

DEVELOPMENT OF DISCOVERY LEARNING-BASED E-LKPD MATERIALS NANOFIBER MEMBRANE-ASSISTED FILTRATION TO TRAIN CREATIVE THINKING SKILLS

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Abstract :

Developing students' creative thinking skills remains a challenge in science learning, particularly when instructional materials do not adequately support exploration and contextual understanding. This study aims to develop an e-LKPD product based on discovery learning and nanofiber membrane filtration to train junior high school students' creative thinking skills effectively. The study employed a development research approach using the ADDIE model and involved 217 seventh-grade students from 10 classes (VIIA-VIII) at SMPN 1 Jambi. The data collection technique in this study was to distribute questionnaires, which were then analyzed using the Content Validity Ratio (CVR) to determine feasibility, one-to-one and small-group evaluations to assess practicality, and N-gain analysis to measure effectiveness. The results showed that all aspects of the e-LKPD met the feasibility criteria and were categorized as very good, with minor revisions related to writing clarity. The practicality analysis indicated a high level of usability, with average scores of 86.76% in the one-to-one evaluation and 95.53% in the small group evaluation. The N-gain analysis yielded an average score of 0.46, which falls into the moderate effectiveness category, indicating an improvement in students' creative thinking skills. It can be concluded that the development of e-LKPD based on discovery learning for nanofiber membrane-assisted filtration materials is feasible, practical, and moderately effective, and has the potential to serve as an alternative digital learning resource to support the development of creative thinking in junior high school science learning.

Keywords: e-LKPD, Nanofiber Membrane, Creative Thinking Skills

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INTRODUCTION

The era of globalization demands that human resources (HR) keep pace with developments in science and technology and compete globally with the requisite competencies and skills. These 21st-century skills include: creative thinking, problem-solving, collaboration, and communication (Fitriyah

& Ramadani, 2021). Creative thinking skills can be optimally developed only through learning in schools from elementary school through university (Saputra et al., 2019). Creative thinking skills can help in making the right decisions by using reason, evaluating information, analyzing facts, solving problems, formulating conclusions, and making decisions (Hadi et al., 2018). Creative thinking is a process that allows a person to generate alternative solutions when responding to a problem (Agusta & Sa'dijah, 2021). These ideas are not always completely original, but can also be a combination of two or more pre-existing concepts (Fajri, 2019).

To improve students' creative thinking skills, teachers need to foster their activeness and creativity during the learning process, according to research conducted by (Husnaini & Kurniawan, 2025). Through a contextual approach, students can develop creative thinking skills that play an important role in learning, one of which is using a discovery learning-based learning model (Ismail et al., 2016). Through the discovery learning model, students are encouraged to learn actively and in a directed manner so that the learning process can take place more effectively. Discovery Learning-based learning syntax, according to Jerome Bruner, includes: (1) providing stimulation, (2) identifying problems, (3) collecting data, (4) processing data, (5) verifying, and (6) drawing conclusions. Research conducted by (Yadrika et al., 2022) shows that discovery-learning-based LKPD is considered valid, practical, and effective for training students' mathematical reasoning skills. Discovery learning-based learning models can be used in physics instruction, requiring students to analyze and solve problems, fostering the skills to seek solutions from an investigation (Ismail et al., 2016). The independent curriculum is designed to enhance literacy and numeracy in learning, enabling students to actively explore, explore, and illustrate existing issues.

SMPN 1 Jambi is one of the public junior high schools in Jambi City that officially implemented the independent curriculum in July 2021. In science learning, teachers use teaching materials such as exercises and modules, making the learning process less meaningful and less attractive. Therefore, an attractive and up-to-date Student Worksheet (LKPD) is needed to support the science learning process. In addition, learning media must also be able to increase student interest and motivation in learning that can be accessed anytime and anywhere independently, one of which is E-LKPD (Putri et al., 2024).

E-LKPD is a learning tool for students designed to engage in curriculum-based independent learning to acquire skills identified by teachers (Yadrika et al., 2022). Electronic Student Worksheets (e-LKPD) are worksheets presented digitally and designed interactively to support the learning process (Putri & Raharjo, 2024). The principle of compiling e-LKPD is based on an approach through the stages of student development by taking into account, namely: 1. student characteristics, because students have their own characteristics in the learning process, 2. Differences in student understanding levels and variations in distance or age gaps between competency levels that may occur at each phase, 3. Teachers must see from various student perspectives that each student has their own uniqueness (Siloto, 2023). According to research conducted by (Maghfiroh et al., 2023) the benefits of e-LKPD not only increase student learning motivation, but also help develop critical and creative thinking skills.

