Development of Interactive e-Worksheets (e-LKPD) in a Guided Inquiry Model to Improve Students' Critical Thinking Skills

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Abstract

Critical thinking is an essential 21st-century competence, yet a preliminary study at a private senior high school in Bandung showed that 71.43% of eleventh-grade students did not reach the minimum mastery criterion in a physics quiz, and instruction remained teacher-centered with static worksheets. This study aimed to develop an interactive electronic student worksheet (e-LKPD) using Wizer.me within a guided inquiry model to improve critical thinking on the topic of vectors, and to examine its validity, practicality, and effectiveness. The research used the Research and Development (R&D) method with the ADDIE model. Six validators (four physics lecturers and two physics teachers) assessed the material, media, and pedagogical aspects using Aiken's V. A limited trial involved 10 students and a field trial involved 27 eleventh-grade students using a one-group pretest-posttest design. Critical thinking was measured with five essay items based on Ennis's five aspects (Cronbach's alpha = 0.758). The e-LKPD was valid in the media (V = 0.92), material (V = 0.85), and pedagogical (V = 0.91) aspects; student responses were very good (88.31%); and the mean score increased from 32.04 to 82.04 with an N-Gain of 0.72 (high category). Gains were found in all five critical thinking aspects, the largest in supposition and integration and advanced clarification. The e-LKPD is therefore valid, practical, and associated with improved critical thinking, although stronger evidence of effectiveness requires a control group.

***Keywords**: e-Worksheet; Wizer.me, Guided Inquiry, Critical Thinking, Vectors.*

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A. INTRODUCTION

21st-century education focuses on student-centered learning with four main competencies: critical thinking, communication, collaboration, and creativity (Wahyuni, Laksana, Arifin, Pamungkas, & Syahapala, 2024). Critical thinking is an essential foundation because students are required to analyze, interpret, and evaluate information, as well as draw conclusions and synthesize ideas to solve problems (Trilling & Fadel, 2009). Ennis (2011) views critical thinking as the ability to think reflectively and reasonably when making decisions about what to believe and what to do. This ability is also part of the objectives of the Pancasila Student Profile in the current curriculum, and physics education is one of the fields that can develop it (Sundari & Sarkity, 2021).

However, conditions in the field are not yet aligned with these demands. A preliminary study at a private senior high school in Bandung City showed that 20 out of 28 eleventh-grade students (71.43%) obtained scores below the Minimum Competency Criteria (KKM) of 75 on a daily physics test, with the highest score being 100 and the lowest being 15. Interviews with the physics teacher revealed two main

problems: students had difficulty solving questions oriented toward Higher Order Thinking Skills (HOTS) and struggled to understand the question formats and the material being taught. Learning is still dominated by lectures and question-and-answer sessions, while digital devices have not been utilized optimally, and teaching materials are limited to printed student worksheets (LKPD) and textbooks. Teacher-centered learning and the inappropriate use of student worksheets hinder students' active participation and their ability to apply knowledge to solve problems (Suwastini, Agung, & Sujana, 2022).

The guided inquiry model can be a solution because it engages students in a process of investigation and concept construction under teacher guidance. Previous studies have reported that guided inquiry-based e-LKPD can improve critical thinking skills (Yuzan & Jahro, 2022) and science process skills (Masruhah, Rusdianto, & Wahyuni, 2022), and that guided inquiry with scaffolding can support the understanding of physics concepts and communication skills (Muhammad, Harso, & Laka, 2025). Febriani et al. (2022) also developed guided inquiry e-worksheets on the topic of optical instruments. On the other hand, Wizer.me is an interactive worksheet creation platform that provides various question types and allows the inclusion of text, images, links, and audio (Kopniak, 2018). The use of Wizer.me in learning has also been reported by Sobri et al. (2022) and Sulastri et al. (2024).

The topic of vectors was selected because it is a fundamental concept in mechanics; force, displacement, and velocity are vector quantities, so a strong understanding of vectors supports the study of kinematics and dynamics in Phase F of the Merdeka Curriculum (Kemendikdasmen, 2024). Although guided inquiry-based e-LKPD and the use of Wizer.me have been widely reported, studies integrating Wizer.me, embedded virtual simulations, and guided inquiry syntax explicitly mapped onto Ennis's five aspects of critical thinking in the topic of vectors remain limited. This study aims to (1) determine the feasibility of the e-LKPD in terms of material, media, and pedagogical aspects, (2) determine the practicality of the e-LKPD based on students' responses, and (3) determine the effectiveness of the e-LKPD in improving students' critical thinking skills in the topic of vectors.

