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Development of Buffer Solution Worksheet Based on Discovery Learning to Improve Students' Critical Thinking Skills

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ABSTRACT .

One of the essential 21st-century skills for students is critical thinking. However, students' critical thinking skills in buffer solution material are relatively low, so appropriate learning models and teaching materials are needed. This research aims to develop worksheet based on discovery learning to improve students' critical thinking skills on buffer solution material, reviewed from validity, practicality, and effectiveness. The method used in this research is Research and Development (R&D) with the 4D development model by Thiagarajan, but this research is limited to the development stage. A limited trial was conducted with 15 students from one of the high schools in Surabaya in June 2024. The results showed that the worksheet is declared valid, with a median score of 4 in the valid category. The practicality of the worksheet is stated to be practical in terms of the results of the response questionnaire, namely that students gave positive responses to the worksheet developed and supported by observations of student activities where relevant student activities exceeded irrelevant activities. The worksheet effectiveness is declared effective in terms of the results of students' critical thinking skills tests which had increased with N-Gain scores in the range of 0.64 to 1.00 in the medium to high category and supported by students' knowledge learning outcomes reaching individual completeness, namely ≥ 75. Based on these results, it can be concluded that buffer solution worksheet based on discovery learning is feasible for improving students' critical thinking skills in buffer solution material.

INTRODUCTION

Chemistry is a science that studies everything related to matter, including composition, structure, properties, changes, dynamics, and energy that accompany changes in matter, so chemistry subjects involve reasoning and skills (Artini & Wijaya, 2020; Astuti, 2020). Besides that, chemistry has special characteristics, namely that it has three levels of chemical representation namely the macroscopic level, submicroscopic level, and symbolic level (Sari & Yerimadesi, 2021). Based on these characteristics of chemistry, chemistry subjects are very suitable as a tool for developing 21st-century skills (Redhana, 2019).

The 21st century is known as the "Knowledge Age", which is centered on the development of the Industrial Revolution era 4.0, which prioritizes knowledge as the main foundation. However, knowledge alone is not enough to realize the Industrial Revolution era 4.0 because there needs to be a balance between knowledge and skills as the basis for quality human resources (Rahmah, 2023). The National Education Association has identified 21st-century skills as 4C competencies, including critical thinking, creative thinking, communication, and collaboration (Redhana, 2019). To achieve maximum educational targets in the 21st century, these skills must be possessed by students in 21st-century

learning. One of the 21st-century skills that students must have is critical thinking. Critical thinking skills are one of the higher-order thinking skills that must be instilled in students' way of thinking (Wayudi et al., 2020). Critical thinking skills are self-regulation in deciding something consisting of interpretation, analysis, evaluation, inference, explanation, and self-regulation, as well as a presentation using evidence, concepts, methodology, criteria, or contextual considerations that form the basis for drawing conclusions or statements (Facione, 2015). Trimahesri & Hardini (2019) stated that critical thinking can help students make conclusions by considering existing facts and data. Apart from that, Syukri et al. (2022) also explain that critical thinking skills can help students in learning because by thinking critically, students can make the right decisions, solve problems, and as a provision to face future challenges.

One of the materials in chemistry subjects that requires critical thinking skills is buffer solutions. Buffer solution material in the Merdeka Curriculum is studied in phase F. One of the learning outcomes that must be achieved at the end of phase F is that students are able to use the concept of acids and bases in everyday life. Based on these learning outcomes, buffer solution material has characteristics that include concepts. Nurhujaimah et al. (2016) also explained that buffer solutions based on their material characteristics have conceptual properties. Apart from that, the learning outcomes that students must achieve at the end of phase F are that students are able to apply mathematical operations in chemical calculations and understand chemical concepts in living things. Therefore, buffer solutions have characteristics that involve calculations and contextual material. Halimah et al. (2019) stated that buffer solutions have characteristics that involve chemical reaction mechanisms and calculations that consist of several stages and are contextual. Based on these chemical characteristics, students' critical thinking skills are needed in buffer solution material. However, based on pre-research conducted at one of the state high schools in Surabaya, students' critical thinking skills in buffer solution material were relatively low. This is supported by research conducted by Jawadiyah & Muchlis (2021) that before the treatment was carried out, students' critical thinking skills in buffer solution material were still very low.

