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DEVELOPMENT OF ELECTRONIC WORKSHEET BASED ON SCIENTIFIC APPROACH TO TRAIN CRITICAL THINKING SKILLS ON MEMBRANE TRANSPORT TOPIC

Pengembangan LKPD Elektronik Berbasis Pendekatan Saintifik untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Transpor Membran

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Abstract

In this 21st century, students need to be mastered with skills that help them face this challenging era. One of the skills is critical thinking skills. Students' critical thinking skills can be train by innovating teaching materials which integrated with scientific approach. This study aims to produce Electronic Worksheets based on a scientific approach to train critical thinking skills on membrane transport materials that are valid, practical, and effective. This development uses the 4-D development model (Define, Design, Develop, Disseminate). The parameters measured were validity, practicality, and effectiveness. The data analysis was using quantitative descriptive techniques. The validity of the electronic worksheet was assessed by 3 validators and obtained an average percentage of 3.69 with a very valid category. Practicality was determined based on the results of observations conducted by 4 observers during the implementation of Electronic Worksheet which got an average percentage of 93.28% in the very practical category. Effectiveness was determined based on the assessment of learning outcomes and got a post-test completeness score of 83.33% in the very effective category, the N-gain score was 0.69 in the moderate category, the average completeness of each critical thinking indicator was 80.18%, and in terms of student responses got an average percentage of 98.14% which was included in the very effective category. Electronic Worksheet is suitable for use at class XI SMA based on the aspects of validity, practicality, and effectiveness. Electronic Worksheet that has been developed can enrich alternative teaching materials in schools.
Keywords: critical thinking skills**,** electronic worksheet, scientific approach, membrane transport, secondary education.

Abstrak

Pada abad 21 ini, peserta didik perlu untuk menguasai keterampilan yang dapat membantunya menghadapi era yang penuh tantangan. Salah satu keterampilan tersebut adalah keterampilan berpikir kritis. Keterampilan berpikir kritis peserta didik dapat dilatihkan dengan melakukan inovasi bahan ajar yang terintegrasi dengan pendekatan saintifik. Penelitian ini bertujuan untuk menghasilkan LKPD Elektronik berbasis pendekatan saintifik yang dapat melatihkan keterampilan berpikir kritis pada materi transpor membran yang valid, praktis, dan efektif. Penelitian pengembangan ini menggunakan model pengembangan 4-D (Define, Design, Develop, Disseminate). Parameter yang diukur yaitu validitas, kepraktisan, dan keefektifan. Analisis data menggunakan teknik deskriptif kuantitatif. Validitas LKPD Elektronik dinilai oleh 3 validator dan memperoleh rata-rata persentase sebesar 3,69 dengan kategori sangat valid. Kepraktisan ditentukan berdasarkan hasil observasi oleh 4 orang pengamat selama pelaksanaan LKPD Elektronik dan memperoleh rata-rata persentase sebesar 93,28% dengan kategori sangat praktis. Keefektifan ditentukan berdasarkan penilaian hasil belajar mendapatkan skor ketuntasan post test sebesar 83,33% dengan kategori sangat efektif, N-gain score sebesar 0,69 dengan kategori sedang, rata-rata ketuntasan tiap indikator berpikir kritis sebesar 80,18% serta respon peserta didik memperoleh rata-rata persentase sebesar 98,14% yang termasuk dalam kategori sangat efektif. LKPD Elektronik layak digunakan pada kelas XI SMA berdasarkan aspek validitas, kepraktisan, dan keefektifan. LKPD Elektronik yang telah dikembangkan dapat memperkaya bahan ajar alternatif di sekolah.
Kata Kunci: *kemampuan berpikir kritis, LKPD Elektronik, pendekatan saintifik, pendidikan menengah, transpor membran,*

INTRODUCTION

All aspects of life are developing rapidly in today's modern era. Many developments have occurred, including in the field of education. Nowadays, students are demanded to master critical thinking skills to face this challenging era. Critical thinking skills are the ability to think reflectively, focusing on decision-making patterns about things that must be believed, done, and accounted for (Ennis, 2011). Fikriyah et al. (2020) stated that critical thinking is the process of active thinking in analyzing as well as identifying problems. There are several indicators of critical thinking skills based on Facione (2011). The indicators were interpretation, analysis, evaluation, inference, explanation, and self regulation. Amongst the indicators, interpretation, analysis, evaluation, inference, and explanation are chosen to be trained in this research.

