

Development of e-worksheet based on ExPRession learning model to train critical thinking skills

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Abstract

Education plays an important role in a country, so in the 21st century, education requires students to have skills that support them in facing global challenges. One of these skills is critical thinking skills. However, in learning, especially physics, critical thinking skills have not been widely applied. This Research aimed to develop e-worksheets based on external physical representation (ExPRession). This development research used the Design and Development Research (DDR) approach. The data analyzed are data from validity tests, namely language and design validity tests and Material and construct validity tests. In addition, the analysis data is also on the results of the practicality test consisting of readability, teacher perception, and student responses. The results of this study indicate that the results of the validity test for the media and design tests obtained a score of 3.50 with a very valid category, and for the material and construct validation test, a score of 3.38 was obtained with a very valid category. The practicality test results obtained a score of 83.8% in the very high practical category.

Keywords: Critical Thinking, Development, E-Worksheet, ExPRession

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I. Introduction

Education plays a pivotal role in national development, with a country's advancement often hinging on the quality of its educational system. In the 21st century, the competition for education is intense, placing high demands on students to equip themselves with essential skills for navigating an increasingly complex life. These skills encompass creativity and innovation, critical thinking and problem-solving, as well as effective communication and collaboration [1], [2].

Critical thinking skills, in particular, are imperative for addressing global challenges and issues related to science and technology. They involve a reflective form of thinking grounded in reasoning aimed at determining beliefs and actions [3]. Enhancing critical thinking skills can elevate students' understanding, making learning more meaningful. It enables them to think systematically when expressing ideas, analyze text structures logically, and foster creativity for generating innovative solutions to problems [4].

Students with well-developed thinking skills can construct meaning from learning in various forms—spoken, written, and graphic. It involves integrating new knowledge with their existing understanding, demonstrating a grasp of conceptual understanding [5]. However, the learning process is not a state of an empty mind; students already possess a basic understanding derived from their experiences. While participants may use this understanding to solve problems, it is essential to acknowledge that conceptual understanding may not

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be perfect. Therefore, a thoughtful process is required to construct thoughts and transform them into comprehensive knowledge [6].

In the context of this study, the focus is on addressing challenges related to critical thinking skills, specifically within the subject matter of light interference in optics. Students often struggle to interpret patterns arising from double-slit or multiple-slit light interference, hindering their ability to comprehend optics concepts and account for interference effects [7]. To assess students' understanding, they are presented with questions related to light interference material, categorizing them into upper, medium, and low groups based on their answers and reasoning. The prevalence of conceptual challenges among students is evident in the variations of correct answers with potentially incorrect reasoning in different groups [8].

To overcome these challenges, the study proposes the implementation of experimental activities, referred to as scientific experiments, as an alternative. These activities are crucial for real-life science learning, allowing students to grasp scientific concepts and methods [9]. To enhance the learning experience, instructional written materials in the form of worksheets are introduced [10]. An innovative step involves transforming traditional worksheets into electronic worksheets (E-Worksheets), incorporating multimedia elements like text, audio, video, and animation. These E-Worksheets aim to guide students toward achieving basic competencies in a directed manner [11].

Based on the results of interviews with high school physics teachers from SMAN 10 Pandeglang, SMAN Cahaya Madani Banten Boarding School (CMBBS), SMAN 2 Kota Bumi, SMA IT At-Raihan, and SMAN 1 Kota Gajah, it was found that learning was more often done using the lecture and demonstration method. The need for such advancements is underscored by the results of these interviews, revealing a reliance on the lecture and demonstration method due to the lack of effective learning media, such as E-Worksheets and incomplete practicum tools in school laboratories. To address this issue, a product development initiative introduces an E-Worksheet utilizing the External Physics Representation (ExPRession) learning model. This model serves as an activity to specifically train students' critical thinking skills, offering a promising solution to the identified challenges in optics education.

II. Methods

This Research used the Design and Development Research (DDR) approach, which is adapted from the research procedure [12], which consists of 4 stages, namely Analysis, Design, Development, and Evaluation. The product developed is an ExPRession-based E-Worksheet, where ExPRession is a learning model developed for mental models and problem-solving abilities. The learning syntax is dominated by activities that train the ability to make various representations of problems as an implication of the structure of building mental models of learners [13]. ExPRession has been tested to help improve students' high-level pioneering skills [14],[15].