B. METHOD

1. Research Design and Procedures

This study employed a Research and Development (R&D) approach, which is a method used to produce a product and test its effectiveness (Sugiyono, 2023), using the ADDIE development model, which consists of five stages: analysis, design, development, implementation, and evaluation. This model was selected because it is systematic and allows improvements to be made at each stage. The analysis stage involved semi-structured interviews with one physics teacher and an analysis of learning outcomes. The design stage produced an e-LKPD page flow that mapped the six guided inquiry syntax stages (orientation, formulating problems, proposing hypotheses, collecting data, testing hypotheses, and drawing conclusions) onto Ennis's five aspects of critical thinking. The development stage included product

creation, expert validation, and revision. The implementation stage consisted of limited trials and large-scale trials, while the evaluation stage involved improvements based on feedback from validators and trial results.

2. Research Subjects

The research subjects included one physics teacher (interviewee), six validators consisting of four physics lecturers and two physics teachers, each of whom assessed the material, media, and pedagogical aspects, 10 students in the limited trial, 31 students in the test instrument trial, and one Grade XI Science class consisting of 27 students in the large-scale trial at a private senior high school in Bandung City.

3. Research Instruments

The instruments used were an interview guide, an expert validation sheet with a 1–4 Likert scale, a limited trial questionnaire and a student response questionnaire with a 1–4 Likert scale, as well as a critical thinking skills test consisting of five essay questions, each representing one aspect of Ennis's (2011) critical thinking: basic clarification, bases for a decision, inference, advanced clarification, and supposition and integration.

4. Data Analysis Techniques

Validation data were analyzed using Aiken's V coefficient (Aiken, 1985). For six raters using a four-point scale, the critical validity threshold was 0.78; therefore, an indicator was considered valid if $V \geq 0.78$. The validity of the test items was examined using Pearson's product-moment correlation (r-table = 0.355 for N = 31 at a 5% significance level), and reliability was assessed using Cronbach's alpha. Student responses were calculated as the average score percentage and categorized according to Arikunto (2013), with 81–100% classified as very good. Limited trial data were analyzed descriptively using the median. Effectiveness was measured using a one-group pretest-posttest design and analyzed using N-Gain (Hake, 1999), with the following criteria: low ($g < 0.3$), moderate ($0.3 \leq g \leq 0.7$), and high ($g > 0.7$)

C. RESULTS AND DISCUSSION

1. Product Development Results

The analysis results showed that students' difficulties with HOTS questions and understanding the learning material, as well as the dominance of conventional learning, indicated the need for interactive learning media. The process skills elements in the Physics Learning Outcomes for Phase F (observing, questioning and predicting, planning and conducting investigations, processing and analyzing data, and communicating findings) are aligned with the guided inquiry syntax (Kemendikdasmen, 2024).

The resulting product consisted of two e-LKPDs on the Wizer.me platform, namely the “Vector Operations” e-LKPD. The e-LKPD follows the six stages of guided

inquiry and utilizes various Wizer.me question types (short-answer questions, essay questions, and data tables), guiding questions as scaffolding, an embedded PhET virtual simulation at the data collection stage, and automatic feedback after students submit their work.

2. e-LKPD Feasibility

The validation results are presented in Table 1. All aspects exceeded the critical threshold of 0.78, as shown in Figure 1; therefore, the e-LKPD was declared valid with a high validity category.

Right-Tail Probabilities (p) for Selected Values of the Validity Coefficient (V)

No. of Items (m) or Raters (n)	Number of Rating Categories (c) 2		3		4		5		6		7	
	V	p	V	p	V	p	V	p	V	p	V	p
2							1.00	.040	1.00	.028	1.00	.020
3							1.00	.008	1.00	.005	1.00	.003
3			1.00	.037	1.00	.016	.92	.032	.87	.046	.89	.029
4					1.00	.004	.94	.008	.95	.004	.92	.006
4			1.00	.012	.92	.020	.88	.024	.85	.027	.83	.029
5			1.00	.004	.93	.006	.90	.007	.88	.007	.87	.007
5	1.00	.031	.90	.025	.87	.021	.80	.040	.80	.032	.77	.047
6			.92	.010	.89	.007	.88	.005	.83	.010	.83	.008
6	1.00	.016	.83	.038	.78	.050	.79	.029	.77	.036	.75	.041
7			.93	.004	.86	.007	.82	.010	.83	.006	.81	.008
7	1.00	.008	.86	.016	.76	.045	.75	.041	.74	.038	.74	.036
8	1.00	.004	.88	.007	.83	.007	.81	.008	.80	.007	.79	.007
8	.88	.035	.81	.024	.75	.040	.75	.030	.72	.039	.71	.047
9	1.00	.002	.89	.003	.81	.007	.81	.006	.78	.009	.78	.007
9	.89	.020	.78	.032	.74	.036	.72	.038	.71	.039	.70	.040
10	1.00	.001	.85	.005	.80	.007	.78	.008	.76	.009	.75	.010
10	.90	.001	.75	.040	.73	.032	.70	.047	.70	.039	.68	.048

