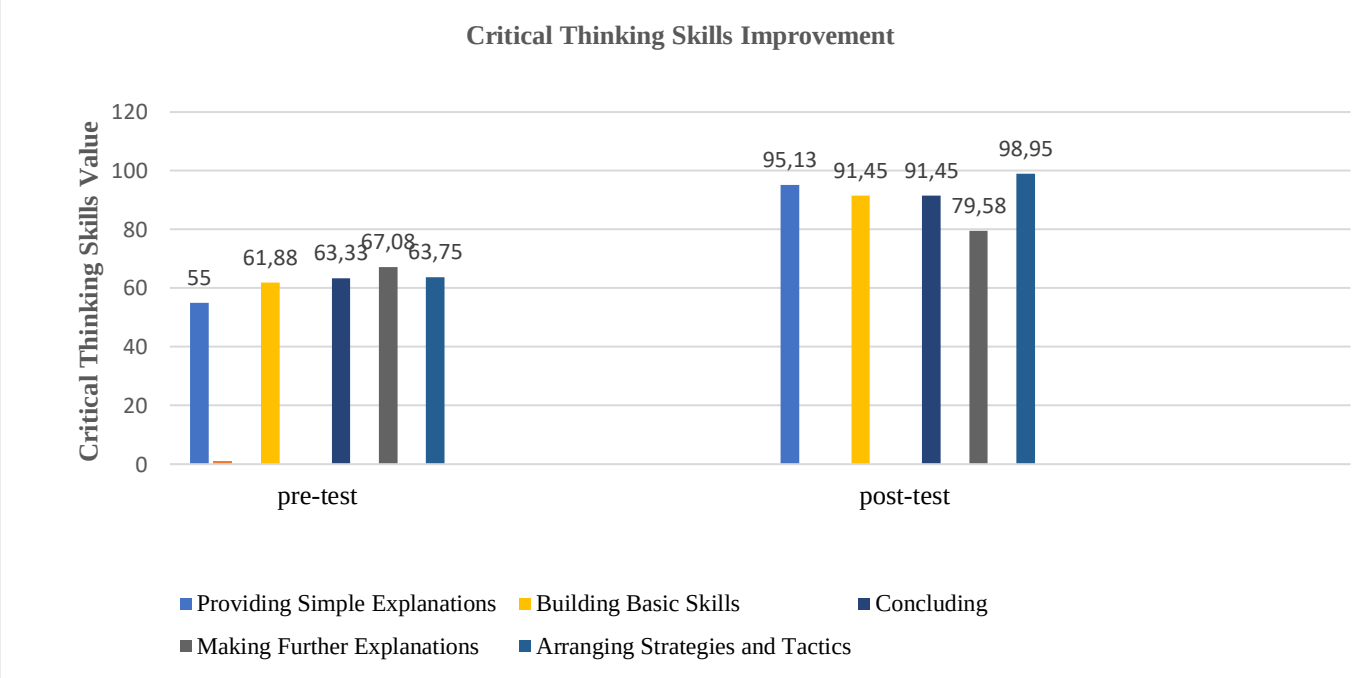

Figure 2: Improving Students' Critical Thinking Skills
Source: Research 2024

Based on **Figure 2**, it is known that critical thinking skills have increased in each indicator. The Elementary Clarification indicator in the pretest got an average of 55, while it increased to an average score of 95.13 in the posttest. The Basic Support indicator in the pretest got an average of 61.88, while in the posttest it increased to an average score of 91.45. The Inference indicator in the pretest got an average of 63.33, while in the posttest it increased to an average score of 91.45. The Advance Clarification indicator in the pretest got an average of 67.08, while it increased to an average score of 79.58 in the posttest. The

https://doi.org/10.17509/jik.v21i4.74743

Strategic and Tactics indicator in the pretest got an average of 63.75, while it increased to an average score of 98.95 in the posttest. Thus, it can be ascertained that each indicator of students' critical thinking skills has increased, so that students' critical thinking skills can be said to have increased.

