Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

Development of e-Worksheet Guided Inquiry-Oriented to Train Students' Critical Thinking Skills on Buffer Solution Material

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Received: June 13, 2024. Accepted: July 14, 2024. Published: July 25, 2024

Abstract: Research titled Development of a Guided Inquiry-Oriented e-Worksheet to Train Students' Critical Thinking Skills on Buffer Solution Materials aims to produce e-worksheets to train critical thinking skills. This research is development research using the ADDIE model. The research design was a one-group pretest-posttest design. The feasibility of e-worksheet refers to three criteria: validity, practicality, and effectiveness. Validity consists of content validity and construct validity. Validity data is obtained from expert assessments through expert judgment. The results of the validity assessment stated that the e-worksheet developed had met the content and construct validity requirements in all aspects. Practicality data is obtained from students' physical activity observations, nonphysical activity observations, and student response questionnaires. Practicality and effectiveness data were obtained during the pilot test. Practicality data was obtained from observations of physical and nonphysical activities and student response questionnaires. The results of activity observations and learner response questionnaires show that the e-worksheet developed has met the practical criteria. Effectiveness data was obtained from the pretest and post-test results of students' critical thinking skills. The test results show that the developed e-worksheet has met the effective criteria.

Keywords: Buffer Solution; Critical Thinking Skills; e-Worksheet; Feasibility.

Introduction

Indonesia currently uses a Kurikulum Merdeka that focuses on developing soft skills such as critical thinking, teamwork, communication, and digital skills. Teaching materials in a *Kurikulum Merdeka* are significant because they can facilitate context-based learning, support active and collaborative learning, encourage creativity and innovation, accommodate a variety of learning styles, integrate technology into learning, and provide choice and flexibility [1]. Updating learning facilities and infrastructure is also a mandatory task that the management of educational institutions must carry out for a smooth learning process. Teachers must be able to guide and direct students in using technology beneficially and adequately for learning. Through updating facilities and infrastructure and utilizing technology properly, schools can undoubtedly carry out the teaching and learning process optimally [2]. The worksheet is one of the teaching materials that can be used. A worksheet is a printed teaching material containing content, summaries, and task guides related to the abilities that students must possess [3]. Worksheets are sheets whose contents are tasks that students must do, containing instructions, steps, and how to complete specific material tasks [4]. According to the findings of the pre-research at SMAN 3 Surabaya, the worksheet is the primary teaching material used in addition to the package book. However, not all materials use worksheets, and those used are worksheets that only contain practice questions.

In the 21st century, global progress is rapid, including in education. 21st-century learning combines mastery of technology, literacy, knowledge proficiency, and attitudinal skills [5]. Using technology, teaching materials such as worksheets can be made in electronic form, which students can access via laptop or smartphone. Furthermore, e-worksheet teaching materials are digital work instructions for students that can be accessed through devices such as computers, laptops, notebooks, or smartphones [6]. Worksheets made using live worksheets are one of the teaching materials that use technology applied in education because they can produce text, images, animations, and videos more effectively so that students do not get bored quickly.

Liveworksheet is a platform that allows us to make worksheets previously printed online and interactive, making students feel like they are playing games. Additionally, the platform features an automatic correction feature, enabling the integration of student assignments with teacher accounts. Thus, the grade-recap process becomes more accessible and more efficient. Liveworksheet can be accessed through its official website at https://www.liveworksheets.com. Live worksheets can contain activities such as a) writing text, b) entering answers, c) multiple choice, d) matching, e) dragging and dropping, f) speaking, and g) inserting video. [7]. Students can directly use worksheets made using live worksheets without having to be printed or downloaded first. Some of the advantages of the worksheet using live worksheets are that they can be accessed for free, are more practical because there is no need for printing, can be accessed using a smartphone or laptop, can be used as media and assignments during online learning, and do not take up storage space [8]. The results of preliminary studies at SMAN 3 Surabaya show that learning still does not use

How to Cite:
Wahyuningtyas, I. N., & Agustini, R. (2024). Development of e-Worksheet Guided Inquiry-Oriented to Train Students' Critical Thinking Skills on Buffer Solution Material. *Jurnal Pijar Mipa*, *19*(4), 623–629. https://doi.org/10.29303/jpm.v19i4.7068

media that utilize electronic technology, and according to students, learning will be more enjoyable. The material will be easier to understand if learning uses electronic technology.

