



# Development of STEM-based discovery learning student worksheets with Lastek Game to improve physics learning outcomes of grade XI students at SMA Negeri 2 Singkep

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## ABSTRACT

This research was motivated by the low conceptual understanding and learning outcomes of eleventh-grade students at SMA Negeri Dua Singkep, caused by teacher-centered learning and the use of conventional teaching materials. This study aimed to develop a Discovery Learning-based Student Worksheet integrated with the STEM approach and the Lastek game as an innovative learning medium, and to test its feasibility, practicality, and effectiveness in Physics learning. The research method used was Research and Development with the ADDIE model, encompassing the stages of analysis, design, development, implementation, and evaluation. The subjects were eleventh-grade students of SMA Negeri Dua Singkep in the academic year of 2024 to 2025. The results showed that the developed Student Worksheet had a very high level of validity, was easy to use in the learning process, and was effective in improving conceptual understanding and student learning outcomes. Therefore, the STEM-based Discovery Learning Student Worksheet with the Lastek game is deemed suitable for use as a teaching material to support interactive, contextual, and student-centered Physics learning.



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## INTRODUCTION

Physics is a branch of science that plays an important role in shaping students' logical, analytical, and critical thinking skills. Physics education at the high school level aims not only to master theoretical concepts, but also to develop scientific thinking skills and the ability to solve problems related to natural phenomena in everyday life. To achieve these objectives, teaching materials that are systematically designed and in line with the characteristics of students and the requirements of the applicable curriculum are needed. Therefore, validity is an important aspect in teaching material development research because it determines the level of suitability of the product before it is implemented in learning.

Validity indicates the suitability of the LKPD with learning objectives, student characteristics, curriculum, and effective learning design principles. In this study, the validity of STEM-based Discovery Learning LKPD with Lastek games was tested through assessment by subject matter experts and media experts. Validation by subject matter experts focused on the accuracy of scientific concepts, the suitability of content with the curriculum, the integration of Discovery Learning syntax, and the integration of STEM elements covering science, technology, engineering, and mathematics. Meanwhile, validation by media experts emphasized aspects of appearance, readability, clarity of instructions, interactivity, and visual design of the LKPD that supported student motivation and active involvement. The experts' assessment at the ADDIE model development stage served as the basis for revising and refining the product so that the LKPD met the requirements of content, appearance, and pedagogy.

However, based on observations and interviews with physics teachers at Singkep 2 Public High School, it was found that students' conceptual understanding and learning outcomes were still relatively low. This condition indicates a gap between the expected physics learning objectives and classroom learning practices, which are still dominated by a teacher-centered approach and the use of conventional

teaching materials that are not yet optimal in stimulating active student engagement. Several previous studies have also shown that low conceptual understanding and student learning outcomes are caused by the lack of innovative learning models based on exploratory activities for students (Hidayat & Muhamad, 2021). Memorization-based learning makes it difficult for students to relate physics concepts to real-life contexts (Ramli et al., 2024). Therefore, learning innovations are needed that not only emphasize student activity but also systematically facilitate the process of concept discovery through structured exploratory activities.

Although various studies have examined the application of innovative learning models to improve the understanding of physics concepts, most have not fully integrated the STEM approach in the form of contextual teaching materials that are easy to use in the classroom. In addition, the use of educational game-based learning media that directly links physics concepts to students' real experiences is still limited. Previous studies also tended to focus on learning models or media separately, without combining Discovery Learning, the STEM approach, and contextual games in a single learning tool. Thus, there is still a research gap regarding the development of student worksheets that are able to integrate these three components in an integrated manner to improve students' understanding of physics concepts and learning outcomes.

One relevant approach to address this issue is the STEM (Science, Technology, Engineering, and Mathematics)-based Discovery Learning model. This model emphasizes the active involvement of students in discovering concepts through a scientific process integrated with the application of technology, engineering, and mathematics. The STEM approach has been proven effective in improving students' conceptual understanding and problem-solving skills through project-based activities and scientific exploration (Mustakim, 2020). In order to support the implementation of STEM-based Discovery Learning, Student Worksheets (LKPD) are needed to facilitate independent and collaborative student activities. LKPDs serve as learning guides that help students understand the learning steps and lead them in the process of discovering concepts (Maharani, 2017). To increase student motivation and engagement, the development of this LKPD is combined with the Lastek (Science and Technology Kite) game as a contextual learning medium that combines educational games with the application of physics concepts. Through the integration of the Lastek game, it is hoped that learning will become more interesting, interactive, and meaningful for students.