The evaluation stage is the final stage of this study. The results of this evaluation are used as the final evaluation of the analysis of the developed product and as a benchmark for the researchers' success in answering the formulation of the problem in this study. Thus, based on the five stages of the ADDIE development model research, which include analysis, design, development, implementation, and evaluation that have been carried out, the product developed, namely STEM-based LKPD for grade IV students of SD Negeri 064027 Karang Sari, has met the elements of feasibility, practicality, and effectiveness to improve students' critical thinking skills using STEM-based LKPD. The evaluation stage at the development stage refers to the results of expert assessments, teachers, and responses from experts and teachers in the form of input, suggestions, comments, or responses (Purwanti et al., 2021). The assessment results are analyzed and immediately revised according to experts' and teachers' input, suggestions, comments, or reactions until the product is considered suitable. The function of product revision is to meet the standards for expert assessments related to the LKPD being developed, so that when the subsequent trial is carried out, practical results will be obtained in its use (Destiara et al., 2021; Winarsih & Nisa, 2024).

Discussion

The results of the data analysis show that students' critical thinking skills have improved. The success of this study is influenced by several aspects, namely the feasibility of STEM-based LKPD, its practicality, and its effectiveness. The feasibility of STEM-based LKPD, based on the validation data of material experts, design experts, and language experts, was evaluated. The scale in Table 2 explains that the average validation percentage of each component is calculated using the calculations described. Based on the assessment results of experts who reviewed STEM-based LKPD products. LKPD has the advantage of helping to accelerate students' understanding and mastery of the material through its teaching materials, as this fosters a high level of interest and motivation among LKPD students.

Student worksheets in Indonesian Lembar Kerja Siswa (LKS), which have been developed and validated by material experts, media experts, and practicum experts, indicate that the product is suitable for use as a learning medium in educational activities for students and teachers (Mahyuny et al., 2022). This study also concludes that the average assessment of the LKS product validation experts is feasible overall. STEM-based LKS are valid for use as learning materials (Nafikah et al., 2024). This can be seen from the validation results by material and media experts, who obtained valid criteria, making them suitable for use as supporting materials in learning. The use of STEM-based LKPD has been implemented in previous studies, which have found that STEM-based LKPD is interesting and practical and can improve students' critical thinking skills (Munawaroh & Supriadi, 2023).

In the validation test, the STEM-based LKPD obtained a percentage value of very high validity. Students' critical thinking skills were assessed at an average value in the moderate category, and students' responses to the use of STEM-based LKPD were excellent. The implementation of STEM-based LKPD is an urgent priority applied in elementary schools. This is supported by previous research related to the implementation of STEM-based LKPD, which can help students to understand and experience the scientific investigation process, so that students learn directly to develop their' skills to apply their knowledge, thereby affecting students' learning achievement and motivating students in learning (Fithri et al., 2021). The results of the STEM-based LKPD research indicate that STEM-based LKPD products are highly suitable for application in science learning activities in elementary schools (Annisa et al., 2023). The description of the LKPD developed has been discussed in detail in Chapter IV. The LKPD is compiled by

https://doi.org/10.17509/jik.v21i4.74743

paying attention to the characteristics of students, where, according to Piaget's theory, grade IV elementary school students have entered the concrete operational stage, so that they can think logically and systematically.

The practicality of STEM-based LKPD can be demonstrated by students' responses to the use of STEM-based LKPD in the learning process. Practicality, in this case, refers to how students consider the intervention interesting and how it can be used under normal conditions. Therefore, the results of individual group responses, small group tests, significant group trial results and teacher responses show that the practicality of STEM-based LKPD also obtained favorable results in the "convenient" category so that LKPD meets the criteria and standards in learning and is worthy of publication and use as teaching materials for science learning, especially life cycle material. The STEM-based LKPD has met the practical criteria from a practical perspective, with a percentage of learning implementation in the excellent category, an average assessment in the good category, and a percentage of student responses to LKPD in the good category (Arisha & Surya, 2024). The results of the practicality questionnaire demonstrate that STEM-based LKPD, incorporating life cycle material, is a practical approach to enhancing students' critical thinking skills in the learning process. The results of the effectiveness analysis, based on data processing, indicated that STEM-based LKPD is efficacious in improving students' critical thinking.

