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Development of Ethnophysics-Based E-Worksheets on Pletokan Bamboo for Parabolic Motion

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ABSTRACT

Ethnophysics is a learning approach that connects culture with the concept of physics. One example of ethnophysics is the bamboo pletokan game. Bamboo pletokan is a traditional game originating from Betawi with the basic material for making this game coming from bamboo. This study aims to produce an ethnophysics-based E-Worksheet on the bamboo pletokan game to improve the problem-solving abilities of high school students on the material of parabolic motion as a learning medium reviewed from the eligibility criteria, namely valid, practical, and effective. The method used in this study is Research and Development (R&D). This method is used to develop a product and test the results of the product. This study uses the ADDIE (Analyze, Design, Development, Implementation, Evaluation) development design. The results of this study produce an ethnophysics-based E-Worksheet on the bamboo pletokan game with an Average E-Worksheet Validity Score in the very valid category. Thus, the ethnophysics-based E-Worksheet on the bamboo pletokan game can be utilized.

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INTRODUCTION

Education is a process that develops humans, who not only have intellectual intelligence but can also think scientifically and philosophically. Quality education is needed to give birth to Indonesia's golden generation 2045 (Himmawan et al., 2023). The quality of education is determined by the learning process, a teacher needs to build students' problem-solving skills (Sastradika et al., 2020). In general, motivation is the impetus for someone to do something (Fitriana & Mardiana, 2022). Problem-solving skills can arise from within a person and the influence of others (Afrizon, Hidayati, & Novitri, 2023). Research Surmaini and Diani (2021) and Risdianto (2021). states that several factors influence the low problem-solving skills in a person, one of which is the difficulty in understanding the subject matter. Someone who has difficulty understanding a subject will have an impact on his learning behavior, especially in physics learning.

Physics is a subject that is considered difficult to understand (Fitriah & Ahmad, 2019; Erinosh, 2020). One of the factors causing it is because physics material is very complex and abstract to understand (Pramudia & Agustin, 2018). This is also supported by the results of a questionnaire response and interest in the implementation of physics learning as much as 54% of students said physics lessons were difficult to learn (Sari et al, 2021). Based on research that has been done Azizah (2015) states that from the results of the questionnaire, as many as 76% of students have difficulty in solving problems in the problem.

The perception of the difficulty of physics subjects can affect the low initial motivation students in learning physics. One solution that can be provided by teachers in overcoming this, is through edutainment-based learning (Mendez & Slisko, 2013). Edutainment learning is one way to improve the concept and motivation of students, especially in physics learning (Arista et al., 2018; Puspitasari, 2021; Mendez et al., 2013; Bouchée et al., 2022). Creating an environment that can encourage the achievement of learning objectives is one of the innovations (Sari et al., 2022). Many positive things can be taken in the implementation of edutainment-based learning such as, students actively participating in learning, students being closer to the surrounding environment, and providing new experiences for students in learning physics (Rahmadani, & Nurmasyitah, 2022). Therefore, physics learning becomes more meaningful and fun with edutainment-based learning. One example of edutainment-based physics learning is utilizing the pletokan bamboo game.

Pletokan bamboo game is a game made from old bamboo stalks that are shaped like a simple gun for the pletokan frame. (Elfinawati & Ismawirna, 2019; Ali et al., 2021; Lasianaa et al., 2021) Bullets are made of moistened paper or can also use seeds (Ma'arif, 2021). Pletokan bamboo is one of the traditional games originating from Central Java and Yogyakarta (Hanif, 2019). This game is also spread throughout Indonesia with different names (Sari et al., 2020). Meanwhile, this game is usually played in groups or individually (Arsa, 2018). Playing pletokan gun can train psychomotor, affective, social skills, and problem-solving skills in matches (Rodiyah, 2020; Masnur, & Aqobah, 2021; Kurniawan & Safitri, 2023). However, this game is now increasingly abandoned and replaced with more sophisticated modern games (Mulyani, 2016; Supahar et al., 2020). One of the efforts to preserve cultural heritage is to integrate pletokan bamboo games into learning (Sunimastuti, 2020). This is because the activity of playing pletokan bamboo is closely related to the concept of physics (Desrianti et al., 2016). In addition, physics learning integrated with traditional games will provide contextual learning make it easier for students to understand concepts, and increase the learning motivation and skills of students (Zayyadi et al., 2018; Purwaningsih, 2016; Doni, 2014; & Sattar, 2016).