This study only focused on the development and testing of STEM-based Discovery Learning worksheets with Lastek games in Physics learning in class XI of Singkep 2 Public High School. The learning material studied was limited to one basic competency in accordance with the applicable curriculum. The research subjects were limited to one class, while the aspects studied included the validity of the content and appearance of the LKPD, the practicality of its use by teachers and students, and the effectiveness of the LKPD in terms of students' understanding of concepts and learning outcomes. This study did not discuss comparisons with other learning models or the long-term effects on student learning outcomes.

Based on this description, this study aims to develop a Discovery Learning-based Student Worksheet (LKPD) integrated with the STEM approach and Lastek games as teaching materials for Physics for students in class XI at SMA Negeri 2 Singkep. This study aims to test the validity and practicality of the developed LKPD based on expert assessment and teacher and student responses. In addition, this study aims to determine the effectiveness of the STEM-based Discovery Learning LKPD with Lastek games in improving the conceptual understanding and learning outcomes of Physics for grade XI students at SMA Negeri 2 Singkep.

## **RESEARCH METHODS**

This research is a research and development study that aims to produce a product in the form of a STEM-based Discovery Learning Student Worksheet (LKPD) with Lastek games. The development model used is ADDIE, which includes the stages of analysis, design, development, implementation, and evaluation. This model was chosen because it has a systematic and flexible development flow, making it suitable for developing teaching materials that are in line with the needs of students and the objectives of Physics learning. The research was conducted at SMA Negeri 2

Singkep in the odd semester of the 2025-2026 academic year. The research subjects were grade XI students who were involved in limited trials of the LKPD, while the validators consisted of education lecturers and Physics teachers who acted as subject matter experts and media experts. The research population included all grade XI students, with the sample determined purposively according to the product trial requirements.

Data collection techniques included interviews and observations at the needs analysis stage, questionnaires to measure validity and user responses, and tests to see student learning outcomes after using the LKPD. The research instruments used consisted of expert validation sheets, student response questionnaires, learning implementation sheets, and learning outcome tests compiled in accordance with learning indicators. Data analysis was conducted using quantitative and qualitative descriptive methods. The validity data of the LKPD was analyzed using a percentage technique based on the scores given by material experts and media experts to determine the level of product feasibility. Suggestions and comments from validators were analyzed qualitatively as a basis for revising and improving the LKPD before it was used in learning. The results of this analysis form the basis for determining the feasibility of the STEM-based Discovery Learning LKPD with Lastek games as teaching materials for Physics.

## RESULTS AND DISCUSSION

### Results

The development of this STEM-based Discovery Learning LKPD was carried out in several stages, namely needs analysis, planning, development, and validation. In the process, the involvement of validators was very important, including subject matter experts, media experts, and observers. The production stage began with the formulation of ideas to produce the initial LKPD product. Next, the initial product was validated by experts to assess its feasibility before being used in learning. The research method used the ADDIE development model, which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. Through these stages, a STEM-based Discovery Learning LKPD with Lastek games was developed to support the learning process.

### Analysis Stage

The analysis stage is the first step in research and development aimed at identifying learning needs in Physics, particularly in the subject of Elasticity and Hooke's Law in grade XI at Singkep 2 Public High School. The analysis was conducted through observation, interviews with teachers, and a review of the curriculum to obtain a realistic picture of the learning conditions.

The results of the analysis show that the learning process is still dominated by teachers and the teaching materials used are limited to textbooks. Students are not given the opportunity to explore concepts independently, and learning does not integrate the STEM approach or educational games that can increase learning motivation. The average score of student learning outcomes is still below the minimum passing grade of 70, especially in understanding the relationship between force, length increase, and spring constant according to Hooke's Law.

Based on these findings, there is a need to develop STEM-based Discovery Learning worksheets with Lastek games to encourage students to actively discover concepts through scientific experimentation and problem solving. This product is expected to help teachers create more interactive, contextual, and meaningful physics lessons for students.

**Table 1. Average Daily Assessment Scores of Students on Elasticity Material**

Aspects Assessed	Average PH Value 2024	Score Change from Previous Year	Average PH Value 2023
Understanding the Concept of Elasticity and Hooke's Law	67,85	Down 2.15	70,00

*Source: Daily Assessment Documents for Physics at Singkep State High School 2 (2023/2024 Academic Year)*

The results of observations conducted by researchers during physics lessons at Singkep 2 Public High School show that student motivation and active participation are still relatively low. Most students still wait for instructions from the teacher when carrying out learning activities, including in laboratory

practice. This passive attitude results in low enthusiasm for cooperation and independence in discovering concepts, even though the physics material, especially Elasticity and Hooke's Law, requires the active involvement of students to understand the relationship between force, increase in length, and spring constant through experimental activities.

