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Practicality of Student Worksheets (LKS) on Sound Waves Based on a Generative Learning Model Using Cognitive Conflict Strategies to Facilitate Creative Thinking Skills in 11th Grade High School Students

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ABSTRACT

Students' creative thinking skills are in the moderate category with percentages in the indicators of fluency (46%), flexibility (55%), originality (58%), and elaboration (43%). Worksheets are the main teaching material in the learning process. The worksheets used are not yet optimal in facilitating creative thinking skills because the learning model applied does not encourage the exploration of creative ideas. The purpose of this study is to produce valid and practical sound wave worksheets based on a generative model to facilitate the creative thinking skills of grade XI students. This research method is Research and Development with a 4-D model (define, design, develop, and disseminate). The research subjects were five physics experts from FMIPA UNP as validators, three physics practitioners, and 23 users from class XI SMAN Padang. The research instruments were validation and practicality sheets analyzed using Aiken's V index and percentage techniques. The experts assessed the validity of the worksheets in terms of the substance of the learning content (0.83), visual communication display (0.93), worksheet content (0.91), generative learning model syntax (0.87), and creative thinking indicators (0.88). Practitioners and users have assessed the LKS as very practical, with scores of 88% and 93%. It was concluded that the generative model-based sound wave LKS developed is highly valid and practical. Practitioners should use the LKS, and users should use it to facilitate the creative thinking skills of 11th grade students.

Keywords :LKS, Generative Model, Creative Thinking, Sound Waves, Validity, Practicality.

I. INTRODUCTION

Education serves as a conscious and planned effort to develop human potential through the teaching process. Education aims not only to increase knowledge, but also to shape the values, skills, character, and attitudes needed in social life. [1]. On the other hand, learning involves an interactive process between students, educators, and learning resources in a dynamic learning environment. These two processes complement each other to create superior human resources and contribute to the progress of the nation.

The learning process must have a relevant context, be student-centered, provide guidance, and be relevant to the way of life of the general public. Learning must be able to inspire students to learn, provide aspiration, provide challenges, and foster student creativity. [2]. The right learning model can increase student engagement and help them achieve learning objectives more easily and effectively. The learning model used in teaching must encourage students to actively participate, focus, be independent, and be creative in order to build their knowledge in the learning process.

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However, conditions in the field show a gap between the ideal situation and the reality of learning. Based on preliminary studies through open-ended questions distributed to 11th grade students, it was found that the worksheets used were not very interesting to students and did not comply with the guidelines for creating worksheets according to Depdiknas 2008. The learning model used in schools does not encourage students to build new knowledge, as it remains focused on explanations from educators, resulting in students being less active in constructing their own knowledge. These suboptimal learning conditions have an impact on students' creative thinking skills.

Initial data shows that students' creative thinking skills are in the moderate category with a percentage of fluency (46%), flexibility (55%), originality (58%), and elaboration (43%). Creative thinking skills are a very important aspect that students must have in the physics learning process, especially in solving problems that require more in-depth alternative solutions. The results of the initial data suggest that the worksheets available in schools are not yet optimal in facilitating students' creative thinking skills. To overcome this problem, it is necessary to first understand the nature of physics learning.

Physics is the science of matter and energy, including the principles governing the motion of particles and the interaction of particles, atoms, molecules, gases, liquids, and solids, both large and small. Almost every human activity involves physics, whether in daily activities or natural phenomena. [3]. The most important elements in good learning are (1) students who learn, (2) teachers who teach, (3) teaching materials, and (4) the relationship between teachers and students. In learning physics, the most important thing is students who actively learn physics. [4]. Therefore, all teachers' efforts must be directed towards helping and encouraging students to study physics on their own. Communication between teachers and students is very important so that they can help each other.

Physics is one of the subjects in the science group that focuses on developing inductive and deductive analytical thinking skills. [5]. Physics is considered important to teach because it relates to everyday life. Learning physics is nothing more than understanding what exists and what happens around us. By understanding the concepts and principles of physics, it is easier for us to carry out and overcome problems in real life. To achieve an optimal understanding of physics concepts, teaching materials are needed that can facilitate students to learn independently and actively.