Currently, the Independent Curriculum initiated by the Ministry of Education, Culture, Research, and Technology (Kemendikbud-Ristek) of the Republic of Indonesia is being implemented. It aims to answer the challenges of education in this modern era. The application of this curriculum must support improvement of critical thinking and problem solving skills, creative and innovative skills, communication skills, and collaborating skills.

The Ministry of Education and Culture-Research and Technology recommend scientific approach to be applied in learning activities to involve students in an active learning process so that their critical thinking skills can be well-trained. The scientific approach also known as process skills in the Independent Curriculum. The learning process with a scientific approach requires students to think systematically and critically to solve problems with challenging solutions (Abidin, 2013). The scientific approach includes observing, questioning, predicting, planning and conducting investigations, processing and analyzing data and information, evaluating and reflecting, and communicating the results of the observations or experiments (Ministry of Education, Culture, and Technology, 2022).

With support from several factors, learning activities can occur effectively and by the goals to be achieved. One factor that significantly influences the learning process is the teaching materials used. The availability of appropriate teaching methods is also needed to support learning activities that implement a scientific approach. Bohori et al. (2015) stated that the scientific approach in its application needs to be supported by teaching materials that can train critical thinking skills.

Membrane transport material is complex. A passive transport sub-material that consists of diffusion and osmosis are part of this topic. Wati and Yuliani (2020) stated that students need to become skilled in orienting problems. Moreover, their critical thinking skills on membrane transport material need to be optimally trained. The learning proccess becomes monotonous, and students become passive if the material is delivered only using existing textbooks. Based on an interview with an eleventh-grade Biology teacher at SMAN 1 Taman, it was found that students need some help to understand the osmosis diffusion sub-material membrane transport material because the material was abstract for students. Thus, students need alternative teaching materials that can support the delivery of abstract material.

To overcome these problems, changes are needed in the learning process, including innovating the teaching materials used to support learning activities. One innovative way to develop teaching materials is to take advantage of current technological advances by integrating student worksheets with the internet, known as Electronic Worksheets, so that students can easily access them online.

Electronic Student Worksheets is a sheet that contains tasks that students must do digitally and carry out systematically and continuously (Ramlawati et al., 2014). Schools in Indonesia commonly use printed worksheets as teaching materials because they are easy to use and accessible to teachers and students. However, Electronic Worksheets can provide more benefits that can help the learning process be more optimal because it has features that make it more exciting.

Previous research conducted by Lestari et al. (2018) related to the development of worksheets based on a scientific approach showed that the developed worksheets obtained a validity value of 87.30% with valid criteria and a practicality value of 85.94% with very practical criteria.

Based on the problem describe above, critical thinking skills need to be trained on membrane transport material through the teaching material developed, namely Electronic Worksheets. This study aims to produce Electronic Worksheets using a scientific approach to train student's critical thinking skills on membrane transport materials that are valid, practical, and effective.

METHODS

This research was development research using 4-D models (Define, Design, Develop, and Disseminate). At the define stage, it was carried out by curriculum

analysis, student analysis, task analysis, concept analysis, and the formulation of learning objectives. At the design stage, it was carried out by compiling the initial design of the Electronic Worksheets through the preparation structure. At the development stage, the first draft of the Electronic Worksheets that were designed was revised according to suggestions and comments from validators. The disseminate stage aimed to carry out dissemination with the publication of articles. The Electronic Worksheets product was developed from February to April 2023 at the Faculty of Mathematics and Sciences, State University of Surabaya. Then the limited trial activity of Electronic Worksheets was carried out at SMAN 1 Taman in May 2023.

The parameters used in this research were measured based on the validity, practicality, and effectiveness. The validity of the Electronic Worksheets was determined from the validation results by a material expert lecturer, a media expert lecturer, and a Biology teacher from SMA Negeri 1 Taman using a validation sheet that is assessed based on Likert scale criteria with a score range of 1-4 (Riduwan, 2013). The final result of validity was calculated using the following formula:

$$Average\ score = \frac{\Sigma\ scores\ per\ criterion}{number\ of\ validator} \quad .....(1)$$

The validation score results were then interpreted based on Table 1. Electronic Worksheets were valid if they got a score of ≥2.51.