Education in the 21st century requires the utilization of technology in learning and requires students to have 4C skills, including critical thinking and problem-solving. Critical thinking is a thought process that assists individuals in analyzing, evaluating, questioning, and making inferences using substantiated, contextual, and conceptual reasoning [9]. Critical thinking skills are essential for students to prepare themselves for the challenges of the current era. Critical thinking skills will encourage a person to investigate, ask questions, propose new answers, challenge doctrines, and discover new information [10]. Preliminary studies conducted at SMAN 3 Surabaya show that there has never been a direct measurement of students' critical thinking skills. Teachers at the school usually include about five essential thinking questions in each exam. If students can answer these questions correctly, it is assumed that students have good critical thinking skills. However, this method has several disadvantages.

First, the small number of questions may not reflect the full range of students' critical thinking skills. Second, relying solely on exam results to assess critical thinking skills may overlook other important aspects of these skills, such as the ability to interpret, analyze, evaluate, and make inferences critically. Using suitable teaching materials and media and applying the appropriate learning model, students can gain essential skills in the 21st century, such as critical thinking skills. The inquiry learning model allows students to actively participate in the learning process through investigation, which encourages students to think critically and be creative [11]. Guided inquiry is one type of learning that can help practice critical thinking skills. In guided inquiry, students are given specific instructions and guidance to gather the information needed to complete the task. Guided inquiry is an inquiry activity in which students are given a phenomenon and the tools and materials used in conducting investigations and experimental procedures. However, the answer to the problem is not provided, so students must explain the answer to the problem supported by the facts they get from the experiment's results [12]. This guidance is gradually reduced as the student experience develops [13]. Guided inquiry is a learning model in which there is a scientific activity, such as students expressing opinions before the topic is explained, investigating a problem in the form of symptoms or phenomena, finding facts, and defining and comparing the theory scientifically [14]. Critical thinking skills learning is based on the guided inquiry learning process. Learning guided inquiry can help students discover new knowledge by training them to improve their critical thinking skills [15]. Guided inquiry helps students develop critical thinking and problem-solving skills through an active discovery process. Students in guided inquiry learning are given space to develop critical thinking and problem-solving skills independently, with the help of teachers who provide direction and guidance. This helps students develop critical thinking and problem-solving skills [16]. An orderly, logical, and deep thought process accompanied by accurate data helps to reach accountable conclusions, which ultimately trains critical thinking skills.

Research Methods

The type of research is development research in the form of electronic student worksheets to train the critical thinking skills of class XI students on buffer solution materials. This research is guided by the research and development (R&D) method, and the ADDIE model is used. The research design is guided by the steps of research and development of the ADDIE model without implementation, namely analysis, design, development, and evaluation. The ADDIE model goes through an evaluation and revision process at every stage to minimize errors [17]. The e-worksheet developed must meet the eligibility criteria before being used by students. The developed product's feasibility must meet the validity and practicality requirements [18]. In addition, it must also meet the criteria for effectiveness [19].

The validity of the e-worksheet is determined by two criteria, namely construct validity and content validity [20]. E-worksheets that are qualified and feasible to be applied in the learning process must meet the validity standards experts assess. Valid e-worksheets are considered to facilitate the delivery of concepts to students [21]. The validation data results were determined based on each aspect's mode (Mo) using the Likert scale. The interpretation criteria for the validity assessment score of the learning tool are listed in Table 1.

Table 1. Likert Scale Criteria for Validity Assessment

Criteria	Scale
Very valid	5
Valid	4
Quite valid	3
Less valid	2
Invalid	1

[22]

Three validators carried out the validity assessment. The e-worksheet is declared valid if the results of the validator assessment obtained mode ≥4 in every aspect.