One of the factors causing students' low critical thinking abilities is the implementation of learning, which tends to be monotonous and does not involve the active participation of students (Winarti et al., 2022). According to Fenanda et al. (2024), teachers have an essential role in the learning process, namely as facilitators to help students participate actively in learning. Juwitasari & Suyono (2023) also stated that the cause of low critical thinking skills is caused by learning methods in class that do not allow critical thinking to be absorbed in depth. Therefore, one way to improve students' critical thinking skills is to use a suitable learning model, one of which is discovery learning. According to Suhana (2014), discovery learning is a learning activity that requires students to search and investigate systematically, critically, and logically. Discovery learning is a learning model that emphasizes the process of students' discovery and understanding of concepts through direct experience and interaction with the learning environment. In addition, students' correct understanding of concepts in buffer solution material is essential for use in other fields such as in studying the structure and function of molecules in biological systems (Orgill & Sutherand, 2008). Therefore, through the discovery learning model, students can independently discover the concept of buffer solutions.

The discovery learning model has several benefits, specifically promoting active student participation in learning tasks, enhancing and boosting students' curiosity, and offering high motivation to students since they can experiment (Khasinah, 2021). On the other hand, there are also some drawbacks of discovery learning, including the requirement of significant time because teachers must shift from being mere providers of information to becoming facilitators, motivators, and guides for students in their learning, and not every student can discover on their own (Afni et al., 2022). Therefore, to address the limitations of discovery learning, it is essential to have supportive teaching materials. One type of teaching material that can be utilized is a worksheet. Worksheets are among the educational tools that can assist and simplify students' engagement in learning activities (Malichah & Yonata, 2023). Lase & Zai (2022) also stated that student activity sheets are teaching materials that can enhance student engagement in the teaching and learning process, aid students in conducting experimental activities across various topics, help students acquire information, and allow students to learn to explore. Consequently, worksheets can serve as a supportive resource for enhancing students' critical thinking

skills. Based on this context, this research aims to create buffer solution worksheets based on discovery learning that are appropriate for use in enhancing students' critical thinking abilities.

RESEARCH METHODS

Research Approach

The type of research used in this research is Research and Development (R&D). The development of this worksheet uses the steps according to Thiagarajan et al. (1974), namely the 4-D development model, which consists of 4 stages, namely define, design, develop, and disseminate. However, this research was carried out only up to the develop stage, namely only through limited trials.

Research Participants

Participants in this research consisted of 2 chemistry education lecturers at Surabaya State University and 1 chemistry teacher at SMA Negeri 7 Surabaya to obtain validity data. Meanwhile, practicality and effectiveness data were obtained from 15 students from class XI SMA Negeri 7 Surabaya and 3 observers who observed students' activities during learning. The students in the research sample were selected heterogeneously based on high, medium, and low cognitive abilities.

Research Instruments

The research instruments used in this research are described as follows.

1. Validation Sheets
   The validation sheet is used to assess the validity of the buffer solution worksheet. The validation sheet contains content and construct validity. Content validity contains the correctness and suitability of the material to the learning objectives and suitability to discovery learning. Construct validity includes layout, appearance, color composition and clarity of images, language, and the size and type of font used.
2. Student Response Questionnaire Sheets
   The student response questionnaire sheet is used to obtain data regarding students' responses to the buffer solution worksheet. The student response questionnaire sheet contains a list of written questions regarding student responses after using the worksheet. This student response questionnaire sheet contains positive and negative questions with the answer choices "Yes" and "No".
3. Student Activity Observation Sheets
   Student activity observation sheets are used to obtain data about student activities during the learning process. The student activity observation sheet is in the form of a table containing rows and columns. In the rows there are relevant and irrelevant student activities during the learning process and in the columns there are observation times for student activities observed every 3 minutes.
4. Critical Thinking Skills Test Sheets
   The critical thinking skills test instrument is used to measure the increase in students' critical thinking skills after using the buffer solution worksheet. This critical thinking skills test sheet contains a pretest and posttest test sheet consisting of 5 questions that refer to the critical thinking component. The critical thinking components used are interpretation, analysis, inference, and explanation.
5. Knowledge Learning Outcomes Test Sheets
   The knowledge learning outcomes test sheet is used to measure the level of mastery and completeness of students' learning outcomes regarding the material after using the buffer solution worksheet. The knowledge learning outcomes test sheet used in this research contains 10 multiple choice questions that represent the learning objectives that students must achieve.

Data Collection

The data collection method used in this research is described as follows.