### Design Stage

The design stage is a follow-up stage after the analysis of needs, student characteristics, and curriculum has been carried out. At this stage, researchers develop a preliminary design for STEM-based Discovery Learning worksheets using Lastek games based on the results of the previous analysis. The LKPD is designed as a learning guide that contains learning outcomes and objectives, student activities, and evaluations in line with the Merdeka Curriculum and the context of Physics learning at SMA Negeri 2 Singkep. The LKPD is compiled systematically by considering the structure of the material, the sequence of learning activities, the design layout, and the integration of game elements to create an interactive and meaningful learning experience.

The structure and content of the LKPD are tailored to the characteristics of the students and the learning needs in the field, integrating the Discovery Learning model and the STEM approach. The LKPD contains learning objectives, usage instructions, core material, experiments, and Lastek games that guide students in discovering the concept of elasticity, sparking questions, reflection, and assessment. Through its communicative and contextual design, this LKPD serves as a student-centered learning tool that supports the development of critical thinking skills and conceptual understanding through discovery activities and educational games.

### Development Stage (*Development*)

The development stage aims to produce STEM-based Discovery Learning LKPDs with Lastek games as innovative digital-based learning products. The LKPDs are developed using Microsoft Word and Canva applications, then compiled in digital format so that they can be used flexibly both online and offline. All components of the LKPD are designed based on an analysis of student needs and the characteristics of elasticity material, integrating STEM elements and Lastek educational games to increase motivation, active engagement, and understanding of physics concepts.

The development process began with the preparation of a prototype, which was consulted with the supervising lecturer, followed by a validation stage by subject matter experts and media experts. Validation was carried out using a questionnaire instrument to assess the suitability of the content, the appropriateness of the application of the STEM-based Discovery Learning model, the media display, and the integration of Lastek games. Input from validators, such as improvements to the glossary and clarity of the relationship between experimental activities and games, was used as a basis for revising and improving the LKPD to make it more systematic, contextual, and easier for students to understand.

After revision, the second stage of validation showed that the STEM-based Discovery Learning LKPD and Lastek game were deemed very suitable for use in Physics lessons for grade XI at Singkep 2 Public High School. The validators assessed that the LKPD was able to combine experimental activities and games in a contextual manner, guiding students to discover the concept of elasticity through a scientific discovery process. It was also considered innovative because it integrated the Lastek game into a STEM approach that is relevant to the demands of 21st-century learning.

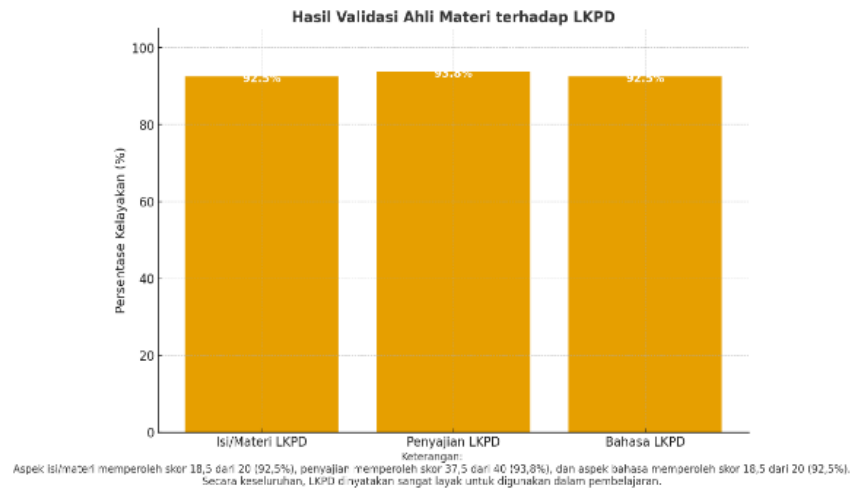
The detailed results of the LKPD feasibility validation by subject matter experts can be seen in Table 2 below.