E-worksheets students should be practical or easy to use for several essential reasons related to efficiency in the learning process, such as easy access without difficulty, improved learning quality, and flexibility in use [23]. The data from the observation of student's physical activities was obtained from the observation results. The criteria for the results of the assessment of student's physical activity are determined based on the Guttman scale. Each criterion is calculated based on a value category and converted into a percentage. The percentages obtained are interpreted according to the scoring criteria in Table 2.

Table 2. Interpretation Criteria for Practicality Assessment Score

Percentage (%)	Category
0-20	Very impractical
21-40	Less Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

[22]

For nonphysical activities, the criteria for assessment results are determined based on the Learning Objectives Completeness Criteria. In the *Kurikulum Merdeka*, teachers have the freedom to decide the Learning Objectives and Completeness Criteria that are adjusted to the needs and abilities of students. At SMA Negeri 3 Surabaya, the KKTP is determined as follows:

Table 3. Criteria for Achieving Learning Objectives

Range	Categories	Information
0-25	Not yet complete	Remedial throughout part
26-50	Not yet complete	Remedial throughout part
51-75	Not yet complete	Remedial in the section required
76-100	It has reached completeness	Need enrichment or more challenges

[24]

The observation of students' nonphysical activities is assessed through the e-worksheet process using the assessment rubric; the results obtained are then interpreted according to the KKTP criteria in Table 4. The e-worksheet is declared practical if it meets the percentage result of ≥61% in physical activities and gets a minimum score of 76 in observing students' nonphysical activities.

The data from the students' responses were analyzed quantitatively and descriptively. The criteria for response results were determined by mode (Mo) using the Likert scale presented in Table 4.

Table 4. Likert Scale Criteria for Response Questionnaire Assessment

Criteria	Scale
Strongly agree	5
Agree	4
Hesitate	3
Disagree	2
Strongly disagree	1

[22]

The e-worksheet developed is declared practical if the response questionnaire obtains the ≥4 mode.

Student achievement can be used to measure the effectiveness of learning devices. Learning tools are effective if they can help students achieve the competencies they must possess [25]. The effectiveness analysis was done through a data analysis of students' critical thinking skills. Different tests were used to determine the effectiveness of e-worksheets. If the data obtained meets the requirements of the parametric statistical test, the t-test is used. Still, if the data obtained does not meet the test requirements of the parametric statistical test, the Wilcoxon sign rank test is used. The effectiveness test steps are the normality test and the paired sample t-test. The normality test is a procedure used to determine whether the data used is usually distributed. The normality test used in this study is the Saphiro-Wilk test. The normality test was carried out using SPSS based on decision-making: if the significance value is >0.05, the data is usually distributed, and if the significance value is <0.05, the data is not normally distributed [20]. Furthermore, a paired sample t-test was conducted to test the hypothesis of increased students' pretest and post-test scores. This test was carried out using the Minitab application with a one-tail test. The basis for decision-making is that if the p-value < 0.05, then H0 is rejected and Ha is accepted; thus, the pretest value is smaller than the post-test value. This means that the e-worksheet developed is said to be effective.

Results and Discussion

The final result of the analysis stage is based on the literature study of previous research. Critical thinking skills need to be improved. In addition, the results of interviews conducted at SMAN 3 Surabaya stated that students' critical thinking skills have never been measured, so measuring and improving these skills is necessary. The instructional goal set by the researcher is to improve students' critical thinking skills. The target students are class XI-IPA SMAN 3 Surabaya students who have received acid-base material. The class used for research is class XI IPA-6. All students carry smartphones, and most students have chemistry package books. The curriculum used at SMAN 3 Surabaya is *Kurikulum Merdeka*. Resources at school that are relevant for research are chemistry laboratories, libraries, and classrooms that fit the capacity with equipment such as blackboards, markers, and projectors as needed. The learning system proposed by the researcher can train critical thinking skills. The learning model used is guided inquiry. The researcher establishes the research design, the schedule for obtaining data, and the observer's involvement in the research process.