1. Questionnaire Method
   The questionnaire method is utilized for validation sheets and student response questionnaires. Three validators completed the validation questionnaire. The validator evaluates the buffer solution worksheet that was created by marking a tick (√) on the assessment scale provided in the validation sheet, which ranges from 1 to 5. Additionally, a student response questionnaire is employed to assess students' reactions to the buffer solution worksheet. Students filled out this questionnaire after the limited trial was conducted. Students respond to this questionnaire by marking a tick (√) on the answer options "Yes" or "No."
2. Observation Method
   The observation method is implemented to gather data on student activities observed by the observers. Three observers complete the observation sheet while watching all learning activities. Observers fill in the observation sheet by marking (√) in the time columns for activities that are relevant and irrelevant.
3. Test Method
   The test method is used to collect quantitative data in the form of test scores for critical thinking skills and student knowledge learning outcomes. Students take the critical thinking skills test both before and after engaging with the buffer solution worksheet. Meanwhile, students take the student learning outcomes test after completing the developed buffer solution worksheet.

Data Analysis

1. Validation Data Analysis
   Validation data obtained from the buffer solution worksheet validation sheet were analyzed quantitatively descriptively. This analysis is carried out for each component listed in the validation sheet. Data was analyzed based on scores given by 3 validators. Each validator gives a score to each aspect on a Likert scale as shown in Table 1.

Table 1. Validity Likert Scale

Category	Scale Value
Very Valid	5
Valid	4
Fairly Valid	3
Invalid	2
Very Invalid	1

(Riduwan adaptation, 2015)

The buffer solution worksheet based on discovery learning developed in this research is declared valid if the median value is in the range ≥ 4 with valid to very valid criteria.

2. Student Response Questionnaire Data Analysis
   Student response data obtained from the student response questionnaire was analyzed quantitatively descriptively. Data were analyzed based on the results of the scores obtained from positive and negative statements on the response questionnaire given to students after using the buffer solution worksheet during limited trials. These students' responses are calculated based on the Guttman scale score, as explained in Table 2.

Table 2. Guttman Scale Criteria

Answer Options	Score	
	Positive	Negative
Yes	1	0
No	0	1

(Riduwan adaptation, 2015)

The formula used to calculate the practicality percentage of a worksheet is as follows.

$$Practically\ percentage = \frac{\Sigma\ score\ obtained}{\Sigma\ maximum\ score}\ x\ 100\%$$

The percentage results are then interpreted according to Table 3 to determine the practicality criteria for the buffer solution worksheet.

Table 3. Interpretation of Student Response Questionnaire Scores

Percentage	Criteria
0% - 20%	Very Less Practical
21% - 40%	Less Practical
41% - 60%	Quite Practical
61% - 80%	Practical
81% - 100%	Very Practical

(Riduwan adaptation, 2015)

Based on the percentages in Table 3, the discovery learning-based buffer solution worksheet is declared practical if it obtains a practicality percentage of ≥ 61% with practical or very practical criteria.

3. Student Activity Observation Data Analysis
Student activity data obtained from student activity observation sheets was analyzed quantitatively descriptively. Analysis of student activity observation data is used as supporting data for student responses in analyzing the practicality of the worksheet. Data from observations of student activities were analyzed by calculating the percentage of activities carried out by students during the learning process. The percentage of each student's activity is calculated using the following formula. 100%

$$\%\ Student\ activities = \frac{\Sigma frequency\ of\ relevant\ actvities\ of\ students}{\Sigma frequency\ of\ overall\ activities\ of\ students}\ x\ 100\%$$

Student activities are carried out well if the percentage of relevant student activities is greater than irrelevant student activities.

4. Students' Critical Thinking Skills Test Data Analysis
Students' pretest and posttest scores were analyzed using the N-Gain test to determine the increase in students' critical thinking skills. The results of the critical thinking skills test analysis were used to determine the effectiveness of the buffer solution worksheet based on discovery learning. The N-Gain formula is as follows.

$$< g > = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}\ x\ 100\%$$

The N-Gain score results are divided into three category shown in Table 4.

Table 4. N-Gain Score Category

<g> Value	Category
<g> < 0,3	Low
0,7 > <g> ≥ 0,3	Medium
<g> ≥ 0,7	High

(Hake, 1999)

In this study, the worksheet was declared effective if the criteria for increasing students' critical thinking skills as measured using the N-Gain score had a score of ≥ 0.3 with fair to high category.

5. Student Knowledge Learning Results Test Data Analysis
Data analysis of knowledge learning outcomes was obtained from learning outcomes test scores which were used to determine students' completeness after using the buffer solution worksheet.

Calculations are carried out by looking for individual learning completeness. The formula used to calculate individual completeness is as follows. The formula used to calculate individual completeness is as follows.

$$Individual\ completeness\ = \frac{\Sigma\ score\ obtained}{\Sigma\ maximum\ score}\ x\ 100$$

In accordance with the minimum completion criteria for chemistry subjects at the school where the researcher conducted the trial, students are declared complete if the score obtained by each student is ≥75.