Student worksheets are teaching materials in the form of worksheets containing guidelines that have been arranged in such a way as to make it easier for students to learn the teaching material independently, thereby creating effective interaction between students and enhancing their creativity [6]. Worksheets are very effective in overcoming students' lack of interest in learning. This is because worksheets are designed to include attractive pictures, the latest information on the subject matter, and questions [7]. Worksheets are designed to be used to educate students to learn independently, be confident, disciplined, responsible, and able to make decisions. LKS has several functions for students, namely: (a) as a supporting resource in creating an effective teaching and learning situation, (b) as a supporting resource in complementing the teaching and learning situation to attract students' attention, (c) as a source of student activities to make them more active in learning, (d) as a means of fostering orderly and continuous thinking in students. To optimize the function of LKS in facilitating student activity and independence, integration with an appropriate learning model is required, one of which is generative learning.

Generative learning means that students acquire knowledge by constructing their own knowledge based on new experiences and linking it to their existing knowledge [8]. Generative learning is said to support the achievement of learning objectives, where students actively participate directly in the learning process and construct meaning from information that becomes prior knowledge and experiences possessed by students. Cognitive conflict is a challenging phase for students to test the validity of their initial conceptions compared to those of scientists [9]. Cognitive conflict has three key elements in the learning process, namely collaboration, reformulation, and awareness. The advantages of the cognitive conflict strategy are that it pays attention to students' conceptions, pays attention to the relationships between concepts, actively involves students, and helps them understand concepts [10]. The stages of generative learning consist of six stages in Table 1 [11]:

Table 1. Stages of the Generative Learning Model

Stages	Description
Orientation	Teachers motivate students, introduce rules, explain cognitive conflict strategies, develop process skills and structured activities, emphasize the importance of thinking processes and self-development, emphasize the importance of material, and relate lessons to life.
Cognitive Conflict	Teachers raise issues through videos, discussions, questions, information, or phenomena triggered by anomalous data or information that contradicts intuitive knowledge, containing cognitive conflicts to challenge students' initial understanding and encourage conceptual change.
Disclosure	Teachers act as facilitators who provoke, listen to, and respond to ideas, observe and identify difficulties in thinking, help improve understanding, provide experiences that help students test and revise their understanding, and ask questions to reflect on students' ideas. Ideas can be formulated in the form of hypotheses. This approach helps students develop critical thinking skills and more meaningful solutions.
Construc	Students build scientific concepts based on ideas that have been presented and classify ideas. Students explore or collect data and analyze data to test hypotheses. Teachers facilitate student discussions. Teachers provide experiences to help students test and revise their understanding through group discussions or experiments, or problem-solving tasks. Students help them overcome confusion and build new understanding based on their learning experiences.
Application	Students implement ideas and receive scaffolding. Teachers give students the opportunity to use new concepts in other contexts, then test the validity of the concepts by solving problems or example questions. Teachers listen to the concepts put forward by students, then provide feedback or follow-up questions to deepen understanding.
Reflection and Evaluation	Reflection is a response to activities, newly acquired knowledge, and evaluation of the process, as well as correction of weaknesses in the knowledge-building process. Teachers assess the extent to which students have understood and applied the concepts they have learned. Teachers ask questions that guide students to reflect on and evaluate their own ideas.

(Source: Ref[11])

This six-stage generative learning model comprehensively facilitates deep and meaningful conceptual change. This approach recognizes that students come to class with initial conceptions that need to be confronted with empirical evidence, tested through investigation, and reconstructed into more scientific understandings. The role of the teacher as a responsive facilitator, rather than as the sole source of knowledge, empowers students to take responsibility for their own learning and develop the higher-order thinking skills essential for lifelong learning. The advantages of the generative learning model include: providing opportunities for students to express their thoughts and understanding, practicing concept communication, practicing respect for others' ideas, providing opportunities to care about initial conceptions, providing opportunities to construct their own knowledge, creating an active classroom atmosphere, and making teachers creative and skilled [12].