However, in this article, the author will discuss the implementation of validity and practicality tests. The validity test was carried out by 3 experts selected according to their expertise in the development of physics learning media. As for the practicality test, it was carried out in class XII in one of the schools and a teacher who taught at that school. The selection of research subjects was carried out using a purposive sampling technique, namely with the consideration of the teacher, where the stages of Research are as follows.

Development Procedure

1. Analysis: This stage is carried out to analyze needs with the aim of obtaining problems faced by students by conducting initial information searches related to literature studies related to the development of E-Worksheets to train critical thinking skills on light interference material.
2. Design: at this stage, a product is designed to be developed based on the results of the analysis that has been carried out on the development of E-Worksheets to train critical thinking skills on light interference material, with a research and development design like Figure 1.
3. Development: this stage is carried out after the completion of the design process to develop the initial form of teaching materials. At this stage, 3 experts also carried out a validity test and a practicality test in terms of 3 aspects that are the readability test, the student response test and the teacher's perception test.
4. Evaluation: the results of the evaluation are used as a form of feedback in revising or improving the product.

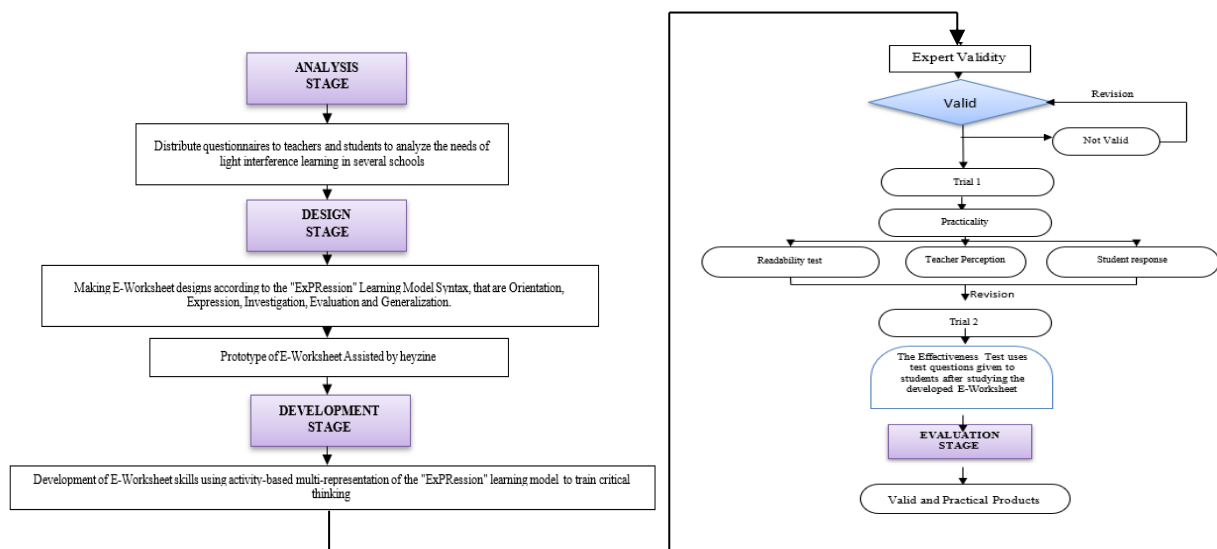


Figure 1. Research and Development Design

Research Instruments

The research instruments used were semi-structured interviews and questionnaires. Semi-structured interviews are used to obtain information related to the Research to be carried out. At the same time, the questionnaire consists of a validity test questionnaire and a practicality test questionnaire (readability test questionnaire, student responses, and teacher perceptions).

Data Collection Technique

The results of the validity test were obtained by carrying out a validation test (Table 1), which was seen from 2 aspects, media and design and Material and constructs, which 3 experts carried out. Meanwhile, the practicality test is seen from 3 aspects that are the readability test, student responses, and teacher perceptions.

Table 1. Aspects of Validity Test

Validity	Aspects	Number of Statement
Material & Construct	Worksheet step presentation	13 Items
	Social System	3 Items
	Reaction principle	4 Items
	Support System	2 Items
	Instructional and Nurturant effect	3 Items
Language & Design	Straightforward	3 Items
	Communicative	3 Items
	Dialogical and Interactive	1 Item
	Suitability to the level of development of learners	2 Items
	Demand ability and cohesiveness of mindsets	2 Items
	Use of terms, symbols, or icons	2 Items
	Cover	9 Items
Content	10 Items	

The number of respondents for the Practicality Test was 20 students, and the questionnaire related to their responses regarding the E-Worksheet (Tabel 2). Meanwhile, The teacher's perception was filled by 9 respondents from different schools.