RESULTS AND DISCUSSION

The aim of this research is to determine the feasibility of the buffer solution worksheet, including validity, practicality, and effectiveness. The validity of the worksheet is viewed from content validity and construct validity. The practicality of the worksheet is seen in the students' responses to the buffer solution worksheet and the results of observations of students' activities. Meanwhile, the effectiveness of worksheet is reviewed from tests of critical thinking skills and tests of students' knowledge learning outcomes.

Result of the validity of the buffer solution worksheet

Validity in this research is measured using the median and is declared valid if the median value obtained is ≥ 4. The results of the worksheet validation can be seen in Table 5.

Table 5. Buffer Solution Worksheet Validation Results

No.	Aspect	Median	Category
Content Validity			
1.	The truth of the facts, concepts, principles and theories contained in the worksheet	4	Valid
2.	The content/topics contained in the worksheet have relevance to the critical thinking skills being trained	4	Valid
3.	Conformity of learning objectives with phase F learning outcomes	4	Valid
4.	Conformity of the contents of the worksheet with the criteria to improve critical thinking skills of interpretation	4	Valid
5.	Conformity of the contents of the worksheet with the criteria for improving critical thinking skills of analysis	5	Very Valid
6.	Conformity of the contents of the worksheet with the criteria for improving critical thinking skills of inference	4	Valid
7.	Conformity of the contents of the worksheet with the criteria for improving critical thinking skills of explanation	5	Very Valid
Construct Validity			
1.	The cover is attractive and represents the contents of the worksheet	4	Valid
2.	There is a place to write the answer to each question	5	Very Valid
3.	Presentation of images and videos accompanied by sources	5	Very Valid
4.	worksheet writing according to EYD	4	Valid
5.	Worksheet writing uses appropriate, clear and consistent terms, formulas and symbols		
6.	The use of fonts (type and size) is easy to read	4	Valid

Based on Table 5, the overall median score for the content validity of the worksheet was obtained as a score of 4 in the valid category. In the construct validity of the worksheet, a median score of 4 was obtained in the valid category. Based on the validity results, it can be seen that the buffer solution worksheet is valid

Result of the practically of the buffer solution worksheet

The practicality of the buffer solution worksheet based on discovery learning that was developed was reviewed based on the results of student response questionnaires and the results of observations of student activities.

1. Results of student response questionnaires

   Student response questionnaire data was obtained through student response questionnaires which were given after students carried out learning using worksheet. The data obtained from the student response questionnaire was calculated using the Guttman scale and the results obtained were shown in Table 6.

Table 6. Student Response Questionnaire Result Data

No.	Aspect	Persentage	Category
1.	The appearance of the worksheet is attractive	100%	Very Practical
2.	Worksheet motivate students to learn	100%	Very Practical
3.	The illustrations and pictures in the worksheet help students understand the material	100%	Very Practical
4.	The activities in the worksheet guide students to understand the concept of the material	100%	Very Practical
5.	Worksheet can train students in critical thinking on interpretation components	93%	Very Practical
6.	Worksheet can train students in critical thinking on the explanation component	93%	Very Practical
7.	Worksheet can train students in critical thinking on analysis components	93%	Very Practical
8.	Worksheet can train students in critical thinking on inference components	93%	Very Practical
9.	Language comprehension in worksheet	93%	Very Practical
10.	Understanding the questions in the worksheet	87%	Very Practical
11.	Clarity of font type and size in worksheet	100%	Very Practical
Average		96%	Very Practical

Based on Table 4.6, it can be seen that the results of the student response questionnaire overall, students gave a positive response to the buffer solution worksheet with a percentage of 96% which is included in the very practical category.

2. Results of observations of student activities

   Student activity observation data is used to see student activity during learning using buffer solution worksheet. Observation data on student activities was obtained through student activity observation sheets filled in by observers. The results of observing student activities can be seen in Figure 1.