The best creative thinking skills according to [13] there are five, namely a) analysis. Before thinking creatively about something, you must first be prepared to understand it. This requires flexibility to look at something carefully in order to understand its meaning. Whether you are observing a text, a set of data, a lesson plan, or a mathematical equation, you need to be prepared to analyze it first; b) open-mindedness. Creativity involves thinking about things in new ways in the context of a question. You must set aside any assumptions or biases you have and see things in a completely new way. By approaching a problem with an open mind, you give yourself the opportunity to think creatively; c) problem solving. Employers don't just want to hire creative people because they look impressive. They need creative employees who can help them solve work-related problems. Therefore, when applying for a job, highlight your ability not only to think creatively but also to use your creativity in solving important problems; d) organization. This influence sounds like a guess: aren't creative people known for being a little disorganized? In fact, organization is a very important part of creativity. While you may need to be a little messy when trying out new ideas, you must then organize your ideas so that others can understand and follow your vision. The ability to formulate an action plan with clear goals and deadlines is essential; e) communication. People will only appreciate your creative ideas or solutions if you are able to communicate them effectively to your colleagues (or to your clients or suppliers). Therefore, you must have strong written and verbal communication skills. Doyle (2019) also emphasizes that you must be prepared to understand a situation thoroughly before thinking creatively about it. Therefore, you must also be an honest listener. By asking the right questions and understanding the problem, you will be able to find unique solutions.

Creative thinking skills are a person's ability to come up with new and original ideas or concepts to find solutions to problems, thereby obtaining several alternative answers [14]. From this statement, it can be concluded that creative thinking skills are the ability to generate new ideas, innovative solutions, or unique approaches to problems or challenges. Indicators In addition, the indicators for assessing creative thinking skills according to [15] namely: a) fluency, measuring the total number of relevant responses in a creativity test. The more responses given, the higher the score. This is a fundamental aspect, because scores for other aspects depend on responses that are considered relevant. b) Originality, which measures how unique and uncommon a response is compared to common responses. More imaginative and unusual responses receive higher scores. If someone combines several concepts into a new idea, their originality score will be higher. c) Flexibility, which assesses the ability to synthesize and organize information. A high score indicates the ability to capture the essence of information, identify important points, and provide a more in-depth perspective. d) Elaboration measures how much detail and complexity is added to a response. More detailed and imaginative responses indicate a higher level of creativity.

II. METHOD

This study uses a Research and Development approach aimed at producing and validating products [16]. The development model used is the 4-D model proposed by Thiagarajan (1974), which consists of four stages: Define, Design , Development, dan DisseminateIn this study, the stages were limited to the Development stage. The research subjects consisted of five Physics experts from the Faculty of Mathematics and Natural Sciences, University of Padang as validators, three physics practitioners, and 23 Grade XI students from Padang State Senior High School as respondents for the practicality test. The research object was a sound wave worksheet based on a generative model to facilitate the creative thinking skills of Grade XI high school students.

Define Stage: This stage consists of five steps, namely: (1) initial-final analysis through the distribution of open-ended questions to teachers and students and creative thinking skills tests; (2) student analysis to determine student characteristics; (3) task analysis detailing learning outcomes and learning objectives in sound wave material; (4) concept analysis to determine material content; and (5) learning objective analysis. Design Stage: This stage consists of four steps, namely: (1) preparing tests for learning evaluation; (2) selecting media in the form of generative model-based worksheets; (3) selecting formats using Microsoft Word; and (4) preliminary design of worksheets, including the cover, subject identity, description of the generative learning model, learning instructions, learning activities, and material summary. Development Stage: This stage includes product validation by five expert validators and practical testing by three physics teachers and 23 students. Product revisions are made based on the validators' suggestions and input to refine the worksheets before testing. The instruments used consist of: 1) a validation sheet covering five aspects: (a) learning content substance; (b) visual communication display; (c) worksheet content; (d) generative learning model syntax; and (e) creative thinking indicators. The instruments used a 1-5 Likert scale; 2) Teacher Practicality Sheet covering four aspects: (a) usability; (b) ease of use; (c) attractiveness; and (d) efficiency; 3) Student Practicality Sheet covering four aspects similar to the teacher practicality sheet, adjusted to the student's perspective.