Table 2. Aspects of the Practicality Test

Practicality	Aspects	Number of Statement
Readability	Structure	1 Item
	Spacing, type, and font size	1 Item
	Layout	1 Item
	Language	1 Item
	User interface	1 Item
	Instructions & Questions	1 Item
	Steps of Activities	1 Item
	Presentation	1 Item
	Phenomena	1 Item
	Learning Activities	1 Item
	Pictures, Graphics, Illustrations, and videos	1 Item
Students response	Characteristics of interactive teaching materials	1 Item
	The Implementation of Knowledge and Skills	1 Item
	Students' perception of satisfaction	1 Item
	Students' Perception of ExPRession	1 Item
Teacher Perceptions	Orientations	1 Item
	Expression	1 Item
	Investigation	1 Item
	Evaluation	1 Item
	Generalization	1 Item

Data Analysis Technique

Data analysis techniques consisted of validity test sheets, practicality test questionnaires, and student response questionnaires. Scoring for the validation test and practicality test uses a Likert scale adapted from Ratumanan and Laurent [16] and Arikunto [17], which can be seen in Tables 3 and 4.

Table 3. Likert Scale in Validation Test

Score Intervals	Criteria
$3.25 < \text{score} < 4.00$	Very Valid
$2.50 < \text{score} < 3.25$	Valid
$1.75 < \text{score} < 2.50$	Less Valid
$1.00 < \text{score} < 1.75$	Not Valid

Table 4. Likert Scale in Practicality Test

Percentage (%)	Criteria
0.00 – 20	Very low
20.1 – 40	Low
40.1 – 60	Moderate
60.1 – 80	High
80.1 – 100	Very high

The product developed is said to be valid and practical if it has an interval score of the results of the assessment, which is in the vulnerable $2.50 < \text{score} < 3.25$ and practically is in the percentage of 40.1% -60%, with the practical category being moderate.

III. Results and discussion

The resulting product is an E-Worksheet to train critical thinking skills based on the ExPRession learning model. The resulting product was tested before being used for validity, where the validity test was carried out by 3 experts consisting of 1 Physics Education lecturer at the University of Lampung and 2 high school physics teachers. This validity test is seen based on 2 aspects, namely the media and design aspects as well as the Material and construct aspects. So that the data obtained can be accounted for, such as the data in Table 5.

Table 5. Validity Test Results

Validity	Aspects	Average Score From 3 Validators	Criteria
Material & Construct	Worksheet step presentation	3.46	Very valid
	Social System	3.89	Very valid
	Reaction principle	2.75	Valid
	Support System	3.67	Very valid
	Instructional and Nurturant effect	3.11	Suitable
	Average	3.38	Very valid
Language & Design	Straightforward	3.56	Very Valid
	Communicative	3.44	Very Valid
	Dialogical and Interactive	3.00	Valid
	Suitability to the level of development of learners	3.50	Very Valid
	Demand ability and cohesiveness of mindsets	3.17	Valid
	Use of terms, symbols, or icons	3.67	Very Valid
	Cover	3.96	Very Valid
	Content	3.67	Very Valid
	Straightforward	3.50	Very valid
	Communicative	3.56	Very valid
	Dialogical and Interactive	3.44	Very valid
	Average	3.50	Very valid

Table 5 presents a thorough evaluation of an educational material's validity, categorizing aspects into Material and construct and Language and design. In Material & Construct, the worksheet step presentation is highly valid (3.46), indicating effective delivery of content, while the social system (3.89) is deemed very valid, reflecting alignment with social learning principles. However, the reaction principle (2.75) scores lower, signalling room for improvement in eliciting desired reactions. The support system (3.67) is very valid, showcasing strong support mechanisms. The instructional and nurturant effect (3.11) is considered suitable, suggesting potential areas for enhancement. The overall average for Material & Construct is very valid (3.38), attesting to the Material's effectiveness.