Childhood games as inspiration for creating works of art (Kurniawan, 2019). Integrating pletokan bamboo p games into physics learning is a form of ethno-physics (Branch, 2009). Therefore, this study aims to develop game-based edutainment E-Worksheet which is one of the learning tools that facilitate students in learning physics. The focus of the problem formulation in this study is the validity of Ethnophysics-based E-Worksheet. Based on previous research, it only explores concepts that have not been developed as media which certainly provides new experiences for students in learning physics. This the results of this study are expected to make it easier for students to understand physics concepts improve students' problem-solving skills and maximize efforts to preserve Indonesian local culture.

RESEARCH METHOD

This research is classified as R&D research because it uses a research and development design with the ADDIE approach: Analysis, Design, Development, Implementation, and Evaluation (Murti et al., 2023).

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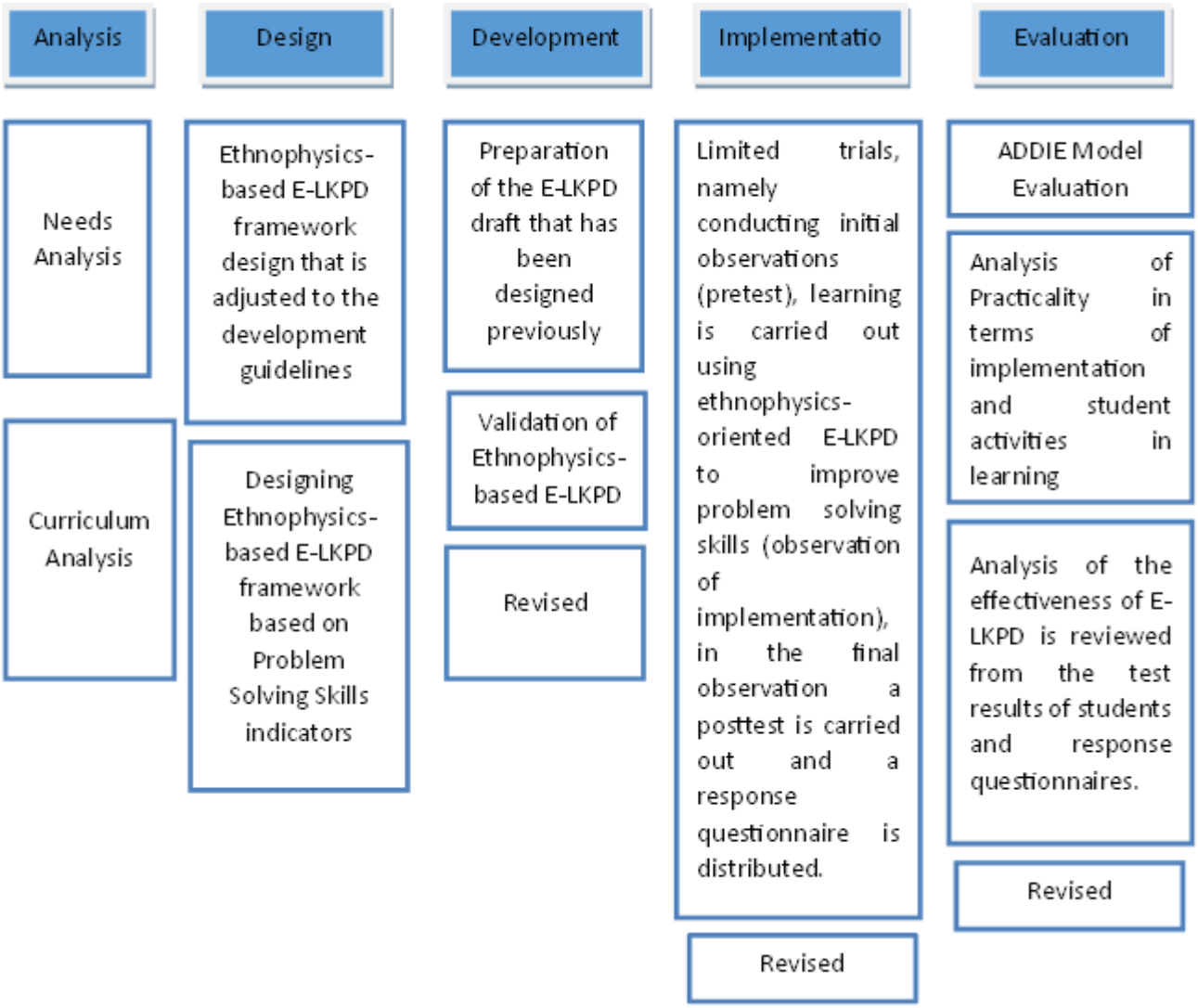