**Table 2. Assessment of Material Expert Validation Results**

No	Assessment Aspects	Mean	Percentage (%)	Interpretasi
1	Contents of LKPD	18,5	92,5%	Highly Recommended
2	Presentation of LKPD	37,5	93,8%	Highly Recommended
3	LKPD Language	18,5	92,5%	Highly Recommended
	<b>Quantity</b>	<b>74,5</b>	<b>93,1%</b>	<b>Highly Recommended</b>

Source: *Researcher's findings*

Visually, the results of the assessment of the suitability of digital teaching modules by subject matter experts are shown in the bar chart in the following figure:



**Figure 1. Diagram of Material Expert Feasibility Results**

Based on the results of validation by subject matter experts on the STEM-based Discovery Learning LKPD and Lastek games on the subject of Elasticity and Hooke's Law, it was found that the products developed are very suitable for use in Physics lessons at Singkep 2 Public High School. The content aspect received a score of 18 out of 20 (90%), indicating the suitability of the material with the learning outcomes of the Merdeka Curriculum, the accuracy of physics concepts, and the integration of STEM elements that are able to guide students to discover the concept of elasticity through contextual experiments and Lastek games.

The presentation aspect scored 38 out of 40 (95%) and the language aspect scored 19 out of 20 (95%), both of which are considered highly feasible. The presentation of the LKPD is considered systematic, interesting, and equipped with clear experimental procedures and game instructions, while the use of language is considered communicative, appropriate for the level of understanding of high school students, and maintains the accuracy of scientific terms. Overall, the average suitability of the LKPD reached 93.3%, making this product suitable for implementation to improve the conceptual understanding and learning outcomes of Grade XI.B students at SMA Negeri 2 Singkep in the subject of Elasticity.

### Results of Media Expert Feasibility Study

Media validation in the development of STEM-based Discovery Learning worksheets and Lastek games was carried out by experts with expertise in educational technology and learning design. The involvement of media experts aimed to ensure the suitability of the worksheets in terms of visual appearance, readability, ease of navigation, and conformity with the principles of digital and print learning media design. The results of the first stage of validation on August 14, 2025, showed that the LKPD was deemed suitable for use, although it still required improvements in terms of technical aspects and visual aesthetics.

Input from the validators included the addition of interactive navigation in the form of hyperlinks, the embedding of QR codes in Lastek experiments and games linked to videos or physics simulations, and improvements to design consistency, such as color, layout, and font size. These suggestions were used as a basis for revisions to improve visual appeal, flexibility of use, and students' understanding of the learning activity flow.

After revision, the second stage of validation on August 22, 2025 showed a significant improvement in the quality of the media's appearance and functionality. The validator stated that the LKPD was very suitable for use due to its consistent visual design, clear navigation, and integration of

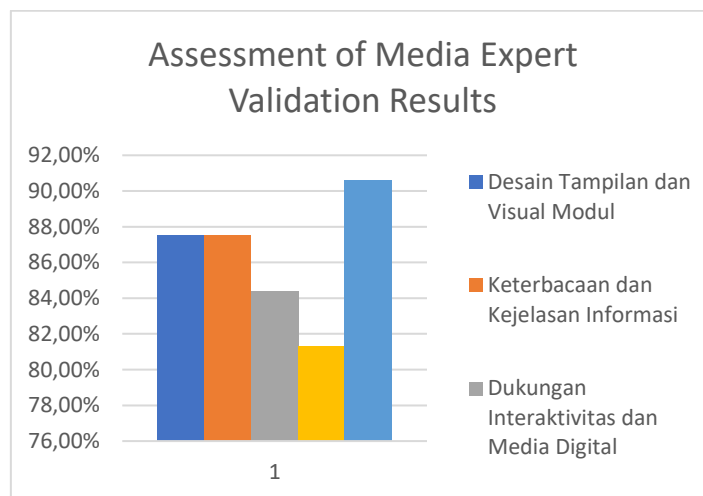
QR codes and Lastek games that strengthened student engagement in the process of discovering the concept of elasticity. A positive assessment was also given by a physics teacher at Singkep 2 Public High School as a media expert, who considered the LKPD to be interesting, easy to use, and in line with the characteristics of students and the needs of STEM-based and discovery learning.

Thus, the results of the second stage of validation by media experts show that the STEM-based Discovery Learning LKPD and Lastek game have met the criteria of being highly feasible for implementation in physics learning. The validation results data can be seen in Table 3 below.