Moving to Language and design, the worksheet excels in being straightforward (3.56), highly communicative (3.44), and using terms, symbols, or icons effectively (3.67). However, dialogical and interactive aspects (3.00) score lower, indicating opportunities for improvement in fostering dialogue. The Material's suitability to the level of development of learners (3.50) is very valid, showcasing alignment with the target audience, while demand ability and cohesiveness of mindsets (3.17) suggest potential enhancements. Notably, the cover (3.96) and content (3.67) are highly valid, underlining strong presentation and relevance. The overall average for Language and design is very valid (3.50), affirming the Material's excellence in these crucial aspects. This comprehensive evaluation guides future refinements to optimize the educational Material's effectiveness and user engagement.

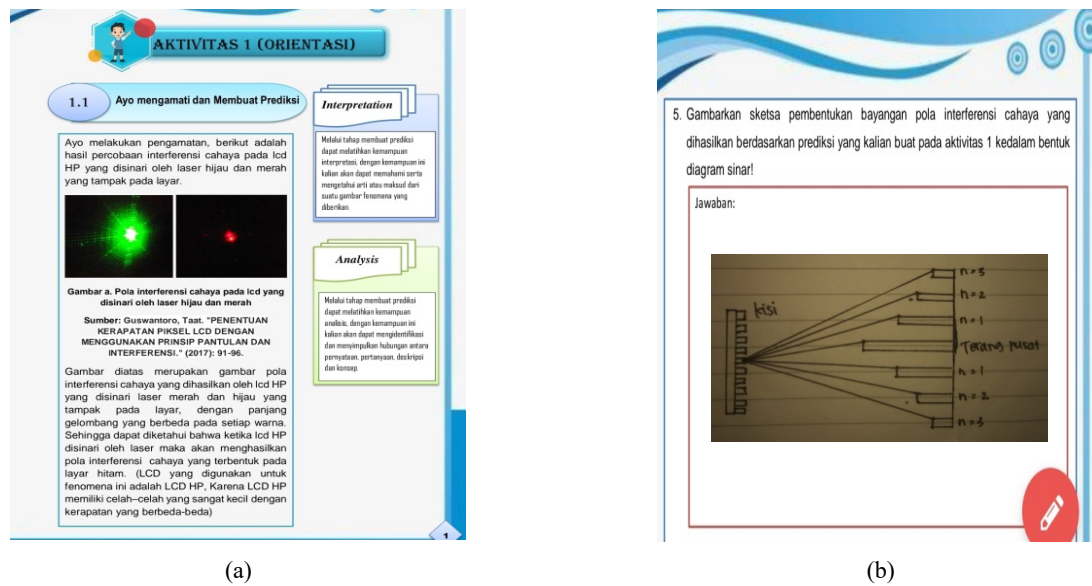


Figure 2. one of the pages from the e-worksheet, students are given Phenomena for Orientation (a) and make representation based on the Phenomena (b)

After making improvements based on the suggestions given by validators. Worksheet is then tested for practicality. Table 6 shows the results of the practicality test.

Table 6 The results of the practicality test

Practicality	Aspects	Average (%)	Criteria
Readability	Structure	83.7	Very High
	Spacing, type, and font size	85.0	Very High
	Layout	77.5	High
	Language	78.7	High
	User interface	80.0	High
	Instructions & Questions	83.7	Very High
	Steps of Activities	83.7	Very High
	Presentation	83.7	Very High
	Phenomena	86.2	Very High
	Learning Activities	78.7	High
	Pictures, Graphics, Illustrations, and videos	82.5	Very High
	Average	82.15	Very High
Students response	Characteristics of interactive teaching materials	81.6	Very High
	The Implementation of Knowledge and Skills	81.0	Very High
	Students' perception of satisfaction	83.7	Very High
	Students' Perception of ExPRession	80.9	Very High
	Average	81.8	Very High
Teacher Perceptions	Orientations	90.2	Very High
	Expression	88.8	Very High
	Investigation	90.2	Very High
	Evaluation	87.5	Very High
	Generalization	83.3	Very High
	Average	87.5	Very High
	Total Average	83.8	Very High

Table 6 provides a comprehensive evaluation of the practical aspects of educational material, assessing readability, students' responses, and teacher perceptions. In terms of readability, the material excels in various dimensions. The structure achieves an impressive 83.7%, indicating a very high level of organization. Elements such as spacing, type, and font size contribute to a readability score of 85.0%, emphasizing the material's

accessibility. While the layout and language scores are slightly lower at 77.5% and 78.7%, respectively, they still achieve high practicality, ensuring an effective learning experience. The user interface, instructions, questions, steps of activities, presentation, phenomena, learning activities, and the use of pictures, graphics, illustrations, and videos collectively contribute to an outstanding average score of 82.15%, solidifying the material's very high practicality in terms of readability.