Based on the results of the initial analysis, researchers found that 199 seventh-grade students (91.7%) agreed that an e-LKPD based on discovery learning for nanofiber membrane-assisted filtration material should be developed, and that science teachers agreed to create an e-LKPD for the filtration material. These results are supported by research conducted (Azmi et al., 2022a) which stated that learning using a discovery-based science e-LKPD will make students more interested and enthusiastic about learning. In improving students' creative thinking skills, appropriate teaching tools are needed that can make students interested in learning (Meitaza, 2024).

Nanofiber membrane-assisted filtration materials are very easy to find in everyday life, so it is hoped that with this method, students will more easily understand the teaching materials provided and be consistent in maintaining water quality while preventing pollution (Sari et al., 2019). Based on the description above, it is necessary to develop e-LKPD teaching materials using discovery learning on nanofiber-assisted filtration materials to train students' creative thinking skills.

RESEARCH METHOD

Research Design

In this study, the researcher used the development research method (Development Research) to create a product that supports the implementation of learning (Sugiyono, 2009). Development Research in this study aims to produce an e-LKPD based on discovery learning on the material of nanofiber membrane-assisted filtration for grade VII junior high school students that meets the criteria of validity, practicality, and effectiveness, so that it can support the science learning process optimally. The development model used in this study is the ADDIE model, which consists of five main stages, namely Analysis, Design, Development, Implementation, and Evaluation.

Research Target/Subject

This study used 217 seventh-grade students from SMPN 1 Jambi as research subjects, from 10 classes (VIIA–VII J), and tested a questionnaire on the need for e-LKPD based on discovery learning of nanofiber membrane-assisted filtration materials in science learning. Furthermore, using cluster sampling, 35 students from class VII H were assigned to the experimental class, and 35 from class VII I to the control class.

Research Procedure

This study used the ADDIE development model, which consists of five stages: analysis, design, development, implementation, and evaluation. The analysis stage aimed to identify learning needs by collecting information from students, teachers, and the learning environment to inform product development.

The design stage involved preparing a prototype of the teaching materials, including media selection, format determination, and initial design of the e-LKPD. The development stage focused on realizing the designed prototype and improving it through formative evaluation and revision. At this stage, feedback was used to refine the e-LKPD, with aspects evaluated including needs suitability, instructional design, learning tools, and the feasibility of e-LKPD implementation (Pratama & Saregar, 2019).

After the final revisions, the e-LKPD was integrated into learning activities to assess its practicality. This implementation stage uses a quasi-experimental model. Using cluster sampling, class VII H was selected as the experimental class, with 35 students, and class VII I was selected as the control class, also with 35 students. The evaluation stage was conducted to review each stage of the ADDIE model and assess the overall quality of the developed product. The evaluation results were used to improve and revise the e-LKPD to ensure it met quality standards and was suitable for learning.

Data Analysis Technique

The data collection technique in this study was through the distribution of questionnaires to respondents, measured at stages of one evaluation and a small group evaluation, also using a Likert scale (Sugiyono, 2009).

Table 1. Likert Scale

Likert scale	Criteria
1	Strongly disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly agree

The data analysis technique used was the CVR (Content Validity Ratio) data analysis test using the Lawshe equation to identify each question item on the questionnaire sheet as valid, with the following validation categories:

Table 2. Validation Value Categories (Lawshe, 1975)

Number of Validators	CVR Critical Value
5	0,736
6	0,672
7	0,622

The next stage is to analyze the questionnaire results from the one-to-one and small-group evaluation stages to test the practicality of the developed e-LKPD. The results of the questionnaire are converted into percentages, with the practicality categories as follows:

Table 3. Categories of practicality levels of project-based LKM

Answer Categories	Skor (%)
Very Practical	86-100
Practical	70-85
Enough	56-70
Impractical	0-56

The final step is the analysis of test data on the test instrument to determine whether there has been an increase in students' creative thinking skills after using e-LKPD, using the N-gain formula by Hake (1998). The results of the gain calculation are then interpreted using the following classification:

Table 4. Gain Criteria

Normalized Average Gain	Criteria
$\langle g \rangle \geq 0,70$	High
$0,30 \leq \langle g \rangle < 0,70$	Medium
$\langle g \rangle < 0,30$	Low

RESULTS AND DISCUSSION

Analysis Stage

The analysis stage revealed several key learning needs related to the development of a Discovery Learning-based E-LKPD on filtration material. Data from teacher interviews indicated that existing learning materials were predominantly memorization-oriented, limiting students' opportunities to explore concepts independently, generate alternative ideas, or express opinions. Students tended to rely heavily on teacher examples and were reluctant to propose new ideas due to the dominance of single-answer tasks, indicating restricted divergent and creative thinking practices.