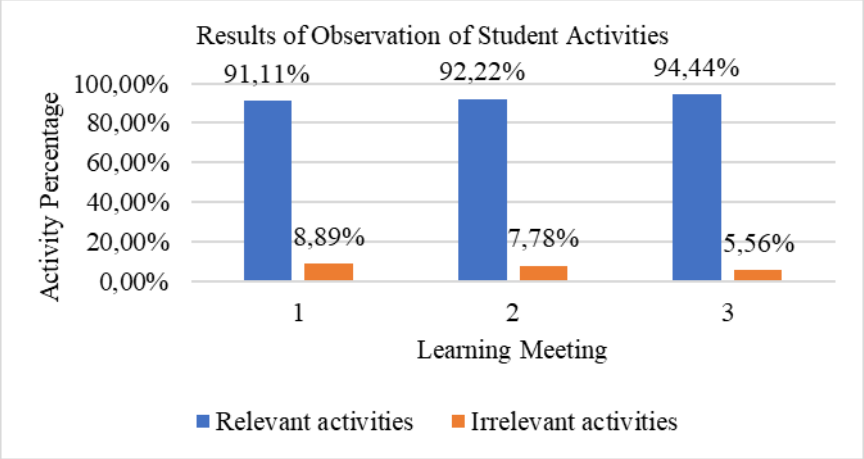


Figure 1. Observation of Student Activities Result Data

Based on Figure 1, it is known that at learning meetings 1, 2, and 3 the percentage of relevant activities was greater than the percentage of irrelevant activities. These results show that students followed the learning well during limited trials using the buffer solution worksheet based on discovery learning.

Result of the effectiveness of the buffer solution worksheet

The effectiveness of the buffer solution worksheet in this study was measured by data from the results of students' critical thinking skills tests and students' knowledge learning outcomes tests.

1. Pretest-posttest results of students' critical thinking skills
   The pretest and posttest data obtained on student' critical thinking skills were analyzed using the N-Gain test to determine the increase in students' critical thinking. The critical thinking skills trained consist of 4 components, namely interpretation, analysis, inference and explanation. The N-Gain score from the students' critical thinking skills test on buffer solution material is presented in Table 7.

Table 7. Data on N-Gain Results of Students' Critical Thinking Skills

Student Number	N-Gain Score	Category
1	0,83	High
2	0,85	High
3	0,81	High
4	1,00	High
5	0,85	High
6	0,82	High
7	0,93	High
8	1,00	High
9	0,64	Medium
10	0,92	High
11	1,00	High
12	0,91	High
13	0,92	High
14	0,69	Medium
15	0,91	High

   Based on Table 7, it can be seen that as many as 13 students got an N-Gain score in the high category. Meanwhile, as many as 2 students got an N-Gain score in the medium category. The N-Gain score shows that there is an increase in students' critical thinking skills after using buffer solution worksheet based on discovery learning to improve students' critical thinking skills.
2. Result of student knowledge learning outcomes test
   The completeness of student learning outcomes is known from data from knowledge test results. This knowledge learning outcomes test contains 10 multiple-choice questions on buffer solution material that students complete after using the worksheet. Based on the data obtained from the knowledge learning outcomes test, it is known that 100% of students have completed it with a score range from 80 to 100. This shows that the knowledge learning outcomes of all students have fulfilled the individual completeness that has been determined, namely ≥ 75 according to the minimum completion criteria in chemistry subjects at the school where this research was conducted.

Discussion of the validity of the buffer solution worksheet

The validity of the buffer solution worksheet can be determined through assessments given by three validators, namely two chemistry education lecturers and one chemistry teacher. This validity aims to

test the feasibility of the product being developed. The validity aspects assessed are content and construct validity.

Content validity in this research consists of seven aspects of assessment. In the first aspect, content validity, namely the truth of facts, concepts, principles, and theories contained in the worksheet, gets a median score of 4 in the valid category. Based on this validity, it can be stated that the facts, concepts, principles and theories contained in the worksheet are correct, namely in worksheet 1 regarding the properties of buffer solutions, worksheet 2 regarding the components and working principles of buffer solutions, and worksheet 3 regarding pH calculations and the role of buffer solutions. In the second aspect, the content or topic contained in the worksheet has relevance to the critical thinking skills being trained, getting a median score of 4 so it can be declared valid. The learning objectives prepared on the worksheet are in accordance with the learning achievements of phase F in the Merdeka Curriculum; this can be seen from the median value obtained in this third aspect, namely 4. The second to fifth aspects relate to the suitability of the contents of the worksheet with the critical thinking skills being trained. In this aspect, the median score was 4, which is a valid category, thus showing that the contents of the worksheet were in accordance with the criteria for critical thinking skills of interpretation, analysis, inference, and explanation. This can be seen in Figure 2, namely that the contents of the worksheet containing activities based on discovery learning syntax are appropriate and related to improved critical thinking skills