Figure 1. Illustration of research

The analysis stage consists of three stages, namely needs analysis and curriculum analysis. This stage conducted interviews and observations related to teaching materials used, values, and the curriculum used. The design stage is carried out by designing an E-Worksheet framework that is adjusted to the development guidelines containing title, topic, time allocation, how to use, objectives, material, and practice questions. This E-Worksheet also contains the stages of Problem-Based Learning and contains features, indicators, and sub indicators of students' problem-solving skills used. The development stage consists of two stages, namely the preparation of E-Worksheet drafts and instruments. The preparation of the draft produces E-Worksheet by the framework that has been designed.

The preparation of the draft is adjusted to the construction requirements, technical requirements, and didactic requirements. Widjajanti (2020) states that the didactic requirements can be described as follows: (1) Inviting students to be active in the learning process, (2) Emphasizing the process of finding concepts, (3) Having a variety of stimuli through various media and student activities with independent curriculum characteristics, (4) Can develop communication, emotional, moral, aesthetic abilities, in students. Construction requirements are requirements that are concerned with the use of language, sentence structure, vocabulary, level of difficulty, and clarity, which in essence must be appropriate in the sense that it can be understood by the user, namely students. Technical requirements are related to the writing, images, and appearance of E-Worksheet. The preparation of the instrument resulted in an E-Worksheet validation sheet.

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The draft that has been prepared is validated to determine the level of validity of the E-Worksheet so that improvements are made by the assessment, comments, and suggestions. However, the fourth and fifth stages, namely the Implementation and Evaluation stages, were not carried out, due to time constraints. The approach was chosen because it was intended to produce Ethnophysics-based E-Worksheet. The data collection method used is the validation method. The validity of the E-Worksheet is determined from the results of validation by expert lecturers using a validation sheet that is assessed based on Likert scale criteria with a score range of 1-4 (Riduwan, 2013). The final result of validity is calculated with the following formula:

$$Average\ Score = \frac{Scores\ per\ criteria}{Number\ of\ validators}$$

The validation score results were then interpreted based on Table 1.

Table 1. Validity score interpretation criteria (Riduwan, 2013).

Score	Category
0≤ Skor ≤ 1.75	Less Valid
76≤ Skor ≤ 2.50	Fairly Valid
51≤ Skor ≤ 3.25	Valid
26≤ Skor ≤ 4.00	Very Valid

Based on the interpretation of these criteria, the E-Worksheet developed can be declared valid and can be used if it meets the percentage results of ≥ 2.51

RESULTS AND DISCUSSION

The development of E-Worksheet based on ethnophysics using the ADDIE model has five stages: analyze, design, development, evaluation, implementation. The following are the results of the analysis of each stage.

Analyze

At this stage, through observation at SMA Negeri 4 Sidoarjo, as a place of research. This is done to find out the basic problems that exist in the physics learning process and obtain information about students' problem-solving abilities during the implementation of learning carried out by physics teachers. The researcher conducted several analyzes as follows.

1. Needs Analysis

   The learning process at SMA Negeri 4 Sidoarjo still uses conventional learning media such as powerpoint, printed LKPD, and whiteboards. One of the negative impacts is that it can reduce students' motivation and interest in learning because learning tends to be monotonous and boring. The main cause is due to the limitations of physics teachers at SMA Negeri 4 Sidoarjo in using technology. In accordance with research Marhama (2025) states that the importance of mastering digital technology as an effort to increase the effectiveness and relevance of learning.

   The physics learning process at SMA Negeri 4 Sidoarjo has not been able to encourage students to be able to solve existing problems. This can be seen from the low ability of students to identify information from the questions given, the formulation of problems is not precise, and the ability to choose and apply physics concepts to find solutions is also still low. Based on the results of observations and interviews with physics teachers, most students tend to memorize formulas without understanding their meaning or application in real contexts. When faced with questions that require reasoning and analysis, they have difficulty in developing the right solution strategy. This condition shows that the learning that takes place is not yet oriented towards the development of high-level thinking skills, especially problem-solving skills.

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On the other hand, SMA Negeri 4 Sidoarjo shows high concern for preserving local culture through various extracurricular activities, such as *karawitan*, dance, *pencak silat*, handicraft exhibitions, and traditional theater arts. This effort is very interesting because it proves that the world of education can be a strategic means in preserving local Indonesian culture. However, unfortunately these cultural values have not been integrated into learning, especially in physics subjects. Therefore, culture-based learning developed in this study, namely ethnophysics in the traditional game "pletokan bambu", is expected to be one of the efforts to form the Pancasila Student Profile through strengthening local wisdom values in the learning process.