Table 1. Validity Score Interpretation Criteria (Riduwan, 2013)

Score	Interpretation Criteria
0 ≤ Score ≤ 1.75	Less Valid
1.76 ≤ Score ≤ 2.50	Quite Valid
2.51 ≤ Score ≤ 3.25	Valid
3.26 ≤ Score ≤ 4.00	Very Valid

The practicality of developed Electronic Worksheets was determined from observations of the implementation in learning activities. Four observers made observations, with details of one group observed by two observers, and these observations refer to the aspects listed in the Electronic Worksheets implementation observation sheet. The implementation assessment refers to the Guttman scale with scores of 1 (performed) and 0 (not performed). The results obtained were then calculated on average using the following formula:

$$Implementations\ (\%) = \frac{\Sigma\ answer\ 'yes'}{\Sigma\ maximum\ score} \times 100\% \quad .....(2)$$

The percentage of implementation obtained was interpreted based on Table 2. Electronic Worksheets were declared practical if they obtained a percentage of ≥71.

Table 2. Electronic Worksheets Implementation Score Interpretation Criteria (Riduwan, 2013)

Score (%)	Interpretation Criteria
86 ≤ Score ≤ 100	Very Practical
71 ≤ Score ≤ 85	Practical
56 ≤ Score ≤ 70	Quite Practical
41 ≤ Score ≤ 55	Less Practical
0 ≤ Score ≤ 40	Impractical

The effectiveness of Electronic Worksheets was determined from the assessment of learning outcomes and student responses to the developed Electronic Worksheets. Learning outcomes were measured using pretest and post-test question sheets. Students were categorized in the completion criteria if they reached the minimum completeness criteria (KKM) with a score of ≥75. Pretest and post-test scores can be calculated using formula:

$$Score = \frac{student\ score}{maximum\ score} \times 100\% \quad .....(3)$$

The pretest and post-test values obtained were then calculated based on the formula developed by Hake (1999).

$$N\text{-}Gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \quad .....(4)$$

The gain score obtained was then interpreted based on Table 3.

Table 3. N-gain Criterion on Assessment of Learner's Critical Thinking Skills (Hake, 1999)

N-Gain Score	Category
0.70 < g ≤ 1.00	High
0.30 < g ≤ 0.70	Medium
0.00 < g ≤ 0.30	Low

Effectiveness assessment was also obtained from students' response using a questionnaire sheet. The guideline used to determine the results of student responses was using the Guttman scale with scores of 1 (yes) and 0 (no). The results obtained were then calculated on average using the following formula:

$$Responses\ (\%) = \frac{\Sigma\ answer\ 'yes'}{\Sigma\ maximum\ score} \times 100\% \quad .....(5)$$

The percentage of positive responses of students obtained was then interpreted using the criteria for interpreting positive responses of students in Table 4. Electronic Worksheets was declared effective if they obtained a percentage of ≥71.

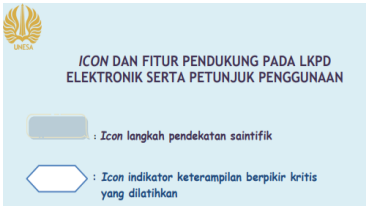
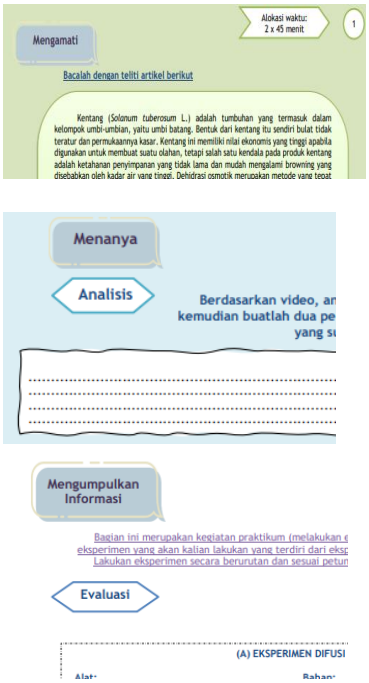
Table 4. Criteria for Interpreting Student Responses (Riduwan, 2013)

Score (%)	Interpretation Criteria
86 ≤ Score ≤ 100	Highly Effective
71 ≤ Score ≤ 85	Effective
56 ≤ Score ≤ 70	Moderately Effective
41 ≤ Score ≤ 55	Less Effective
0 ≤ Score ≤ 40	Ineffective

RESULT AND DISCUSSION

The result of this development research was an Electronic Student Worksheet based on a scientific approach to train critical thinking skills on membrane transport material that was feasible in terms of validity, practicality, and effectiveness. There were three main sections in Electronic Worksheets, namely the introduction, the content, and the closing. The introduction contains the cover page, preface, learning objectives, characteristics, instructions for using Electronic Worksheets, and a table of contents. The content section contains allocating time and learning activities with a scientific approach, and the closing section includes a bibliography. The appearance of the developed Electronic Worksheets is presented in Table 5.