**Table 3. Assessment of Media Expert Validation Results**

No	Assessment Aspects	Maximum Score	Validator 1	Validator 2	average	Percentage (%)	Interpretasi
1	Media Design and Display	16	14	14	14	87,5%	Highly Worth It
2	Readability and Clarity of Information	16	14	14	14	87,5%	Highly Worth It
3	Interactivity and Digital Media Support	16	13	14	13,5	84,4%	Worthy
4	Consistency and Attractiveness of Presentation	16	13	13	13	81,3%	Worthy
5	Conformity with Learning Media Principles	16	14	15	14,5	90,6%	Highly Worth It
	<b>Quantity</b>	<b>84</b>	<b>68</b>	<b>70</b>	<b>69</b>	<b>86,25%</b>	<b>Highly Worth It</b>

The results of the feasibility study of digital teaching modules by media experts can be seen visually in Figure 2 below:



**Figure 2. Media Expert Results Diagram**

Based on the tables and diagrams of the two validators' assessments, data on the feasibility of the developed LKPD learning materials was obtained in five main aspects, namely display and visual design, readability and clarity of information, support for interactivity and digital media, consistency and attractiveness of presentation, and suitability with learning media principles. The aspects of display design and readability each received an average score of 14 out of 16 (87.5%) in the Very Suitable category, while the aspect of interactivity support received a score of 13.5 (84.4%) and consistency of presentation received a score of 13 (81.3%), both of which were in the Suitable category. The aspect of suitability with learning media principles received the highest score, namely 14.5 out of 16 (90.6%) with a Very Suitable category.

Overall, the LKPD received an average score of 69 out of a maximum score of 84 with a percentage of 86.25%, thus falling into the Very Suitable category. These results indicate that the developed LKPD has met the quality standards for learning media in terms of appearance, readability, interactivity, and pedagogical suitability, so that it can be used effectively to support Physics learning and improve the conceptual understanding and learning outcomes of grade XI students.

## Discussion

The development of Student Worksheets (LKPD) based on Discovery Learning in Physics was carried out by adapting the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation, because it has systematic and flexible steps in producing valid, practical, and effective learning products. The developed LKPD combines the Discovery Learning model with the integration of STEM elements and Lastek educational game elements to create interactive and meaningful Physics learning. Through discovery-based learning stages, students are guided to discover Physics concepts independently through experiments and investigations, thereby improving conceptual understanding and learning outcomes. The integration of the STEM approach and Lastek games also aims to foster critical, creative, and collaborative thinking skills and increase student motivation to learn. The final product is an interactive digital LKPD equipped with visual illustrations, simulations, and reflection spaces, which has the potential to support the achievement of 21st-century competencies and help teachers deliver contextual and student-centered physics learning.

The high validation score of the STEM-based Discovery Learning worksheet with Lastek games shows that the developed product has comprehensively met the criteria for content, pedagogical, and media feasibility. This is due to the alignment between the learning objectives, Discovery Learning syntax, and the integration of STEM elements that are systematically designed in each worksheet activity. In addition, the use of the Lastek game as a learning context provides added value because it is able to link abstract physics concepts with the concrete experiences of students. These findings are in line with the research by Safitri et al. (2023) which states that discovery-based and STEM-based teaching materials tend to obtain high validity when designed in accordance with the characteristics of students and curriculum requirements. Thus, the high validation score reflects the quality of the worksheet design, which is not only conceptually correct but also relevant and applicable in physics learning.

The results of this study support Bruner's constructivism theory, which emphasizes the importance of students' active involvement in discovering concepts through the investigation process. The integration of Discovery Learning and STEM in LKPD reinforces Suastra (2017) findings, which show that STEM-based learning effectively improves students' conceptual understanding and problem-solving skills in Physics. In addition, this study complements the findings of Zainuddin et al. (2020) by adding educational games as a contextual medium, which previously had not been widely combined in an integrated manner in STEM-based LKPD. Thus, this study not only confirms the effectiveness of the Discovery Learning and STEM approaches but also offers novelty through the integration of Lastek games as a motivator and to increase student engagement in learning.

The findings of this study have important implications for physics learning, particularly in efforts to improve students' conceptual understanding and learning outcomes through a more active and contextual approach. STEM-based Discovery Learning worksheets with Lastek games provide alternative teaching materials that can shift learning from teacher-centered to student-centered. This is in line with the opinion of Rohmah & Sumarsih (2017) and reinforced by the results of Rusmono (2020) research, which confirms that STEM learning encourages students' critical, collaborative, and creative thinking skills. Thus, the use of this LKPD not only has an impact on improving cognitive learning outcomes but also supports the development of 21st-century competencies and the Pancasila Student Profile in Physics learning in high school.

The product development process was carried out systematically through the five stages of the ADDIE model, namely: needs analysis, design, development, implementation, and evaluation. Each stage was carried out sequentially to ensure that the resulting LKPD had high quality in terms of content, appearance, and usefulness in supporting discovery-based Physics learning (Sari et al., 2021).