Figure 1. Critical Threshold of Aiken's V Validity

Source: (Aiken, 1985)

Table 1. Expert Validation Results (Aiken's V, n = 6 Validators)

Aspect	Sub-aspect	V	Category
Media	Visual appearance and design	0,972	Valid
Media	Feature and multimedia optimization	0,833	Valid
Media	Technical aspects and accessibility	0,944	Valid
Media (average)		**0,92**	**Valid (high)**
Material	Conceptual accuracy and appropriateness	0,83	Valid
Material	Language aspects	0,87	Valid
Material (average)		**0,85**	**Valid (high)**
Pedagogical	Integration of guided inquiry syntax	0,94	Valid
Pedagogical	Critical thinking skills (five Ennis indicators)	0,89	Valid
Pedagogical	Methodology and readability of instructions	0,89	Valid
Pedagogical (average)		**0,91**	**Valid**

		(high)

In the media aspect, 6 out of 7 indicators were valid. One indicator, namely the visual quality of the vector component images and the clarity of the embedded images, obtained a V value of 0.722 (below the critical threshold); therefore, the images were revised before the trial. In the material aspect, the lowest-scoring indicator (V = 0.778) was the accuracy of vector notation, component symbols, and unit vector operations, which was exactly at the critical threshold and was therefore still considered valid. In the pedagogical aspect, the coherence of the six guided inquiry steps and the proportion of scaffolding obtained the highest score (V = 0.944), while the allocation of working time and the task structure encouraging students to consider conflicting assumptions obtained the lowest score (V = 0.833), which was still considered valid.

3. Limited Trial Results

The limited trial involving 10 students resulted in a median score of 4 (very good) across all aspects and items. Of the 160 responses, 144 received a score of 4 and 16 received a score of 3, with no responses scoring below 3. Students suggested adding images to the orientation stage and providing clearer markers to distinguish the observation steps, data tables, and conclusion questions. Some students also experienced difficulties in drawing conclusions from the simulation results. This feedback was used to revise the e-LKPD during the evaluation stage.

4. Validity and Reliability of the Test Instrument

After expert validation, the five essay questions were tested on 31 students. All items were valid (r-calculated = 0.579–0.847 > r-table = 0.355; significance < 0.001), with the highest correlations found in the supposition and integration question (0.847) and the inference question (0.824). The Cronbach's alpha coefficient of 0.758 indicated high reliability; therefore, the instrument was suitable for use as a pretest and posttest.

5. Practicality of the e-LKPD

The response questionnaire was completed by 24 out of 27 students. The results are presented in Table 2.

Table 2. Student Response Questionnaire Results (n = 24)

Aspect	Average Percentage	Category
Media appearance	88,19%	Very good
Ease of use	89,24%	Very good
Benefits of use	87,50%	Very good
Average	**88,31%**	**Very good**

The highest indicator in the appearance aspect was the use of easily understandable language and explanations (89.58%), while in the ease-of-use aspect, it was the ease of using the e-LKPD features (89.57%). In the benefits aspect, 89.57% of

students stated that virtual simulations made them more engaged in learning activities.

6. Effectiveness of the e-LKPD in Improving Critical Thinking Skills

The large-scale trial was conducted over three days: the first day involved technical explanations, account creation, an introduction to the features, and the pretest; the second day involved learning activities using the e-LKPD, followed by the posttest on the third day. An analysis of the improvement in students' critical thinking skills for each indicator is presented in Figure 2.