The results of the effectiveness of the STEM-based LKPD developed make students happy in learning according to Vygotsky's constructivism theory, a student's actions will spontaneously continue to be repeated so that students are ready to think critically, this shows that the STEM-based LKPD developed makes students happy when learning because it can make students more responsive and active so that the LKPD developed is declared effective in improving students' critical thinking skills in line with previous research, which revealed that the average experimental class was higher than the control class (Gandi et al., 2021). This indicates that the implementation of integrated STEM project-based learning positively impacts students' critical thinking skills. In line with the research results, STEM-based LKPD meets the effective category of review of the percentage of learning completion of the "high" category and the n-gain score is in the high category, this shows that there is an increase in students' critical thinking skills with a high category after using LKPD based on the STEM approach in learning (Arisha & Surya, 2024).

The STEM-based LKPD developed in this study possesses characteristics that enable training in critical thinking skills. The indicator of teaching essential thinking skills shows an outstanding category. LKPD emphasizes the importance of providing simple explanations, as demonstrated in the question section, by selecting perfect and imperfect metamorphosis animals. The questions in this section train students in providing simple explanations, focusing on questions, analyzing queries, and answering questions about explanations. The questions in this section contain science material, one form of STEM application from the science subject.

The LKPD section, the first stage of training students in decision-making, involves providing explanations and appropriate reasons and developing ideas from the animal life cycle. Analyzing and interpreting information can enhance students' critical thinking skills. The second stage concludes by inviting students to describe the phases of the animal life cycle that undergo metamorphosis. The questions in this section train students to provide the correct explanation or develop ideas to focus on questions, analyze queries, and answer questions about the animal life cycle.

The fourth stage is Further Explanation. At this stage, students describe the phases of the animal life cycle that undergo metamorphosis, aiming to analyze them more deeply and help students become more focused on observing the stages of the animal life cycle, including those of perfect and imperfect metamorphosis. This process also involves group discussions that train students to interact with others. This section also applies the STEM approach to engineering subjects.

https://doi.org/10.17509/jik.v21i4.74743

CONCLUSION

STEM-based LKPD products on life cycle material that have been validated by material experts, learning design experts and language experts are declared suitable for use as a support in the learning process, especially for science subjects on life cycle material for grade IV Elementary Schools, the results of this research analysis also state that STEM-based LKPD is also practical to use, this can be seen from the responses of students and teachers who are categorized as "very practical", the results of the analysis of the effectiveness of STEM-based LKPD in improving students' critical thinking skills are also classified as "high" as seen from the N-gain value of 0.79. Thus, STEM-based LKPD is declared feasible, practical, and effective in improving students' critical thinking skills.

The development of STEM-based LKPD implies that the final assignment in the form of development research, which serves as a scientific work in the form of a thesis, helps researchers develop their ideas in solving education-related problems. In addition, researchers possess knowledge of research data analysis and gain direct experience in the field, observing research subjects and collecting data. The results of this study help students improve their critical thinking skills and utilize STEM-based LKPD as an additional learning resource or supplement that supports teaching and learning activities, particularly in life cycle materials. In addition, with the technological content in the form of learning videos on STEM-based LKPD, students can learn anytime and anywhere by utilizing smartphones that are integrated with learning videos, allowing the concept of the material to be conveyed effectively to those who undertake independent learning. This study can be a reference for teachers to continue developing their work and enhance classroom learning quality. The study's results, in the form of STEM-based LKPD, which includes learning outcome questions, can be used by teachers to measure the critical thinking skills of grade IV students.

Based on the results of the findings that have been described, several suggestions are put forward, namely: 1) Students, to further improve concentration and motivation during the learning process, because the material presented by the teacher needs to be digested and understood, and in particular students continually improve their critical thinking skills by learning using other learning media such as LKPD; 2) Teachers can use STEM-based LKPD teaching materials, because by using STEM-based LKPD, students' motivation can increase, this is because students can learn while doing an activity and not just listening or reading. So that it can affect students' motivation and focus on learning in improving critical thinking skills; 3) Schools facilitate teachers and students in utilizing and developing STEM-based LKPD teaching materials which aim to expand the scope of other science materials, not just one science material; 4) For other researchers, STEM-based LKPD teaching materials to improve critical thinking skills can be further developed with a broader sample and require trials by including other variables**.**

AUTHOR'S NOTE

The author declares that there is no conflict of interest regarding the publication of this article and confirms that the data and content are free from plagiarism.

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