## Analysis Stage

The analysis stage is the first step in the research and development process, which aims to identify the needs, problems, and actual conditions of Physics learning at Singkep 2 Public High School. The analysis was conducted to ensure that the product developed, namely the STEM-based Discovery Learning worksheet with Lastek games, was truly in line with the needs of students, curriculum requirements, and the characteristics of the Physics subject.

Based on the results of observations and interviews with subject teachers, it was found that Physics learning on the topics of Elasticity and Hooke's Law was still teacher-centered (teacher-centered learning) with a predominance of lectures and exercises. The use of teaching materials such as textbooks has not been able to help students understand the concepts in depth because they are abstract and not interactive enough. This condition results in low conceptual understanding and learning outcomes for students, as reflected in the average daily test scores below the minimum passing grade of 70.

In addition, the ongoing learning has not fully emphasized the development of higher-order thinking skills (HOTS) and the integration of the STEM (Science, Technology, Engineering, and Mathematics) approach. In fact, STEM-based learning has been proven effective in fostering students' critical, collaborative, and creative thinking skills through scientific activities and contextual problem solving (Susiloningsih et al., 2025)

Analysis of student characteristics also shows that most students have a high interest in experimental activities and educational games. However, they need systematic guidance to be able to discover concepts independently. Therefore, the development of STEM-based Discovery Learning worksheets with Lastek games is a strategic solution to create more active, interesting, and meaningful Physics learning. The discovery learning approach allows students to discover scientific principles themselves through exploration and reasoning, while game-based learning elements such as Lastek increase motivation and engagement in learning (Waruwu, 2024).

In addition to considering student characteristics, curriculum analysis is also conducted by examining the Merdeka Curriculum, which emphasizes mastery of competencies through contextual and project-based learning. This curriculum provides space for the integration of the STEM approach and the application of learning models that foster students' creativity and problem-solving skills (Afdalia et al., 2020).

Based on the results of this analysis, it can be concluded that the development of STEM-based Discovery Learning worksheets using Lastek games is highly relevant for application in physics education. These worksheets are expected to overcome the problems of low conceptual understanding and learning outcomes among students through learning that emphasizes active involvement, scientific exploration, and strengthening the connection between physics concepts and real-life phenomena.

## Design Phase

At the analysis stage, the main objective is to identify the potential and problems that occur in the physics learning process at Singkep 2 Public High School. This stage is carried out through three main activities, namely needs analysis, student characteristics analysis, and curriculum analysis. These three aspects are an important basis for designing STEM-based Discovery Learning worksheets and contextual, interesting, and appropriate lastek games that meet the real needs and conditions in the field.

The results of the needs analysis show that physics learning at SMA Negeri 2 Singkep is still dominated by lecture and exercise methods with limited use of learning media, such as textbooks and blackboards. This condition causes the learning process to tend to be teacher-centered and does not fully provide opportunities for students to discover physics concepts themselves through direct learning experiences. This type of one-way learning has proven to be ineffective in developing students' critical thinking skills and conceptual understanding (Syavira, 2021).

Observations show that most students have difficulty understanding abstract concepts in physics, such as motion, force, and energy. Therefore, learning media that can provide active, exploratory, and meaningful learning experiences are needed. The discovery learning model is one

solution because it provides opportunities for students to discover concepts through investigation and experimentation (Anggraini, 2023). In line with this, the STEM (Science, Technology, Engineering, and Mathematics) approach is also considered relevant because it integrates various disciplines to improve students' critical thinking and problem-solving skills (Wati et al., 2017).

In addition, analysis of student characteristics shows that students at Singkep 2 Public High School have a high interest in digital technology and game-based learning activities. However, they tend to be passive during learning due to a lack of variety in media and interactive activities. Therefore, the development of LKPD that combines elements of educational games (Lastek) is expected to increase student motivation and active involvement in the learning process. (Jufrida et al., 2022).

Meanwhile, curriculum analysis was conducted by reviewing the independent curriculum documents and learning outcomes for the 11th grade physics subject. Based on the results of this analysis, it was found that the competencies to be achieved include the ability to understand concepts, apply principles, and analyze physics phenomena in everyday life. Thus, the development of STEM-based Discovery Learning worksheets is aimed at supporting learning that emphasizes the process of discovering concepts and their application in real-world contexts (Fatimah et al., 2019).