2. Material Analysis
   The substance of the material in the teaching materials used is too general and examples of the application of the material are not contextual, so that they have not been fully able to link the concept to the daily lives of students. One effort to overcome the gap that occurs in SMA Negeri 4 Sidoarjo is to develop more contextual teaching materials with a local wisdom approach that is close to the lives of students. In line with research Ardyansyah (2025) revealed that a contextual approach makes it easier for students to understand concepts and can make learning more meaningful. By implementing the learning process while playing, students can more easily understand physics concepts concretely through direct experience. One of the traditional games that is relevant to be associated with physics learning is bamboo pletokan. This game involves various physics concepts, such as potential energy, pressure, Newton's second law, Newton's second law, friction, ideal gas, effort, kinetic energy, sound waves, collisions, and parabolic motion. The material that can be observed directly in the bamboo pletokan game is parabolic motion.
3. Curriculum Analysis
   After conducting the material analysis, it was continued to identify learning achievements in the parabolic motion material and then formulate the learning objective flow and learning objective indicators. The following analysis results are presented in Table 2.

Table 2. Learning outcomes and learning objectives

Learning Outcomes	
At the end of phase F, students are able to apply the concept and principle of vectors into kinematics and dynamics of motion, work and energy, fluids, harmonic vibrations, sound waves and light waves in solving problems, and apply the principles of heat and thermodynamics, with various changes in heat engines. Students are able to apply the concept and principle of electricity (both static and dynamic) and magnetism in various problem solving and various technological products, apply the concept and principle of electromagnetic wave phenomena in solving problems.	
Learning Objective Flow	**Learning Objective Indicator**
1. Analyze the factors that influence the motion of bamboo bullets.	1. Students can analyze the factors that influence the motion of bamboo projectiles.
2. Applying the parabolic motion equation to solve problems related to parabolic motion using the bamboo pletokan game.	2. Students can apply the parabolic motion equation to solve problems related to parabolic motion using the bamboo pletokan game.
3. Designing a simple parabolic motion experiment using the bamboo pletokan game.	3. Students can design a simple parabolic motion experiment using the bamboo pletokan game.
4. Conduct a simple parabolic motion experiment using the bamboo pletokan game.	4. Peserta didik dapat melakukan percobaan gerak parabola sederhana menggunakan permainan pletokan bambu.
5. Analyze the effectiveness of the experimental design with a simple parabolic motion experiment.	5. Students can analyze the effectiveness of the experimental design with a simple parabolic motion experiment.