Table 5. Teacher interviews need for engagement and relevance

Responses	Required Analysis
Students often perceive that the material being studied has no connection to their daily lives.	This indicates a gap between the presented science concepts and students' everyday experiences. The lack of contextual grounding reduces the meaningfulness of learning and limits students' ability to interpret concepts functionally.
The teacher observed that students are more interested when the lesson is related to events in their surroundings, such as water filtration, pollution, or the use of natural materials.	These observations suggest that students' engagement increases when instructional content aligns with familiar real-world phenomena. This pattern highlights the importance of incorporating context-based stimuli to trigger curiosity and support inquiry.
The teacher expects students to connect the knowledge acquired at school to situations they experience in their daily lives.	This expectation reflects a need for instructional materials that bridge formal scientific concepts with practical applications. Without this alignment, students may struggle to transfer classroom knowledge to real-life problem-solving.

As a result, students tend to rely on teacher examples and demonstrate low confidence in proposing new solutions, reflecting limited development of creative and divergent thinking skills. Student questionnaire results support these findings.

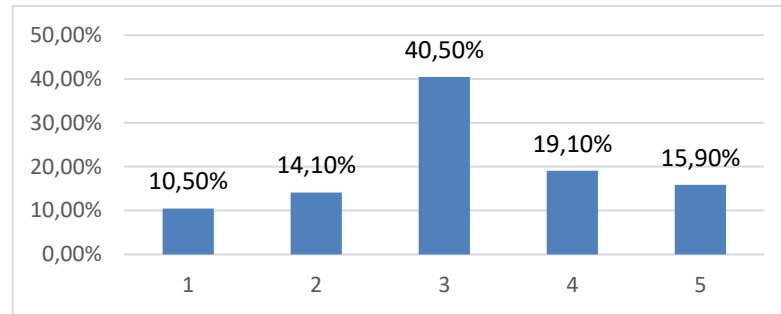


Figure 1. Percentage of material needs

Student questionnaire results supported these findings. More than half of the students (65.1%) reported limited understanding of filtration concepts, particularly when learning relied solely on textbooks without real-life contextualization. This suggests that abstract and theory-driven instruction is insufficient to support deep conceptual understanding. In addition, most students expressed a strong need for learning activities that are connected to everyday phenomena, such as clean water issues and environmental filtration, with 53.6% strongly agreeing and 27.3% agreeing that contextual learning increases engagement and relevance.

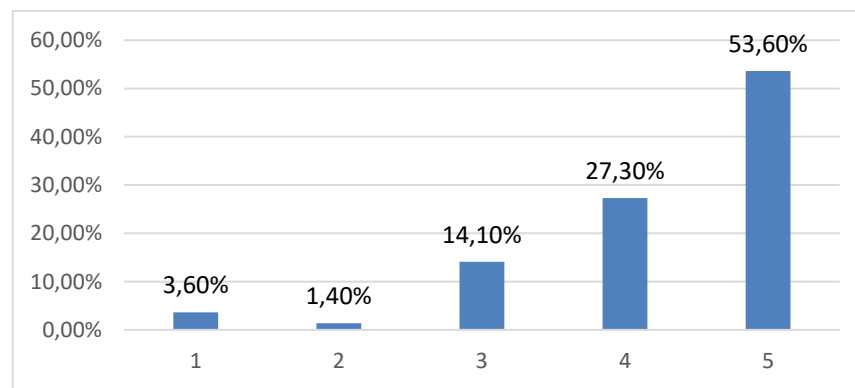



Figure 2. The need for engagement and relevance

This suggests that conventional textbook-based instruction is insufficient to support deep conceptual understanding. Taken together, these findings indicate a clear gap between current learning practices and students' cognitive needs, thereby justifying the development of a Discovery Learning-based E-LKPD that integrates contextual learning and inquiry-oriented activities as a foundation for subsequent development stages.

Design Stage

This stage begins with designing a storyboard that explains the project in detail using words and rough descriptions of the contents of the product to be produced.

Table 6. Product storyboard

No.	Scene
1.	 <p>The e-LKPD contains the title and material, the author's name, the group name, and the member information for students to fill in. The UNSRI logo and images of various water filters are also displayed.</p>

2.