The final result of the design stage is a review of the e-worksheet that has been developed to get comments and suggestions for improvement and perfection. The final result of the development stage is the e-worksheet. The developed e-worksheet was then formative evaluated. The formative evaluation process is called validation. Data on construct validity and content validity of e-worksheet are presented in Table 5. e-worksheet construct validity data is the score given by the expert in the range of 1 to 5, which represents the level of confidence of the indicator construct and the relevance of the e-worksheet to the activities to be carried out to achieve instructional objectives. Data on the content validity of the e-worksheet is the score given by the expert in the range of 1 to 5 related to the substance contained in the e-worksheet in terms of content correctness.

Table 5. Validator Assessment Score of the e-Worksheet Construct and Content

No	Components Assessed	Validator			Mo	Criteria
		1	2	3		
	CONSTRUCT VALIDITY					
	e-Worksheet Construct with Criteria Related to Presentation					
1	Suitability of TP with CP	5	4	5	5	Very valid
2	Suitability of ATP with TP	5	4	4	4	Valid
3	Completeness of the components presented in the e-worksheet	5	4	5	5	Very valid

No	Components Assessed	Validator 1	Validator 2	Validator 3	Mo	Criteria
	1. Title, material, class 2. TP by CP 3. Tools and materials 4. Work steps 5. Data table 6. Questions (Abdurrahman, 2015)					
4	The cover presents the contents of the e-worksheet	5	4	5	5	Very valid
5	There is a place to write answers as needed	5	4	5	5	Very valid
	e-Worksheet Constructs as Critical Thinking Skills Guides					
6	Provide direction to students to formulate problems according to the variables that have been determined by the phenomena presented (interpretation)	5	4	5	5	Very valid
7	Provide direction to students to be literate to formulate Thinking patterns to formulate a simple summary of the material that will help in forming hypotheses	5	5	5	5	Very valid
8	Provide direction to students to write hypotheses using the framework that has been made (inference).	5	4	5	5	Very valid
9	Give directions to students to evaluate data (evaluation)	5	4	5	5	Very valid
10	Give directions to students to collect data according to the experiments that have been carried out	5	4	5	5	Very valid
11	Give directions to students to analyze the data from the experiment by answering several questions that have been provided (analysis)	5	4	5	5	Very valid
12	Provide direction to students to make conclusions (inferences)	5	4	5	5	Very valid
13	Instruct students to write arguments based on evidence, methodology, concepts, and context (explanation).	5	5	5	5	Very valid
14	Provide direction to students to evaluate, analyze, and correct the statements presented and provide appropriate arguments (self-regulation)	5	4	5	5	Very valid
	VALIDITY OF CONTENT					
	Correctness of e-Worksheet with Content					
15	Correctness of facts, concepts, principles, laws, and theories contained in e-worksheet	5	4	5	5	Very valid
16	Content or topics have relevance to the thinking skills set as learning targets.	5	4	5	5	Very valid
17	The phenomenon presented is by the subject matter	5	4	5	5	Very valid
18	The practicum activities carried out in the e-worksheet are by the material	5	4	5	5	Very valid

The construct and content validity of the e-worksheet are assessed through a validation process. Construct validity and content validity of e-worksheets are evaluated quantitatively by giving scores on the components listed and qualitatively by providing comments and suggestions for improvement. E-worksheet is declared valid in terms of construct and content if the quantitative assessment results obtain the mode of assessment with minimum criteria. Quantitative assessment results obtain an assessment mode with at least valid criteria. The e-worksheet developed was declared valid. The construct validity aspects reviewed by the validators consisted of two aspects, namely the e-worksheet construct with criteria related to the presentation composed of five components, where four components obtained a very valid mode and one component obtained a valid mode. The second aspect is the construct of an e-worksheet as a guide to critical thinking skills consisting of nine assessment components, where all nine components obtained the mode of assessment with very valid criteria.