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Design

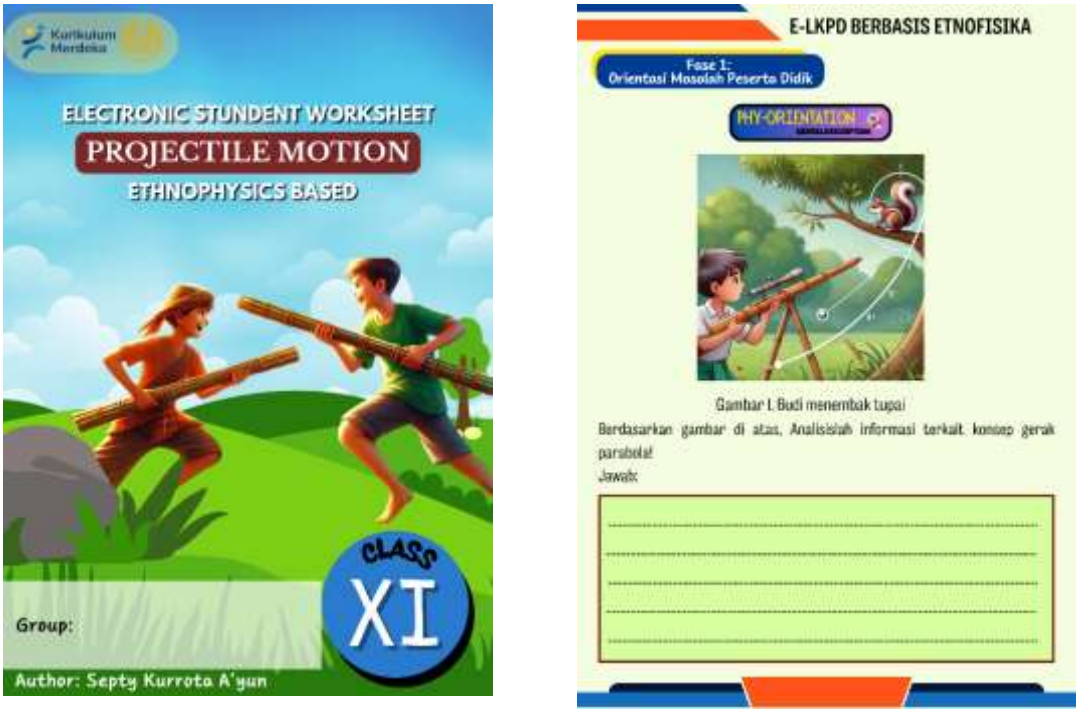

Figure 2. Cover design and problem orientation

Development

At this stage, start developing and perfecting all the E-Worksheet designs that have been made at the design stage. The next step is to validate three validators who have expertise according to the research topic. After validation, the next step is to revise according to the comments and suggestions from the validators at the validation stage. The following are the results of several suggestions given by the validator team presented in Figure 3-6.

Figure 3. Before revision in the physics symbol index.

Figure 4. After revision in the physics symbol index.

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Figure 5. Revise the image size completeness of questions related to the parts and functions of bamboo pletokan, with the aim of inviting students to collaborate and discuss in groups.

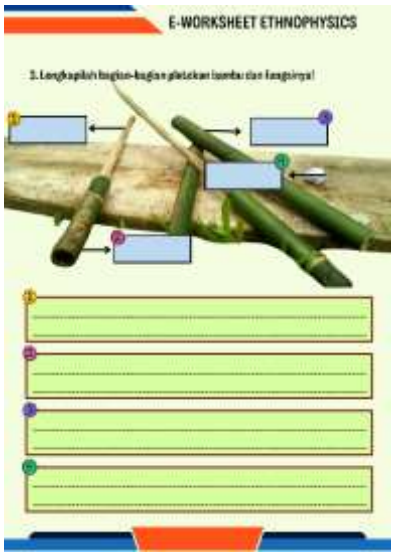

Figure 6. After revising the image size, complete the questions related to the parts and functions of bamboo pletokan, with the aim of inviting students to collaborate and discuss in groups.

Table 3. Validation E-Worksheet

No	Rated aspect	V1	V2	Average	Validation Category
	Presentation				
1.	E-Worksheet Access	4	4	4,00	Very Valid
2.	Compliance of the appearance of the E-Worksheet with the content of the material	3	4	3,50	Very Valid
3.	Layout Quality	4	4	4,00	Very Valid
4.	Image and video quality	3	4	3,50	Valid
5.	Completeness of the E-Worksheet section	4	4	4,00	Very Valid
	Contents				
6.	Suitability of the contents of the E-Worksheet with the parabolic motion material	4	4	4,00	Very Valid
7.	Suitability of the concept with the independent curriculum	3	4	3,50	Very Valid
8.	Suitability of the material with the ethnophysical concept of "Traditional Bamboo Pletokan Game"	4	3	3,50	Very Valid
9.	The suitability of E-Worksheets to develop students' problem-solving skills	4	4	4,00	Very Valid
	Linguistics				
10.	Language compatibility	4	4	4,00	Very Valid
11.	Use of terms	3	4	3,50	Valid
12.	Quality of identity and sources of information	4	3	3,50	Very Valid
	Average Validity Score of E-Worksheet			3,75	Very Valid

Description: V1: Validator 1 and V2: Validator 2

Based on Table 3, the results of the validator's assessment of the Ethnophysics-based E-Worksheet developed obtained an average validity score of 3.75 with a very valid category. In addition to the assessment given by the validator, at the validation stage also provided suggestions and comments on the E-Worksheet developed, namely on the Physics Play feature

the quality of the video presented is less clear. The validity of the E-Worksheet is reviewed based on five aspects, namely aspects of technical requirements, aspects of didactical requirements, aspects of construction requirements, conformity with the econophysics approach steps, and coverage of improving students' problemsolving skills. The first aspect is the technical requirements aspect. The three each obtained an average validation result with a very valid category, and one obtained an average validation result with a valid category. In the sub-aspects of image presentation and color composition, the average validation results are lower than the other three sub-aspects but still classified as valid. The comments and suggestions from the validators on the presentation aspect are that the title on the electronic student worksheet is less interesting for students. A characteristic cover will increase brand awareness so that it can build emotional attraction with prospective students (Figure 2). This is in line with (Nurasa et al., 2025) statement that one of the elements of the E-Worksheet is the title, so the title must be clear. The solution is to create a brand name that reflects the content of the E-Worksheet and pay attention to the color contrast between the title and the back cover (Figure 2). Adhelacahya (2023) state that E-Worksheet is classified as good to be presented if it contains attractive colors and images so that it can increase student understanding in line with the statement of Yang and Ogata (2023) which states that E-Worksheet has a combination of images, writing, and good layout can attract students' interest. Overall, the technical requirements aspect falls into the very valid category. This shows that the E-Worksheet developed has been designed and presented attractively.