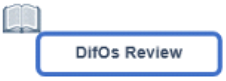
Table 5. Electronic Worksheets Appearance

No	Display	Description
	Introduction Section	
1.		The main cover of Electronic Worksheets
2.		Characteristics of Electronic Worksheets
	Content Section	
3.		Learning activities in Electronic Worksheets are following the steps of the scientific approach

No	Display	Description
	Closing Section	
4.	DAFTAR PUSTAKA Jones, M., Fosbery, R., Taylor, D., Gregory, J. 2020. *Biology for Cambridge Internat AS & A Level*. Fifth Edition. United Kingdom: Cambridge University Press.	Bibliography

The developed Electronic Worksheets also contains supporting features, including DiFos Info, Guess What, and DiFos Review. These supporting features are described in Table 6.

Table 6. Supporting features of Electronic LKPD

No	Features	Description
1.		It contains brief information about osmosis and diffusion to increase students' knowledge
2.		It contains brief questions about osmosis and diffusion
3.		It contains a brief description of the concepts in membrane transport material

Validity of Electronic Worksheets

The validity of the Electronic Worksheets was determined from the validation results by two validators who are material expert lecturer and media expert lecturer, and one Biology teacher from SMA Negeri 1 Taman using a validation sheet that was assessed based on Likert scale criteria with score provisions 1-4 (Riduwan, 2013). The results of Electronic LKPD validation are presented in Table 7.

Table 7. Recapitulation of Validation Results Scores

No	Aspects	Score			Av	C
		V1	V2	V3		
Technical Requirements						
1.	Cover display	4	4	4	4	VV
2.	Electronic Worksheets Title	4	4	4	4	VV
3.	Image presentation and color composition	3	3	3	3	V
4.	Electronic Worksheets Components	3	3	4	3.33	VV

No	Aspects	Score			Av	C
Didactic Requirements						
5.	Suitability of activities in Electronic Worksheets with learning objectives	4	4	3	3.67	VV
6.	Suitability of activities in Electronic Worksheets with the level of thinking of students	4	4	4	4	VV
Construction Requirements						
7.	Level of understanding of the language used	4	4	4	4	VV
8.	Language compatibility with General Guidelines for Indonesian Spelling	3	3	4	3.33	VV
Scientific Approach Steps						
9.	Observing	4	3	4	3.67	VV
10.	Questioning	4	3	3	3.33	VV
11.	Gathering information	3	4	4	3.67	VV
12.	Processing information	4	4	4	4	VV
13.	Communicating results of experiment	3	4	4	3.67	VV
Coverage Of Critical Thinking Skills						
14.	Critical thinking skills	4	4	4	4	VV
Average Score of Electronic Worksheets Validity					3.69	VV

Information:
V1: Material expert validator; V2: Media expert validator; V3: Biology teacher; Av: Average; C: Category; V: Valid; VV: Very Valid.

Based on Table 7, the results of the validator assessment of the developed Electronic Worksheets obtained an average validity score of 3.69 with a very valid category. In addition to the assessment provided by validators, at the validation stage, there were also suggestions and comments given regarding to the developed Electronic LKPD; namely, articles presented in the 'observing' section and videos presented in the 'questioning' section should be adjusted to the experiment to be carried out.

The validity of Electronic Worksheets was reviewed based on five aspects: technical requirements, didactic requirements, construction requirements, conformity with scientific approach steps, and coverage of critical thinking skills.

The first aspect was technical requirements. Each of the three sub-aspects got the average validation result with the very valid category, and one sub-aspect got the average validation result with the valid category. In the sub-aspects of image presentation and color composition, the average validation results were lower than the other three, but they were still classified as valid. Pratama et al. (2020) stated that Worksheets is classified as good to be presented if it contains attractive colors and images so that it can increase student understanding in line with the statements of Iswantini and Purnomo (2017), which states that Worksheets has a combination of images, writing, and good layout can attract students' interest. Overall, the aspect of technical requirements falls into the category of very valid. This shows that the developed Electronic Worksheets has been designed and presented attractively.