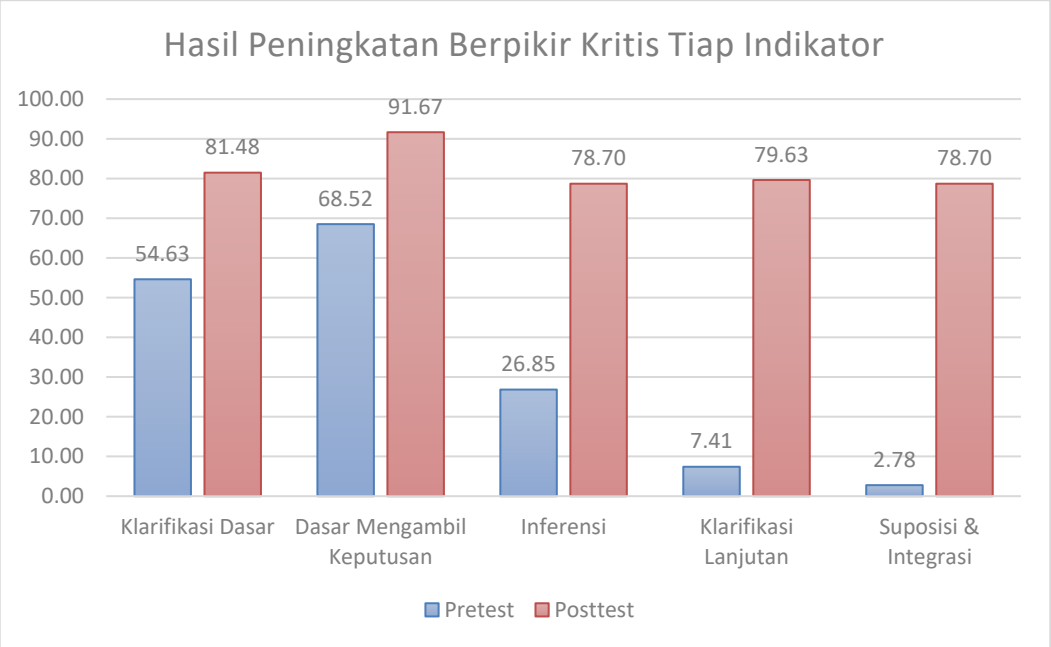


Figure 2. Bar Chart of Improvements in Critical Thinking Skills for Each Indicator.

The average score increased from 32.04 on the pretest to 82.04 on the posttest, with an N-Gain of 0.72 (72.30%), which falls into the high category. The details for each aspect are presented in Table 3.

Table 3. Pretest, Posttest, and N-Gain Scores for Each Critical Thinking Aspect (N = 27)

Critical Thinking Aspect (Ennis)	Pretest	Posttest	N-Gain	Category
Basic clarification	54,63	81,48	0,59	Sedang
Bases for a decision	68,52	91,67	0,74	Tinggi
Inference	26,85	78,70	0,71	Tinggi
Advanced clarification	7,41	79,63	0,78	Tinggi
Supposition and integration	2,78	78,70	0,78	Tinggi

All five aspects showed improvement. The aspects with the lowest initial scores, namely supposition and integration (2.78) and advanced clarification (7.41),

showed the greatest increases (75.92 and 72.22 points, respectively). In the pretest, 24 out of 27 students obtained a score of 0 in the supposition and integration aspect, whereas in the posttest, 24 students obtained a score of 3 or higher, and all students showed improvement. The basic clarification aspect achieved the moderate category (N-Gain of 0.59), with an initial score of 54.63; three students experienced a decrease in scores, and four students showed no change.

The e-LKPD completion scores of the 27 students showed that the supposition and integration aspect also obtained the lowest process score (53.9), compared with inference (69.0), advanced clarification (68.5), bases for a decision (65.6), and basic clarification (61.9), as shown in Figure 3.