The findings of the above analysis reinforce the urgency of developing STEM-based Discovery Learning LKPD and Lastek games as innovative learning media that can overcome the problems of learning Physics in schools. Discovery-based learning integrated with contextual activities has been proven effective in improving students' conceptual understanding and learning outcomes (Karo-Karo & Rohani, 2018). In line with the results of research by Wulandari & Indrawati (2021), The development of discovery-based teaching tools can foster positive character and motivation to learn through an active and meaningful learning process. Thus, the LKPD developed in this study has great potential to increase student engagement, deepen their understanding of physics concepts, and shape their scientific thinking skills.

### **Development Stage**

The development stage is a crucial process in this research because it aims to produce and test the quality of STEM-based Discovery Learning worksheets and Lastek games that were designed in the previous stage. The main focus at this stage is to evaluate the validity, practicality, and effectiveness of the developed products through a series of expert validation activities, limited trials, and feedback analysis from teachers and students. Thus, this stage serves as the basis for ensuring that the resulting LKPDs are truly suitable for use in Physics learning (Hidayat & Muhamad, 2021).

The validation process is carried out by subject matter experts and media experts to assess the quality of LKPD from various aspects. Subject matter experts focus on the suitability of the content with basic physics competencies, the accuracy of the Discovery Learning model application, and the integration of STEM elements in each learning activity. Meanwhile, media experts focus on the appearance, attractiveness of the design, clarity of instructions, and interactivity of the LKPD. The experts' assessments are an important benchmark to ensure that the product meets the standards of digital learning media (Nugroho & Wibowo, 2020).

Next, a practical test was conducted by giving the LKPD to physics teachers and a number of 11th grade students to obtain feedback on the ease of use and effectiveness of implementing the LKPD in the classroom. Teachers responded positively to the clarity of discovery-based learning steps, the flow of experimental activities, and the integration of game elements (Lastek), which were considered capable of fostering student motivation and active involvement. This is in line with Widiyono's findings (2021) which states that the application of STEM-based Discovery Learning significantly improves students' conceptual understanding and interest in learning Physics.

A limited trial was conducted to observe the implementation of LKPD in the classroom. The results of the observation showed that students were more enthusiastic, actively participated in discussions, and were able to relate physics concepts to real-life applications. The educational game element (Lastek) was also proven to increase participation and create a fun learning atmosphere. These findings are in line with the research by Nisa et al. (2020) which confirms that integrating game elements into STEM learning can increase student motivation and creativity.

The results of validation and testing show that STEM-based Discovery Learning LKPD and Lastek games meet the criteria of being feasible, practical, and effective for use in physics learning. The developed product not only facilitates conceptual understanding but also trains students' critical and collaborative thinking skills—important competencies in 21st-century learning (Purwono, 2014). Thus, this development stage provides a strong foundation for the implementation stage in the ADDIE model to test the effectiveness of LKPD in a broader classroom context.

### **Expert Analysis Materials**

The assessment by subject matter experts of the STEM-based Discovery Learning worksheets and Lastek games focused on several key aspects, namely the suitability of learning objectives, the appropriateness and depth of the physics material, the structure and systematics of the worksheets, the integration of the Discovery Learning model and the STEM approach, and the clarity of the learning activity steps. The validation results show that the developed LKPD has met the criteria for excellent feasibility and is considered suitable for use as a physics learning tool in high schools. This is demonstrated by the clarity of the learning objectives formulation in line with the Merdeka Curriculum Learning Outcomes, the accuracy of the physics concepts, and the completeness of the LKPD components, which are systematically arranged (Kusumaningtyas et al., 2024).

Subject matter experts assessed that the integration of STEM elements in discovery activities has added value to the learning process, as it helps students relate physics concepts to the application of technology and everyday life. In addition, the inclusion of game elements (Lastek) is seen as capable of increasing students' motivation and interest in learning through experimental activities that require active involvement. This assessment is supported by the findings of Kiswari et al. (2023), whose research on the development of STEM-based E-LKPD demonstrates that such learning materials are feasible, effective, and practical for classroom use. The study reported a moderate improvement in students' learning outcomes (N-Gain = 0.64) with a high effect size, as well as very positive responses from both teachers and students, indicating that STEM-based E-LKPD can effectively support active and meaningful learning.

An important input from subject matter experts is the need to add a glossary of terms and a summary of physics concepts, especially terms used in the context of STEM or discovery activities, so that students can understand the terminology more accurately. The addition of these features aims to strengthen conceptual understanding and make it easier for teachers to direct learning activities in a contextual manner. This is in line with the opinion of Nugroho & Wibowo (2020) that good teaching materials must be equipped with components that support understanding, such as glossaries, summaries, and usage guides, so that students can understand the learning content in a focused and systematic manner.