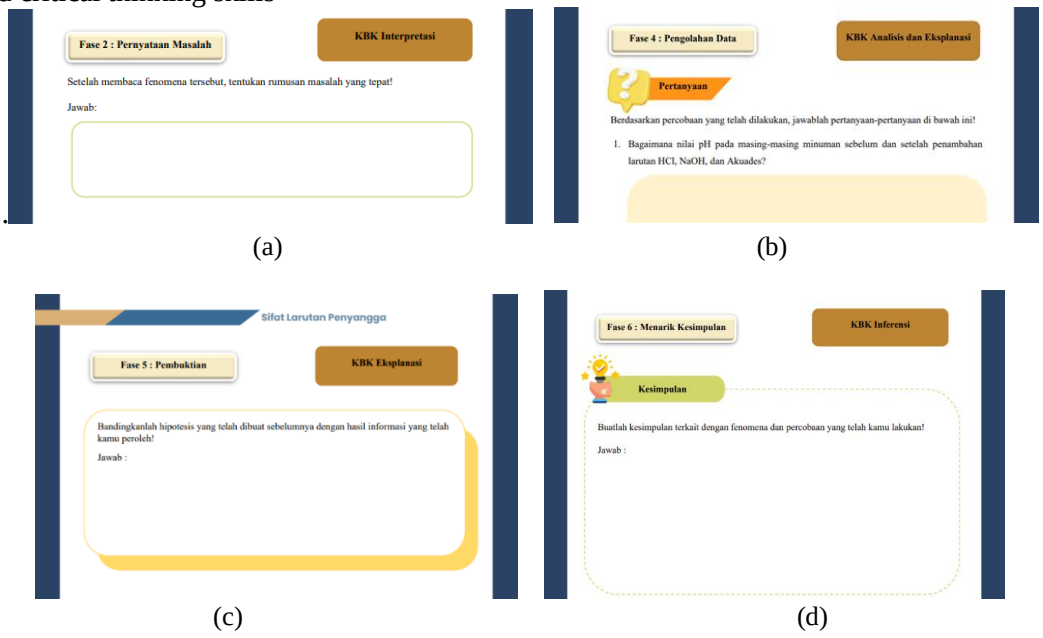


Figure 2. Activities on Worksheet for Critical Thinking Skills Components (a) Interpretation (b) Analysis (c) Explanation (d) Inference

Construct validity in this research consists of six aspects of assessment. The first aspect, namely that the worksheet cover is attractive and represents the contents of the worksheet, gets a median score of 4 in the valid category. The buffer solution worksheet cover uses a combination of dark blue, light brown, and white and contains images related to the contents of the worksheet so that it attracts students' interest. Febriani and Medika (2023) stated that worksheet designed with attractive pictures and colors can attract students' attention so that students are more enthusiastic when participating in learning.

In the second aspect, there is a place to write the answer to each question, which gets a score of 5 in the very valid category. This shows that for each question in the worksheet, a place has been provided for students to write the answer. The third aspect, namely the presentation of images and videos accompanied by a source, gets a median score of 5 with a very valid category, indicating that every image and video contained in the worksheet has been accompanied by a source. The fourth to sixth aspects relate to writing worksheet. In this aspect, the median score was 4 in the valid category. This

shows that the writing of the buffer solution worksheet is in accordance with *EYD*, uses terms, formulas, and symbols that are appropriate, clear, and consistent, and the font used is easy to read.

Discussion of the practically of the buffer solution worksheet

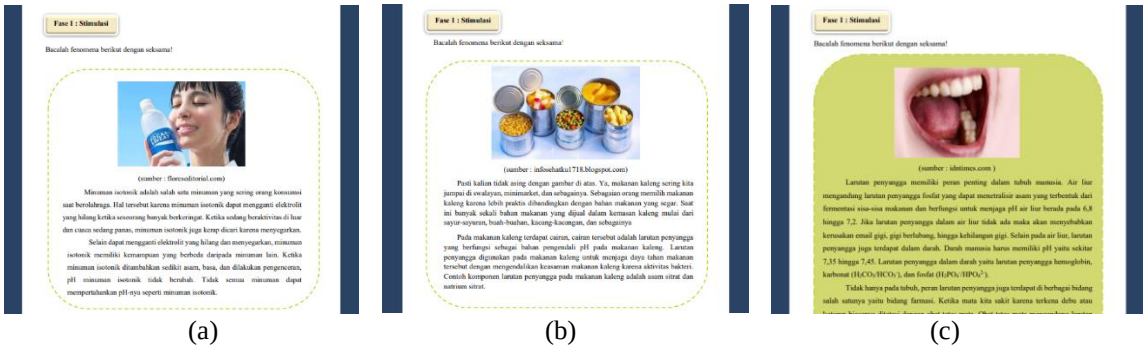
The results of the student response questionnaire were used to determine the practicality of the buffer solution worksheet that was developed and supported by the results of observations of student activities.