The validated data were analyzed using Aiken's V index with the following formula:

$$V = \frac{\Sigma s}{n(c-1)}$$

where
s=r-I_0,
with
r being the score given by the validator,
I_0 being the lowest score (1),
c being the number of categories (5),
and n being the number of validators (5).

To determine the feasibility of the research instrument, content validity testing was conducted by five expert validators who were competent in their fields. The assessment of instrument validity referred to validity criteria [17] which divides the validation results into two categories based on the V value range. An instrument is declared invalid if it obtains a V value < 0.80, while an instrument is declared valid if it obtains a V value ≥ 0.80. The validity assessment criteria according to [17] can be seen in Table 2.

Table 2. Validity Criteria

Interval	Assessment
V < 0,80	Not Valid
V ≥ 0,80	Valid

(Source: Ref[17])

Practicality data was analyzed using a percentage technique with the formula below, with a value range of 0-100% and criteria ranging from less practical to very practical [18].

$$Score = \frac{points\ earned}{maximum\ points} \times 100\%$$

III. RESULTS AND DISCUSSION

A. RESULTS

The LKS product validation was conducted by five expert validators from the Faculty of Mathematics and Natural Sciences, UNP. The validation results for the five assessment aspects are presented in Table 3.

Table 3. LKS Validation Results

Aspect	Value V	Category
Learning Content Substance	0,83	Valid
Visual Communication Display	0,93	Valid
Student Worksheet Content	0,91	Valid
Generative Learning Model Syntax	0,87	Valid
Creative Thinking	0,88	Valid

Table 3 shows a very good level of feasibility in all aspects assessed. The average validity score of 0.88 indicates that the LKS developed is highly valid and feasible for use in learning. Learning Content Substance (0.83), this aspect consists of three indicators, namely accuracy (0.85), relevance (0.80), and readability (0.84). The lowest score on the current indicator shows that some content needs to be updated to be more relevant to current developments, but overall the substance of the material is in line with the concept of physics and is easy for students to understand. Visual Communication Display (0.93), this aspect received the highest score with perfect color composition and layout indicators (0.98), attractive cover (0.95), appropriate text display (0.90), and complete worksheets (0.85). The high score indicates that the design, layout, color selection, and visual elements of the LKS are very attractive and communicative, thereby motivating students in their learning.

LKS Content (0.91), this aspect includes perfect LKS identity (1.00), learning design (0.92), learning plan (0.88), and learning content (0.84). LKS identity has met all criteria, while learning content still has room for improvement in terms of material depth and relevance to competencies. Generative Learning Model Syntax (0.87), this aspect consists of six stages with the construct obtaining the highest score (0.93), followed by reflection and evaluation (0.90), application (0.88), orientation and disclosure (0.85), and cognitive conflict (0.80). These results indicate that LKS has optimally facilitated students in constructing new knowledge through the stages of the generative model, although the stage of creating cognitive conflict still needs to be strengthened. Creative Thinking (0.88) covers four indicators, with originality and elaboration receiving the highest scores (0.90), followed by fluency and flexibility (0.85). This indicates that LKS is optimally designed to encourage students to generate unique ideas and develop them in detail, but more attention needs to be paid to the ability to generate many ideas and see problems from various perspectives. After validation, revisions were made based on the validator's suggestions, which included: (1) revising the author and advisor sections to reflect the author's identity; (2) adding a description of the generative learning model based on cognitive conflict; (3) revising the learning outcomes in accordance with the latest 2025 curriculum; (4) revising the use of punctuation in scientific works; and (5) adding mathematical equations to the material on sound intensity levels.

The practicality test involved three physics practitioners from SMAN Padang who assessed four aspects of the worksheets. The results of the teachers' practicality assessment are presented in Table 4.