Expert content validation is conducted to ensure the suitability of content, accuracy of concepts, and relevance of learning activities to the objectives of discovery learning and the STEM approach before the product is implemented in the classroom. Content validation by experts is an important step to ensure content validity because it involves professional assessment of the accuracy of concepts and the integration of content with learning outcomes. The results of expert content validation confirm that STEM-based discovery learning worksheets and lastek games have met academic and pedagogical standards and have the potential to support more active, contextual, and student-centered physics learning.

### **Media Expert Analysis**

The assessment by media experts of the STEM-based Discovery Learning LKPD and Lastek game shows that it is highly suitable for use in Physics learning. The aspects assessed include the design and visuals of the LKPD, the integration of layout and graphic elements, ease of navigation and interactivity, learning technology support, and the suitability of the media design to the characteristics of 21st-century learners. The validation results show that the developed LKPDs have met the principles of readability, design consistency, and ease of use, and are able to support the implementation of discovery-based learning in an interesting and interactive manner (Nugraha et al., 2020).

The interactive aspect of LKPD is realized through a digital display that contains links to experiment simulations, educational videos, and game-based activities (Lastek) that can be accessed using simple technological devices. LKPD is also designed with a proportional layout and harmonious color selection to maintain students' visual focus and strengthen cognitive engagement during the learning process. Aesthetically and ergonomically consistent media design has been proven to influence student comfort and motivation to learn (Syavira, 2021).

The LKPD is equipped with a QR (Quick Response) code that links to supporting resources such as experiment videos and simple STEM tool guides. This technological integration supports learning accessibility both online and offline, allowing the LKPD to be used flexibly by teachers and students. This type of media innovation is in line with the findings of Hartini et al. (2017) which states that interactive and easily accessible technology-based teaching materials can increase student participation and learning outcomes in science education.

In the context of discovery learning, attractive displays and visual media also play an important role in creating meaningful learning experiences. Interactive and contextual learning media can improve students' scientific thinking skills, because students not only observe but also actively explore concepts through visual and experimental experiences. Therefore, media validation is a strategic step to ensure that the LKPD developed is not only aesthetically appealing, but also pedagogically and contextually relevant to physics learning.

The results of media expert validation indicate that the STEM-based discovery learning LKPD and the Lastek game have met the criteria for excellent media feasibility. This LKPD is considered effective in supporting learning that emphasizes interactivity, contextuality, and student creativity, and can serve as a guide for teachers in implementing discovery-based learning aligned with the requirements of the Pancasila Student Profile and 21st-century competencies.

## **CONCLUSION**

The Development Process of STEM-Based Discovery Learning Worksheets and Lastek Games. The products developed are STEM-based Discovery Learning Worksheets and Lastek games for the Physics subject in grade XI at Singkep 2 Public High School. The development was carried out using the ADDIE model, which consists of five stages, namely: Analysis, Design, Development, Implementation, and Evaluation. In the analysis stage, learning needs, student characteristics, and the suitability of the material with the STEM approach and Discovery Learning model were identified. In the design and development stage, the LKPD was designed to facilitate students in discovering concepts through experiments and problem-solving based on Lastek games. Next, the implementation and evaluation stages were carried out to assess the feasibility, practicality, and effectiveness of the product in supporting the improvement of understanding and learning outcomes in physics.

Based on the results of research and development, the resulting STEM-based Discovery Learning LKPD and Lastek games obtained a very valid criterion with an average validation percentage of 92%. These results indicate that the content, media display, and suitability of the learning components with the Discovery Learning model and STEM approach have met the feasibility standards for use in the physics learning process in high schools. This high validity confirms that the LKPD is in line with the principles of constructivism and is able to facilitate students in discovering concepts through meaningful scientific activities.

This study has limitations in the scope of the trial, which only involved 11th grade students in one school, and the development of LKPD, which is still limited to certain physics materials, so that the results of the study cannot be generalized widely. In addition, product evaluation emphasizes validity, while the effectiveness of higher-order thinking skills in students has not been studied in depth. Therefore, further research is recommended to conduct trials on a broader scale involving various school and student characteristics, develop LKPD on other physics materials, and examine the effect of using STEM-based Discovery Learning LKPD and Lastek games on students' higher-order thinking and problem-solving skills, including through the development of digital-based learning media.

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