1. *Student response questionnaire*

The response questionnaire consists of eleven aspects and is divided into three criteria, namely content, language and graphics. The content criteria for the student response questionnaire are in aspects number 2, 4, 5, 6, 7, and 8. In aspect number 2, namely regarding the worksheet motivating students to learn and aspect number 4, namely regarding the activities in the worksheet guiding students to understand the concept of the material, 15 students gave positive responses so that the percentage was 100%. The activities in the worksheet developed are structured based on the syntax of the discovery learning learning model proposed by Syah (2004), which consists of stimulation, problem statements, data collection, data processing, verification, and generalization. The discovery learning learning model can make students more independent and actively involved in discovering material concepts so that learning activities become more meaningful (Sunarto & Amalia, 2022). Aspects number 5 to number 8 are aspects related to worksheet that can train students in critical thinking in the components of interpretation, analysis, inference and explanation. In the fifth to eighth aspects, 14 students gave positive responses and 1 student gave a negative response, so the percentage obtained was 93%. This percentage shows that after students use discovery learning-based buffer solution worksheet, students feel capable of interpreting, analyzing, inferring and explaining.

The language criteria are found in aspects number 9 and 10, namely regarding the comprehensibility of the language in the worksheet and the comprehensibility of the questions in the worksheet. In the ninth and tenth aspects, an average percentage of 90% was obtained, indicating that the language used in the worksheet is easy for students to understand. This is in accordance with what Prastowo (2015) explained that the sentences used in worksheet must be clear, effective, short and simple so that they are easier for students to understand.

Graphic criteria are found in aspects number 1, 3, and 11. In these three aspects, 15 students gave positive responses so that a percentage of 100% was obtained, indicating that the buffer solution worksheet has an attractive appearance and an easy-to-read font. Also, the illustrations and pictures in the worksheet help students understand the material. Examples of illustrations contained in worksheet to support the contents of the worksheet and attract students' attention are found in phase 1 of discovery learning, namely stimulation as can be seen in Figure 3.



(a) (b) (c)

Figure 3. Stimulation Phase (a) Worksheet 1: Properties of The Buffer Solution (b) Worksheet 2: Components and Working Principles of The Buffer Solution (c) Worksheet 3: pH Calculation and The Role of The Buffer Solution

Based on the results of the students' responses, it can be seen that the students' responses to all questions obtained a percentage of ≥61% so that the buffer solution worksheet developed could be declared practical (Riduwan, 2015).

2. *Observation of student activities*

Based on the observations of student activities shown in Table 6, it is clear that relevant student activity is increasing at each meeting while irrelevant student activity is decreasing. This shows that students are interested and eager to engage in learning with the buffer solution worksheet. This aligns with student feedback in the response questionnaire, which indicated that they found the buffer solution worksheet easy to use. Students tend to be more motivated to keep learning when they feel successful in tackling the challenges presented in the worksheet (Febriani & Medika, 2023). Additionally, the worksheet's design can also capture students' attention. This is reflected in the student response to the appealing design of the worksheet, earning a score of 100%, and in the aspect of the worksheet motivating students to learn, also receiving a score of 100%.

Furthermore, the buffer solution worksheet based on discovery learning encourages active and independent learning, reducing irrelevant student activities like joking and using phones that are not for educational purposes. This supports the findings of research by Dwiputri et al. (2022), which showed that worksheets using the discovery learning model foster active student participation during learning. Research by Malichah and Yonata (2023) further indicates that relevant student activity exceeds irrelevant student activity when learning is conducted with discovery learning worksheets. The observations of student activities, showing that relevant student activity is greater than irrelevant student activity, reinforce the practical findings from the student response questionnaire.

Discussion of the effectiveness of the buffer solution worksheet

The results of the pretest and posttest of students' critical thinking skills were used to determine the effectiveness of the buffer solution worksheet which was developed and supported by test data on students' knowledge learning outcomes.