The second aspect was didactic requirements which include the suitability of activities in Electronic Worksheets with learning objectives and the suitability of activities in Electronic Worksheets with the level of thinking of students, which obtained average results of validation of all aspects with very valid categories. Adjustment of activities in Electronic Worksheets with learning objectives was needed so that students got a meaningful learning experience under current demands.

The third aspect was the construction requirements which include the level of understanding of the language used and the suitability of the language with General Guidelines for Indonesian Spelling. Overall, the sub-aspects of construction requirements got an average validation result with a very valid category. Sihafudin and Trimulyono (2020) stated that language is an essential factor in preparing teaching materials so that students can understand the meaning and avoid misinterpretation in Worksheets. The accuracy of language use and adjustment of the level of language understanding following the maturity level of students are essential requirements in the preparation of Worksheets (Umbaryati, 2016). In research by Fransiska et al. (2021), interactive Worksheets that has used communicative language and has been adapted to General Guidelines for Indonesian Spelling can improve student readability of worksheets and make it easier for students to understand materials.

The fourth aspect was conformity with the steps of the scientific approach, which includes observing, questioning, collecting, processing, and communicating. The step in the scientific approach provides experience for students to think analytically and critically (Oktavianty et al., 2020). The five steps of the scientific approach got the average validation result with a very valid category. These results show that developed Electronic Worksheets follows the steps of the scientific approach. Validators gave some comments and suggestions regarding the steps of the scientific approach contained in the Electronic Worksheets, starting from the first step in the scientific approach, which was the observing step, to the last step, which was communicating, preferably containing the same and coherent topic of discussion. Overall, the suitability of the scientific approach steps included in the Electronic Worksheets obtained the average validation results with very valid categories.

The fifth aspect was the coverage of critical thinking skills, which got an average validation result of 4 with a very valid category. Learning with a scientific approach is appropriate for training student's critical thinking skills (Kusumah, 2019). The Electronic Worksheets used includes indicators of critical thinking skills following the indicators described by Facione (2011). Overall, the coverage of critical thinking skills in Electronic Worksheets received an average validation result with a very good category and it can be able to train student's critical thinking skills.

Based on the explanation of validity results of Electronic Worksheets described above, the developed Electronic Worksheets received an average validity score of 3.69 and was included in the very valid category because it contains the technical, didactic, and construction requirements, in accordance with scientific approach steps and was able to train student's critical thinking skills.

Practicality of Electronic Worksheets

The practicality of Electronic Worksheets was seen from observations of the implementation of Electronic Worksheets in learning activities. Four observers made observations, with details of one group observed by two observers, and these observations refer to the aspects listed in the Electronic Worksheets implementation observation sheet. The results of observations on the implementation of Electronic Worksheets presented in Table 8.

Table 8. Results of Observation of Electronic Worksheets Implementation

No	Activities in Electronic Worksheets	Percentage of Implementation
1.	Students read the topic of Electronic Worksheets	100%
2.	Students read learning outcomes per element	83.33%
3.	Students read the instructions for using Electronic Worksheets	94.44%
4.	Students read the time allocation on the Electronic Worksheets	91.67%
5.	Students read the text and observe the video presented	100%
6.	Students answered the questions based on the articles presented	88.89%
7.	Students made questions based on the results of the video analysis presented	100%
8.	Students prepared tools and materials	88.89%
9.	Students did the experimental activities	100%
10.	Students wrote experimental result data in the experiment results table	94.44%
11.	Students conducted discussions to answer questions related to experiments	88.89%
12.	Students made a conclusion based on the results of the experiment	88.89%
Average		93.28

Based on Table 8 above, the average percentage of Electronic Worksheets implementation was 93.28%, with a very practical category. There were 12 activities observed by observers. From the 12 activities, 4 of them obtained a percentage of implementation of 100%, the activities were students reading the topic of Electronic Worksheets, students reading the text and observing the videos presented, students making questions based on the results of the video analysis presented, and students carrying out experimental activities.

The topic of Electronic Worksheets, which was clearly written on the cover, can increase student's curiosity to carry out activities in Electronic Worksheets and can attract students to learn membrane transport material. Then students carried out experimental activities enthusiastically in groups and were carried out in a structured and directed manner to get a maximum percentage of implementation of 100%. This aligned with the statement presented by Mursitaningrum et al (2019) that the curiosity and enthusiasm of students doing experiments is higher if carried out in groups.