Table 4. Practical Results for Practitioners and Users

Aspects	Practical Value		Criteria	
	Practitioner	User	Very Practical	Very Practical
Usability	85%	92%	Very Practical	Very Practical
Ease of Use	86%	93%	Very Practical	Very Practical
Appeal	88%	93%	Very Practical	Very Practical
Efficiency	93%	93%	Very Practical	Very Practical

The results in Table 4 show that the LKS developed is very practical from the perspective of practitioners in terms of efficiency, obtaining the highest percentage (93%), indicating that LKS is very efficient in the use of learning time, does not require complicated preparation, and helps teachers achieve learning objectives optimally. The Usability aspect (85%) covers six indicators, with independence and activity obtaining the highest percentage (90%), followed by learning efficiency (87%), creative thinking skills (85%), and three other indicators (83%). LKS is very effective in encouraging independent learning and increasing student activity, as well as contributing significantly to the development of creative thinking skills through the systematic implementation of generative model syntax. Ease of Use (86%), this aspect consists of three indicators, namely ease of access and use (90%), ease of practical work (87%), and ease of material delivery (80%).

The workbooks are easy to access and use with a clear format and explicit instructions, and practical activities are easy to facilitate with systematic procedures, although some concepts may require additional elaboration from the teacher. Attractiveness (88%), this aspect includes three indicators with contextuality receiving the highest percentage (93%), visual design and typography (87%), and supporting media (83%). The material and activities in the LKS are highly relevant to everyday life, making learning meaningful and easy to relate to students' experiencesThe visual appearance is also very attractive with the use of harmonious colors and supporting illustrations. Efficiency aspect (93%), the time indicator obtained a very high percentage, indicating that the time allocation designed in the LKS is very appropriate and proportional for each stage of learning, allowing teachers to carry out all activities comfortably without rushing or experiencing unproductive excess time.

The practicality test also involved 23 grade XI students from SMAN Padang. The results of the user practicality test are presented in Table 4. Table 4 shows that the LKS is very practical in terms of usability (92%). This aspect covers six indicators, with learning independence obtaining the highest percentage (94%), followed by the development of creative thinking skills (93%), GLBCC model syntax and time efficiency (92%), and learning activities and creative thinking skills (90-91%). The LKS greatly supports students in learning independently with clear instructions, and the generative learning stages can be easily followed to understand concepts gradually. Ease of Use (93%), this aspect consists of two indicators, namely ease of practical work (93.5%) and ease of understanding (93.2%).

The practical activities are designed to be very easy to carry out with clear procedures and simple tools, while the language used is very communicative and appropriate for the students' cognitive level. Attractiveness (93%), this aspect includes three indicators with contextuality receiving the highest percentage (96%), visual design (94%), and typography and media (90%). The material and activities are highly relevant to everyday life, the visual display is very attractive with harmonious colors and illustrations that support understanding, although the

typography and media aspects can still be further optimized. Efficiency aspect (93%), the time indicator shows that the time allocation is very appropriate and proportional, allowing students to complete all activities comfortably and have enough time to think, discuss, and develop creative thinking skills optimally.

B. DISCUSSION

The results of the study show that the generative learning worksheets developed have a very high level of validity and practicality, both in terms of content and structure. Based on validity tests conducted by experts, these worksheets obtained a validation index of 0.83 in terms of learning content substance, 0.93 in terms of visual communication display, 0.91 in terms of worksheet content, 0.87 in terms of generative learning model syntax, and 0.88 in terms of creative thinking, with all five aspects categorized as valid.

This study aims to develop valid and practical generative learning worksheets for 11th grade high school students, specifically on the subject of sound waves. The development process uses a 4-D model, which consists of the define, design, development, and disseminate stages. Each stage plays an important role in ensuring that the developed worksheets can meet the needs of effective learning and are in line with the independent curriculum. In the define stage, preliminary analysis showed that sound wave worksheets based on the generative learning model were needed, based on preliminary data from teachers and students. The validity assessment was obtained through various indicators developed based on the stages of the generative learning model, from the orientation stage to reflection and evaluation. Each of these stages makes an important contribution to the LKS and ensures that the LKS compiled can guide students gradually through an active and participatory learning process.