Furthermore, the content validity aspect includes four assessment components, which determine the mode of assessment with very valid criteria. The developed e-worksheet has validly represented the indicator construct's trustworthiness with the activities carried out to achieve the learning objectives and is valid in terms of content correctness. E-worksheets suitable for use in the learning process must meet the validity standards assessed by experts. E-worksheets validated in terms of construct and content can help facilitate planned learning activities, increase learning activities and achievement, and establish effective interactions. A valid e-worksheet is considered to facilitate the delivery of concepts to students [26].

The final stage of the development phase is the pilot test. The pilot test is the final series of formative evaluations. Pilot test data was obtained from students' physical and nonphysical observation sheets by three observers, response questionnaires, and pretest and post-test work by students. The data was processed to describe the practicality and effectiveness of the pilot test. In practicality, which is reviewed from the results of observations of students' physical activity, the observer must observe 20 aspects of physical activity.

The practicality of e-worksheets is assessed by the ease and helpfulness of students in using e-worksheets. The practicality of the e-worksheet was collected through observations of learner activities by observers and by students filling out response questionnaires. E-worksheets used by students must be practical or easy to use for several reasons related to efficiency in the learning process, such as

easy access without difficulty, improving the quality of learning, and flexibility in use. Scores on the assessment of students' physical activity by three observers are presented in Table 6.

Data from the observation of students' physical activity were analyzed quantitatively. Twenty components must be observed by the observer, of which 16 are relevant, and four are irrelevant. The percentage obtained by the whole group is 81–100%, which means it meets the efficient criteria.

The practicality of e-worksheets is reviewed based on the results of observations of students' nonphysical activities carried out by assessing e-worksheet work. Learning using e-worksheets is considered practical if the results of students' e-worksheets show a work score of at least 76, which means that students have reached mastery and need more enrichment or challenge. Scores on activity assessment students' nonphysical activity assessment are presented in Table 7.

Table 6. Results of Observation of Physical Activity of Students

Activity Observed	Group					
	1	2	3	4	5	6
Total score of students' physical activity observation results	18	20	19	19	20	19
Percentage (%)	90	100	95	95	100	95
Criteria	Very Practical	Very Practical	Very Practical	Very Practical	Very Practical	Very Practical

Table 7. Results of Observation of Nonphysical Activities of Students

Group	Students	Score	Group Score	Completeness
1	S2	81	87	Completed
	S3	85		
	S5	92		
	S14	84		
	S28	93		
2	S6	88	89	Completed
	S10	96		
	S15	81		
	S16	85		
	S17	93		
3	S12	96	88	Completed
	S13	81		
	S20	88		
	S21	88		
	S22	87		
4	S1	84	88	Completed
	S8	87		
	S27	88		
	S29	92		
	S30	88		
5	S4	90	90	Completed
	S7	88		
	S19	96		
	S23	88		
	S25	87		
6	S9	93	88	Completed
	S11	87		
	S18	81		
	S24	88		
	S26	88		

The results of students' e-worksheet work scored in the score range of 81–100, which means that all students have met the category of having achieved completeness. Based on Table 7, some groups get the lowest scores. There are several possibilities. There are several possibilities as to why this can happen, including that the group consists of members who have lower initial abilities than other groups, the learning model used is not by the learning style of group members, and the group may experience problems in terms of cooperation and communication between members, so they cannot work together. Communication between members is poor, so they can't work well together.

The student response questionnaire collects students' opinions or responses to indicators representing the implementation of e-worksheets to train critical thinking skills. The score of students' assessments of the response questionnaire is shown in Table 8.

The data shows that two questions were obtained in mode 5 and 16 in mode 4. This indicates that the e-worksheet used for learning meets the practical criteria. The results of the students' response questionnaire with a rating scale of 1–5, according to Table 8, show that although most students gave high ratings (4 or 5), some gave low ratings (1 or 2). This can occur for several reasons, such as the fact that each student may have different experiences or perceptions of learning using the developed e-worksheet. Personal conditions such as health problems, stress, or family problems can affect the student's learning experience assessment. Using guided inquiry models in e-worksheets that are effective for most students may not be suitable for all. Students with different learning styles may feel less helped by guided inquiry models. Students may have different expectations of learning. If their expectations are not met, they may give lower grades. There may be misunderstandings about the questions in the questionnaire or ignorance about how to give an appropriate assessment.