There is an identity from LKPD and a concept map of water filtration.

3.

Nanofiber explanation (100nm fiber, electrospinning, bacteria filter), YouTube video, and 4 creative “Let’s Think!” questions about improving water clarity, alternative materials, camping equipment, and manufacturing steps.

4.

Experiment Instructions: Prepare two 1.5L mineral water bottles, cloudy water, a nanofiber membrane, and filter paper. Divide the bottles into two parts, puncture the lids, insert the filter media, pour cloudy water into the bottles, and record the results in the experimental data table.

5.

There is a problem formulation in the form of reading about the Batanghari River, and problem identification from the reading above.

The review included content feasibility, design feasibility, language feasibility, and creative thinking feasibility.

Table 8. Aspects of Content Suitability (Hosnan, 2014)

Indicator	CVR	CVI
Compliance with the CP and TP curriculum	1	1
Suitability of Science Content (IPA)	1	1
Strengthening the Profile of Pancasila Students	1	1
Quality of Learning Activities (Discovery Learning)	1	1
Clarity of Instructions and Use of E-LKPD	1	1

Based on the table above, the contents of the e-LKPD prototype product are appropriate and in accordance with the existing material and curriculum related to the topic of nanofiber membrane-assisted filtration. With corrections, the addition of a bibliography, further deepening the material according to scientific concepts, and the inclusion of aspects and assessments that demonstrate the e-LKPD are helpful for training students' creative thinking skills.

Table 9. Aspects of the Feasibility of Creative Thinking (Torrance, 1974)

Indicator	CVR	CVI
Fluency	1	1
flexibility	1	1
originality	1	1
elaboration	1	1

Based on the table, the feasibility of creative thinking shows high validity in supporting the development of students' creative thinking skills, including analytical, evaluative, and reflective abilities, which will later contribute to their daily lives.

Table 10. Aspects of Design Feasibility

Indicator	CVR	CVI
Clarity of learning content	1	1
Clarity of instructions and activity flow	1	1
Visual media display quality	1	1
Typographic quality and readability	1	1
Layout, neatness, and professional design	1	1

Based on feasibility, the design is declared valid, with several revisions from experts regarding neatness. However, numbering was found to be inconsistent in several parts. Hence, they needed to be rearranged to follow a coherent pattern. The barcode used needs to be supplemented with information so that students understand the functions and links that will be accessed. The sequence of compiling the activity steps in the e-LKPD needs to be reviewed to ensure that all of them follow the discovery learning syntax correctly starting from the stimulation stage, problem formulation, data collection, information processing to conclusions, so that after these improvements the e-LKPD will have a more precise learning flow, a more professional appearance, and a more optimal interactive media function for students.

Table 11. Aspects of Language Suitability

Indicator	CVR	CVI
Language Readability	1	1

Conformity with Indonesian language rules	1	1
Effective and efficient use of language	1	1

Based on expert validation, the linguistic aspects of e-LKPD are considered suitable for use, as the entire content meets the correct Indonesian language rules, is easy to understand for students, and exhibits a fairly strong coherence between sentences. However, there are several revisions submitted by the validator, such as the presence of words or phrases that are still typo, the use of spelling and punctuation that is not yet fully consistent, and several sentences that can be simplified to be more effective and appropriate to the level of thinking of junior high school students, so that by making these linguistic improvements e-LKPD will become more readable, more communicative, and increasingly suitable as digital teaching materials.

These results align with research conducted by Aisyah et al. (2025), which stated that material expert validation yielded perfect CVI and CVR scores, indicating that the material content met the criteria for curriculum suitability, scientific conceptual accuracy, relevance to learning objectives, and compatibility with discovery learning syntax. Research conducted by Nazhifah and Wiyono (2023) also found high creative thinking aspects. In terms of design, although the validity score was also high, the validator provided several suggestions for improvement, such as rearranging inconsistent numbering, adding more informative information to the barcode, and adjusting the sequence of steps to align with discovery learning syntax. Therefore, to examine the initial effectiveness of the revised e-LKPD and to identify any remaining limitations before broader implementation, the study proceeded to the developmental testing stage.

The developmental testing stage aimed to evaluate the initial effectiveness and identify any shortcomings of the e-LKPD before its widespread distribution. The trial was conducted on small groups of students, with teachers acting as facilitators. This stage consisted of one-to-one and small-group evaluations.