1. Pretest and Posttest of students' Critical Thinking Skills

Before carrying out a limited trial using buffer solution worksheet, a critical thinking skills pretest was carried out, which aimed to determine the student's initial skills. Then, after students learn using worksheet, namely worksheet 1 regarding the properties of buffer solutions, worksheet 2 regarding the components and working principles of buffer solutions, and worksheet 3 regarding pH and the role of buffer solutions, students are asked to do a posttest on critical thinking skills which aims to determine students' final skills after using the worksheet developed. After that, the data was analyzed using the N-Gain test to determine the increase in students' critical thinking skills after using the worksheet. Based on Table 7, it is known that students' N-Gain scores are in the range of 0.64 to 1.00 in the medium to high category, indicating that there has been an increase in students' critical thinking skills after using the buffer solution worksheet.

Critical thinking skills on buffer solution worksheet are trained in the phases of discovery learning. Interpretation skills are trained in the problem statement phase, analysis skills are trained in the data processing phase, inference skills are trained in the generalization phase, and explanation skills are trained in the data collection, data processing, and verification phases. In the problem statement phase, students determine problems related to the subject matter, formulate the problem, and formulate a hypothesis (Rini & Desyandri, 2020). Thus, in this problem statement phase, students' interpretation skills are needed. In the data processing phase, students process the data or information obtained in the previous stage and then analyze it (Khasinah, 2021). So, in his phrase, students' analysis skills are trained. In the data collection phase, before experimenting, students must explain the experimental steps that will be carried out. Next, students explain the logical reasons for the answers found in the data processing phase. Then, in the verification phase, the buffer solution worksheet explain the comparison of the hypothesis made previously with the results of the data/information that was obtained (Khasinah, 2021). So that in the data collection, data processing, and verification phases, explanation skills are trained. In the generalization phase, the activity carried out by students is drawing conclusions based on experiments and information that has been obtained (Rini & Desyandri, 2020). So, in the final stage of discovery learning, namely generalization, students' inference skills are trained.

2. Student Knowledge Learning Outcomes Test

The test of students' knowledge learning outcomes in this study aims to determine the completeness of students' knowledge learning outcomes after using the buffer solution worksheet. Based on knowledge learning outcome data, it is known that all students have achieved the individual completeness, namely ≥ 75. This is in line with research conducted by Fadlina & Ritonga (2021) that there is an increase in student learning outcomes after the implementation of discovery learning. The student knowledge learning outcomes test in this study consisted of 10 multiple choice questions with 7 indicator questions. The first indicator is that students can determine the properties of the buffer solution correctly, which is used to prepare question number 1. In question number 1, 15 students answered correctly. The second indicator is that students can correctly analyze the solution which includes the buffer used to prepare question number 2. In question number 2, 15 students answered correctly. The third indicator is that students can correctly evaluate the solution which includes the buffer used to prepare question number 3. In question number 3, 13 students answered correctly. The fourth indicator is that students can correctly analyze the components of the solution that produces the buffer solution used to prepare questions number 4 and 5. A total of 14 students answered correctly on question number 4 and as many as 15 students answered correctly on question number 5. The fifth indicator is that students can correctly evaluate the working principles of the buffer solution used to prepare question number 6. In question number 6, 15 students answered correctly. The sixth indicator is that students can calculate the pH of the buffer solution correctly which is used to prepare questions number 7 and 8. A total of 11 students answered correctly in question number 7 and as many as 13 students answered correctly in question number 8. The seventh indicator for students can correctly determine the role of buffer solutions in daily life which is used to prepare questions number 9 and 10. In questions number 9 and 10, 15 students answered correctly.

CONCLUSION

Based on the findings of the research conducted, the buffer solution worksheet created for discovery learning to enhance students' critical thinking abilities is appropriate for use in terms of validity, practicality, and effectiveness. According to the validity findings related to content and construct validity, the designed worksheet was deemed valid, receiving a median score of 4 in the valid category. The practicality of the worksheet is affirmed through the student response questionnaire, where students provided a positive reaction to the buffer solution worksheet based on discovery learning, which is also supported by observations of student activities, indicating that relevant student activity exceeds irrelevant student activity. The worksheet's effectiveness was confirmed by improvements in students' critical thinking skills test results, evidenced by an n-gain score in the range of 0.64 to 1.00, categorized as medium to high, and backed by learning outcomes where students achieved individual completeness in knowledge.

This research only utilized the N-Gain score test to assess the improvement in students' critical thinking skills, so it is anticipated that future researchers will include additional statistical tests to determine any enhancements in students' critical thinking capabilities. Furthermore, in this study, the enhancement of critical thinking skills was based on the framework provided by Facione (2015) and focused solely on four components: interpretation, analysis, inference, and explanation. Therefore, future researchers could address additional components of critical thinking skills, including evaluation and self-regulation, and improve critical thinking skills in other chemical topics.

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