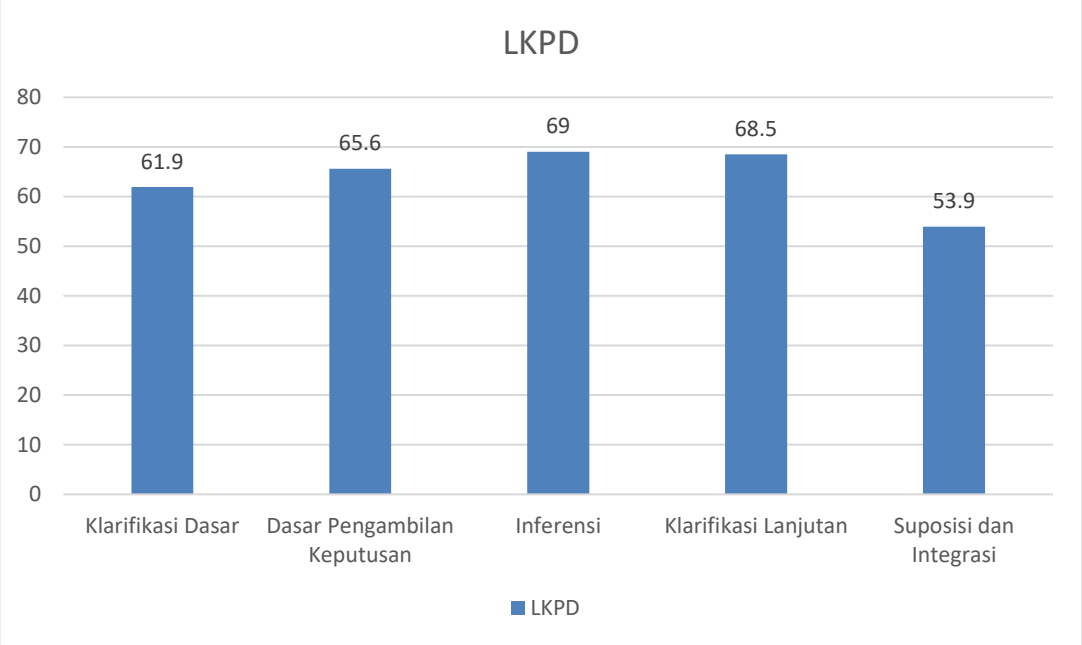


Figure 3. Bar Chart of Wizer.me e-LKPD Results

Discussion

1. Feasibility of the e-LKPD

All validation groups were categorized as highly valid (V = 0.85–0.92), and the integration of the six guided inquiry syntax stages obtained the highest score in the pedagogical aspect (V = 0.944). This finding indicates that the mapping of inquiry syntax stages onto critical thinking indicators was considered appropriate by the experts. Attention needs to be given to visual quality and the accuracy of vector notation, which are crucial aspects of vector material; the visual indicator that was initially invalid (V = 0.722) was revised before the trial, and students' feedback from the limited trial was used to improve the orientation stage and the markers between steps.

2. Practicality of the e-LKPD

Students' responses were categorized as very good across all three aspects

(87.50–89.24%). This result is consistent with the advantages of Wizer.me, which allows assignments to be completed and submitted online while also providing multimedia elements (Sulastri, Mahardika, Sugiarti, & Sudrajat, 2024). Thus, the e-LKPD can be considered practical based on students' responses. It should be noted that the practicality in this study was assessed only from the students' perspective and did not yet include implementation by teachers.

3. Effectiveness of the e-LKPD

The average N-Gain of 0.72 indicates a high level of improvement in critical thinking skills after students learned using the e-LKPD. The greatest improvements in the aspects of supposition and integration and advanced clarification can be associated with the characteristics of the e-LKPD: the stages of proposing hypotheses, testing hypotheses, and drawing conclusions require students to reason based on potentially incorrect assumptions and then integrate findings into decisions, while the guiding questions at each stage train students to define terms and identify hidden assumptions, which are the essence of advanced clarification. The inference aspect (N-Gain of 0.71) is related to the stages of collecting data and testing hypotheses, during which students observe PhET simulations, record data, and draw conclusions from them.

The basic clarification aspect only achieved the moderate category. One contributing factor was the relatively high initial achievement, which limited the room for improvement; in addition, three students experienced a decrease in scores and four showed no change. This indicates that the ability to focus questions and analyze arguments was not yet optimal after the short learning period, suggesting that the orientation and problem-formulation stages in the e-LKPD need to be strengthened. The pattern in which higher-order critical thinking aspects showed the greatest development is consistent with the findings of Yuzan and Jahro (2022), who reported that guided inquiry-based e-LKPD can improve critical thinking skills.

The supposition and integration aspect, which also obtained the lowest process score, appears to be the most challenging because it requires reasoning based on potentially incorrect assumptions and integrating all findings at the final stage. Therefore, the addition of open-ended questions and guiding questions at the data analysis and conclusion-drawing stages should be considered.

4. Research Limitations

This study used a one-group pretest-posttest design without a control class; therefore, the improvement cannot be attributed solely to the e-LKPD. The learning activities were conducted over three days in one class consisting of 27 students, the pretest and posttest used the same questions within a short interval, and the analysis was not supplemented by inferential tests. Further research is recommended to use a control class, a larger sample, a longer duration, and other topics to examine the

sustainability of the results.

D. CONCLUSION

Based on the research findings, the Wizer.me-assisted interactive e-LKPD using the guided inquiry model for vector material: (1) was feasible based on expert validation, with a high validity category in the media (V = 0.92), material (V = 0.85), and pedagogical (V = 0.91) aspects; (2) was practical based on students' responses, with an average percentage of 88.31% (very good); and (3) demonstrated an improvement in critical thinking skills with an N-Gain of 0.72 (high), with improvements in all five critical thinking aspects, four of which were categorized as high and one (basic clarification) as moderate. Teachers can utilize this e-LKPD as an alternative teaching material to develop critical thinking skills and further improve it by adding open-ended questions and guiding questions at the data analysis and conclusion-drawing stages.

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