Table 12. One-to-one evaluation stage

No.	Student Name	Percentage (%)
1.	MA	67%
2.	STA	93,3%
3.	ANZ	100%
Average percentage and practicality category = 86,76%		

Based on the one-to-one evaluation table, the e-LKPD given to three students was found to be very practical, as evidenced by an average score of 86.76%. However, several students commented that the e-LKPD was very interesting and excellent, but the nanofiber media used was difficult to use and obtain.

Table 13. Small group evaluation stages

No.	Student Name	Percentage (%)
1.	MHA	100%
2.	HRA	100%
3.	SNZ	100%
4.	AGHS	100%
5.	GIL	100%
6.	RA	100%
7.	SRA	93,3%
8.	AAA	93,3%
9.	NZQ	100%
Average percentage and practicality category = 95,53%		

Based on the small group evaluation table, the average score was 95.53%, indicating that the e-LKPD designed by the researcher was highly practical. At this evaluation stage, no revisions were needed based on the input provided. Thus, prototype 2 was declared the final result of the development of the e-LKPD based on discovery learning on nanofiber membrane-assisted filtration material to train students' creative thinking skills.

The results of this study are in line with research conducted by (Lutfi Hidayah, 2025) which obtained a practicality level of 93%, stating that e-LKPD really helps students understand the concept of filtration, makes learning more exciting, and makes it easier for them to follow the steps of the discovery learning process. In addition, students did not provide significant additional revision suggestions because the overall content and appearance were considered good and interesting. (Aisyah et al., 2025) also stated the same thing: that e-LKPD is not only theoretically valid but also accepted and liked by students as an easy-to-use learning medium.

Implementation Stage

At this stage, the E-LKPD is directly integrated into the science learning process in the classroom, fully involving students. At this stage, E-LKPD is integrated directly into the science learning process in the classroom, with full student involvement. This implementation stage uses a quasi-experimental model. Where class VII H is the experimental class consisting of 35 students, and class VII I is the control class, which also consists of 35 students. The teacher acts as a facilitator, guiding students through the digital E-LKPD using the Canva platform. Testing is conducted using pre-test and post-test methods.

Table 14. N-Gain test pre-test and post-test

No.	Indicator	Pre-Test	Post-Test	Average N-gain
1.	<i>fluency</i>	0,55	0,76	0,46 (Medium)
2.	<i>flexibility</i>	0,36	0,64	
3.	<i>originality</i>	0,47	0,67	
4.	<i>elaboration</i>	0,32	0,71	

The N-Gain Score analysis shows a consistent increase in average scores on all critical thinking indicators after the implementation of a large-scale trial. The average N-Gain Value of 0.46 falls within the moderate effectiveness category according to standard criteria, indicating that this learning strategy has a significant positive impact on developing students' creative thinking skills. This finding strengthens the evidence that a discovery-based learning approach, combined with digital media and nanofiber content, can be an effective alternative for improving the quality of science learning. Thus, it can be concluded that the implementation of e-LKPD based on discovery learning with nanofiber support has significantly improved students' creative thinking skills.

The results of this study are in line with research conducted by (Layyina et al., 2021) which obtained an N-gain value of 0.56, categorized as moderate and influenced by several factors, one of which is the age of the students. Research conducted by (Dinanti, 2025) which obtained an N-gain value of 0.47, which is categorized as moderate, also stated that the cause was the limited time to adjust the learning process to support student exploration and creativity. However, this increase shows that e-LKPD can improve students' conceptual mastery and creative thinking skills. These results are also in line with previous research conducted by (Irman et al., 2025) which stated that discovery-based learning can improve students' higher-order thinking skills and creativity.

Evaluation Stage

The evaluation was conducted to review all aspects of the development process and assess the success of the resulting product. Based on expert feedback, the developers made revisions to make the e-LKPD more engaging, communicative, and tailored to students' characteristics.

The final evaluation results show that the developed e-LKPD is valid, practical, and effective, making it suitable for use in the learning process in grade VII of Junior High School. These results indicate that the media can be an effective and contextual learning tool because it integrates local cultural values into students' learning experience. Research conducted by Fitriyana supports these results (2025) which shows the use of E-LKPD based on project-based learning in the sub-material on environmental pollution is declared valid, practical, and effective for use as teaching materials. Meitaza (2024) also stated that the development of E-LKPD based on problem-based learning is necessary to improve students' critical thinking skills by incorporating nanofibers into learning.

CONCLUSION

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Based on the research results, it can be concluded that the development of e-LKPD based on discovery learning for nanofiber membrane-assisted filtration material is feasible and acceptable, and effective in training students' creative thinking skills.

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