Learners have no difficulty reading the content in the e-worksheet. This proves that the e-worksheet prepared has met the quality criteria of the worksheet as described by Arsyad [27], namely using the same format on each page, text information that students easily accept, and the appropriate font size. In addition, the e-worksheet also fulfills the preparation requirements according to Darmojo and Kaligis [28], namely the use of proper language, clear sentence structure, and a good combination of images and

text. The systematics of the worksheet include several main parts that must be present so that the worksheet is practical and valuable for students. The parts in the e-worksheet are arranged based on the systematic preparation of worksheets, according to Abdurrahman [29], with minor modifications or adjustments as needed. The adjustments are adjusted to the syntax of guided inquiry and critical thinking skills.

Table 8. Student Assessment Score on Response Questionnaire

Questions to-	Score				
	5	4	3	2	1
1	7	16	2	1	4
2	12	13	4	1	0
3	5	13	6	4	2
4	6	12	5	4	3
5	5	12	8	3	2
6	12	9	6	3	0
7	10	14	5	1	0
8	9	15	4	2	0
9	4	16	6	3	1
10	5	15	3	4	3
11	7	17	3	7	1
12	9	11	9	1	0
13	8	10	8	2	2
14	4	14	9	1	2
15	5	13	8	4	0
16	11	10	7	2	0
17	9	11	7	2	1
18	5	12	7	3	3

The effectiveness of the e-worksheet was reviewed based on the measurement of students' critical thinking skills. Students' critical thinking skills are measured through pretest and post-test results. The pretest and post-test results of students' critical thinking skills contain indicators of interpretation, analysis, explanation, evaluation, inference, and self-regulation. The Shapiro-Wilk normality test results show that the significance is 0.102 and 0.105. The normality test results are listed in Table 9.

Table 9. Pretest and Post-test Normality Test Results

Shapiro-Wilk		
Statistic	df	Sig
.942	30	.102
.942	30	.105

The significance value is more than 0.050, so the data obtained is usually distributed, meaning it met the parametric statistical test requirements. The test continued with the Paired Sample t-test test using Minitab software. The results of the paired sample t-test are shown in Figure 2.

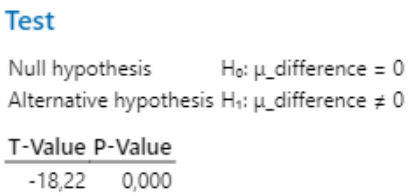

Figure 1. Paired Sample t-Test Results Using Minitab Software

Based on the data above, the P-value is 0.000, which means it is smaller than 0.05. The basis for decision-making on the paired sample t-test is that if the P-value is <0.05, Ho is rejected, and Ha is accepted. Thus, a guided inquiry-oriented e-worksheet to train students' critical thinking skills is effective because there is an increase in students' critical thinking skills after using the developed e-worksheet.

The student's achievement on the pretest and post-test can be used to measure the effectiveness of the e-worksheet. An e-worksheet is said to be effective if the e-worksheet used can help students achieve the competencies that must be possessed [30]. Learning using the guided inquiry model can train students' critical thinking skills. This was proven in a study conducted by Putri and Sukarmin [31], where the post-test results showed a higher value than the pretest. The research indicates that students can develop their critical thinking skills more effectively through guided inquiry learning.

Conclusion

Based on the research results, the conclusion is that the Guided inquiry-oriented e-worksheet to train students' critical thinking skills has met content and construct validity criteria. Guided inquiry-oriented e-worksheets to train students' critical thinking skills have met the practical criteria. Guided inquiry-oriented e-worksheets to train students' critical thinking skills have met the effectiveness requirements.

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