The second aspect is didactical requirements which include the suitability of activities in E-Worksheet with learning objectives and the suitability of activities in E-Worksheet with the level of thinking of students, which obtained the average results of validation of all aspects with very valid categories. Adjustment of E-Worksheet activities with learning objectives is needed so that students gain meaningful learning experiences by the demands of the times. The third aspect is construction requirements which include the level of understanding of the language used and the suitability of the language with the General Guidelines for Indonesian Spelling. Overall, the sub-aspects of construction requirements obtained average validation results with a very valid category. Sihafudin and Anggraeni (2024) stated that language is an important factor in the preparation of teaching materials so that students can understand the meaning and avoid misinterpretation in E-Worksheet. The accuracy of language use and adjusting the level of language understanding according to the maturity level of students are absolute requirements in the preparation of E-Worksheet (Azizah, Dewi, Sutanri, 2024). In the research of Ghaisani and Setyasto (2023), interactive E-Worksheet that have used communicative language and have been adjusted to the General Guidelines for Indonesian Spelling can increase students' readability of E-Worksheet and make it easier for students to understand the material. The fourth aspect is the suitability of the content with the steps of the Ethnophysics approach is very valid. This is in line with the research of Johler and Krumsvik (2024), integrating subject matter with local wisdom around the student's environment, not only aims to facilitate students in understanding the material but also to make students more familiar with local wisdom which may begin to be replaced by foreign cultures. Then this E-Worksheet is also packaged with an attractive appearance and equipped with interactive features to support students' learning styles,this is also supported by the statement of Kumalasari (2024), namely learning media that is packaged attractively will affect the learning process of students in increasing student motivation and understanding of learning. Ethnophysics-based E-Worksheet on Pletokann Bamboo Game has advantages including,there is physics material integrated with local wisdom, besides being able to help students in learning physics,this application learning media can also help introduce local wisdom to students as a strengthening of the Pancasila student profile according to the vision and mission of the Ministry of Education and Culture. E-Worksheet can be accessed through live worksheets is very interactive so that students can immediately

know the results of the evaluation and there is feedback in working on questions. Then this E-Worksheet is very flexible because it is used anytime and anywhere without space and time limits. The fifth aspect, namely the coverage of problem-solving skills, obtained an average validation result of 4 with a very valid category. Learning with an ethnophysical approach is appropriate for improving students' problem-solving skills (Oikarinen et al., 2024). The E-Worksheet used includes indicators of participants' problem-solving skills by the indicators described by Doktor (2016).

Implementation

At this stage, a limited trial was conducted using E-Worksheet based on ethnophysics in the bamboo pletokan game that had been validated previously. The trial process was carried out in class XI-A of SMA Negeri 4 Sidoarjo using the PBL model for 2 meetings (each meeting duration was 90 minutes) to determine the practicality and effectiveness of the E-Worksheet based on ethnophysics that was developed. The results of the implementation stage were in the form of pretest and posttest scores, assessment of learning implementation observation sheets, and student response questionnaires.

Evaluation

At this stage, an evaluation was carried out by analyzing the validity aspects of the ethnophysics-based E-Worksheet on the bamboo pletokan game that was developed with the aim of finding out the results of the development carried out.

CONCLUSION

Based on the results of the study, it can be concluded that the ethnophysics-based E-Worksheet on traditional pletokan bamboo games to improve students' problem-solving skills is valid and practical. This is supported by the results of E-Worksheet research which obtained a validation score of 3.75 with a very valid category. Future research suggests that ethnophysics-based E-Worksheet on traditional bamboo pletokan games to improve problem-solving skills can be developed on other topics, local wisdom, and culture because the development of ethnophysics-based E-Worksheet is still limited. For further research, it is expected to implement learning using ethnophysics-based E-worksheets in the bamboo pletokan game on a larger scale and make comparisons between classes and even between schools.

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