Examining students' responses, the material demonstrates exceptional practicality. Characteristics of interactive teaching materials, the implementation of knowledge and skills, students' perception of satisfaction, and students' perception of the External Physics Representation (ExPRession) model all score above 80%, with an average score of 81.8%. These high ratings reflect the material's effectiveness in engaging students, implementing knowledge, and fostering satisfaction, showcasing its very high practicality in eliciting positive responses from learners.

Turning to teacher perceptions, the material earns overwhelmingly high scores, with an average of 87.5%. Teachers recognize the material's practicality in terms of orientations, expression, investigation, evaluation, and generalization, all-surpassing 80%. This suggests that educators find the material highly applicable, aligning with their teaching orientations and facilitating effective expression, investigation, evaluation, and generalization of concepts. The consistently high scores across readability, students' responses, and teacher perceptions collectively affirm the very high practicality of the educational material in diverse educational settings.

Based on the results of teachers' perception, it can be seen that the highest percentage of scores is found in investigative activities, with a score of 90.2% in the very high category. In this activity, students are led to conduct experiments to be able to prove the hypotheses that they have previously compiled. Starting with determining the experimental variables and conducting experiments so that students are able to draw a conclusion based on the observed data and relate it to relevant concepts so that a hypothesis that has been compiled is proven. This is in line with [18], which states that in the learning process, implementing experimental or practicum activities will provide opportunities for students to be able to experience it themselves or do it themselves, observe a process, observe an object, analyze, prove and draw conclusions, so as to improve the skills of students. Activity 5, namely generalizing the percentage of student's E-Worksheet work, was the lowest, with a score of 83.3%. This is because when the teacher provides feedback, many students do not pay attention, so when they are asked about learning evaluation, they are not able to explain in more detail. [19] students' reflection activities can help them learn knowledge through content, acquire professional skills, and carry out cognitive processes in more depth.

Meanwhile, the practicality of worksheets is related to the ease with which teachers can implement them in the learning process and it is easy for students to understand them. [20] Teaching materials are said to be practical if these teaching materials can be easily used by teachers and students in learning. Based on the results of the data analysis on the readability test aspect filled out by students, a score of 82.15% was obtained in the readable category. The aspect that dominates and has very high achievability is in question 9, that is the phenomenon presented in the E-Worksheet based on the ExPRession learning model activity is easy to understand, with a score of 86.2% in the very readable category. This is because they often encounter pictures and videos of phenomena displayed in the E-Worksheet in everyday life. [21] Natural events and phenomena that are often encountered by students in the surrounding environment, it is one of the learning resources that can be used by teachers to stimulate students' skills. This is in line with the opinion [22] When a teacher provides a phenomenon, the teacher provides opportunities for students to find facts, concepts, and principles through their direct experience.

Furthermore, based on the results of the student response questionnaire, an average score of 81.8% was obtained in the very good category. Students said that they felt happy and satisfied when learning to use the E-Worksheet based on the ExPRession learning model. [23] A person's learning satisfaction will arise when individual needs are met, but satisfaction will not arise if individual needs are not met. As for the teacher's perception questionnaire, it has the highest score with an average score of 87.9% in the very good category. the teacher said that the E-Worksheet based on the ExPRession learning model was easy to implement, and in each of its activities, it was able to train students' critical thinking skills, thus helping students understand the Material. This means that it can be concluded that students and teachers feel helped by the development of E-Worksheet based on the ExPRession learning model to train these critical thinking skills.

IV. Conclusions

In conclusion, the findings of the validity assessment, considering both media and design as well as material and constructs, underscore the robustness of the E-Worksheet developed through the ExPRession learning model for enhancing critical thinking skills. The collective evaluation yielded an average score indicating a high level of validity. Furthermore, the practicality of the developed E-Worksheet is evident, as revealed through the analysis of readability, student responses, and teacher perceptions. The overall average score places it in the highly practical category.

For future research endeavors, it is recommended that researchers explore the implementation of the E-Worksheet grounded in the ExPRession learning model for cultivating students' critical thinking skills. Additionally, researchers are encouraged to assess the effectiveness of the developed E-Worksheet, thereby contributing to the continuous enhancement of educational tools and methodologies.

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