The orientation stage of the LKS begins with opening questions and relevant context to draw students' focus to the material to be studied. Based on the validation results, the orientation stage in the LKS received a validation index score of 0.85, which is categorized as valid. This score indicates that the orientation component in the LKS has been designed in accordance with the objective of stimulating students' curiosity. Learning begins with activities that are relevant and also helpful to students. Learning begins with activities that are relevant and also help students connect new concepts with their prior knowledge [8].

The cognitive conflict stage aims to provide challenges that encourage students to question their initial understanding through problems that trigger creative thinking. Based on the validation results, the cognitive conflict stage received a validation index of 0.80, which is categorized as valid. Cognitive conflict triggers conceptual change, helps students recognize misconceptions, and encourages students to improve the processing of irrelevant stimuli [9]. This valid stage shows that LKS has successfully facilitated students in overcoming intellectual challenges that increase student activity in learning.

The idea disclosure stage provides space for students to express their ideas, test ideas, and discuss new ideas with their group members. This stage obtained a validation index score of 0.85, which is categorized as valid. This score indicates that this stage provides opportunities for students to freely express their understanding and discuss it. This stage helps students broaden their understanding and learn from the ideas of their groupmates [9]. Validity at this stage indicates that the workbook accommodates student involvement in meaningful and collaborative discussions.

The construction stage in the worksheet allows students to build understanding independently through experimental activities. Based on the validation results, the construction stage in this worksheet received an index score of 0.93, which is categorized as valid. This index score indicates that the worksheet has facilitated students with activities that enable them to form new knowledge independently using the principles of generative learning.

The application stage gives students the opportunity to apply the concepts they have constructed in real situations or everyday contexts. The validation results show that the application stage in the worksheets obtained an index value of 0.88, which is categorized as valid. This stage provides an opportunity for students to solve problems through the application of the concepts they have learned [11].

The reflection and evaluation stage provides students with the opportunity to assess their own understanding, evaluate the learning process, and identify concepts that still need improvement. Based on the validation results, the reflection and evaluation stage obtained an index of 0.90, which is categorized as valid. This stage provides students with the opportunity to evaluate and improve weaknesses in the knowledge formation process [11].

In addition to testing the validity of the LKS, its practicality was also tested. Validity and practicality tests are evaluations of the practical usefulness of a developed product. Based on the results of the practicality test of the four components, namely: usability, ease of use, attractiveness, and efficiency, the assessment carried out by teachers obtained an average of 88% in the very practical category. The results of the educators' practicality analysis can be seen in Appendix 9. The practicality results obtained by students obtained an average of 93% in the very practical category. The results of the students' practicality analysis can be seen in Appendix 11. This high practicality score indicates that the generative learning model can increase students' active and participatory involvement in learning. This shows that the sound wave worksheet product based on the generative learning model is practical.

Overall, this study shows that sound wave worksheets based on generative learning models can facilitate creative thinking skills in 11th grade high school students. The assessment of validity and practicality by teachers and students shows that these worksheets are ready to be further tested in the field to support the achievement of student competencies in physics learning.

IV. CONCLUSION

The sound wave LKS based on the generative model that was developed has been declared highly valid with an average validity score of 0.88. All aspects of the assessment met the validity criteria, including learning content substance (0.83), visual communication display (0.93), worksheet content (0.91), generative learning model syntax (0.87), and creative thinking indicators (0.88). The generative model-based sound wave worksheet developed has been declared highly practical based on assessments from teachers with an average percentage of 88% and students with an average percentage of 93%. All aspects of practicality (usability, ease of use, attractiveness, and efficiency) were categorized as highly practical. The developed worksheets are suitable for facilitating the creative thinking skills of 11th grade students on sound wave material, by providing adequate space for the development of fluency, flexibility, originality, and elaboration through the systematic implementation of generative learning model syntax.

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