Learning activities in Electronic Worksheets were carried out by all students. Still, some activities were not carried out optimally, so the percentage of implementation was lower than other activities. One

activity observed by observers obtained a lower percentage of implementation when compared to other activities. The activity was students reading learning outcomes per element, which got a percentage of implementation of 83.33%. Learning outcomes per element (in the independent curriculum) or learning objectives are things that important to include in the teaching materials and should be read by students before the activity begins. However, students consider reading learning objectives optional because it is not material that needs to be mastered so that students pass through the section. Hendratmoko et al. (2017) stated that learning objectives are a reference for knowledge, concepts, and skills that are students' expected to be achieved after learning activities are completed, so it is necessary for students to read learning objectives. To increase the interest of students in reading learning objectives, it can be done by improving the display that contains these learning objectives. For example, changing the placement of learning objectives initially written in monotonous paragraphs can be enhanced by using interesting shapes in *Ms. Word*, which then can be filled with essential sentences containing learning objectives.

Overall, students did the learning activities on Electronic Worksheets, which contains scientific approach steps to train critical thinking skills in a structured manner. Based on the results and explanation above, it showed that the practicality of Electronic Worksheets based on observations of the implementation Electronic Worksheets got an average result of implementation from 4 observers of 93.28% and it was included in the very practical category so that Electronic Worksheets was very practical to be used in learning activities.

Effectiveness of Electronic Worksheets

The effectiveness of developed Electronic Worksheets was determined based on the assessment of learning outcomes and student responses to the developed Electronic Worksheets. Assessment of learning outcomes was carried out by developing each indicator of critical thinking skills that were trained into appropriate questions. Students were categorized in the completion criteria if they reached the minimum completeness criteria (KKM) with score of ≥75. Recapitulation of learning outcomes was presented in Table 9.

Table 9. Recapitulation of Student's Learning Outcomes

Students No-	Pretest		Post test		N-Gain
	Score	Completeness	Score	Completeness	
1	40	No	80	Yes	0.67
2	60	No	90	Yes	0.75
3	50	No	90	Yes	0.80
4	30	No	80	Yes	0.71
5	40	No	90	Yes	0.83
6	40	No	80	Yes	0.67
7	50	No	80	Yes	0.60
8	40	No	90	Yes	0.83
9	30	No	80	Yes	0.71
10	30	No	70	No	0.57
11	30	No	70	No	0.57
12	60	No	90	Yes	0.75
13	30	No	80	Yes	0.71
14	40	No	80	Yes	0.67
15	40	No	70	No	0.50
16	60	No	90	Yes	0.75
17	40	No	80	Yes	0.67
18	50	No	80	Yes	0.60
Completeness (%)	0%		83.33%		0.69

The pretest results were listed Table 9. It showed that 18 students did not achieve KKM scores because the pretest scores of all students were still less than 75, and the percentage of completeness was 0%. This result indicated that students still not understand the membrane transpor material and needs to be improved. This membrane transport material was taught to class XI science students the previous semester. Another factor that causes low pretest results was that students were passive in asking teachers in learning previous membrane transport materials. This aligned with the statement of Mahjatia et al. (2020) that student's hesitation causes low pretest results to ask the teacher even though students do not understand the lesson.

The post-test results showed that 15 students completed or reached the KKM, while the other three were incomplete or had yet to reach the KKM. Students who are failed in the post test were considered as 'not good' by observer based on their observation during the class. These students were less active in activities and this can affected the students' post test results. If students do not participate in structured activities, this will have an impact on students' understanding that is less than optimal. However, the learning outcomes of learners was improved based on the results that have been presented. The percentage of completeness obtained was 83.33%. Improved learning outcomes with critical thinking skills are significantly linked. Increased student learning outcomes can occured because students have high critical thinking skills (Roswati et al., 2022). Hadi (2021) stated

that worksheets could be used as a learning tool to improve learning outcomes.

The pretest and post-test results were analyzed using the N-gain score formula with an average N-gain score of 0.69. The average N-gain score was in the medium category. Similar research conducted by Wuri and Mulyaningsih (2014) also showed that scientific approaches could improve critical thinking skills with an N-gain score of 0.54 and were included in the medium category. Student's critical thinking skills were also measured according to the achievement of student learning outcomes on each indicator critical thinking skills. These results are shown in Figure 1.

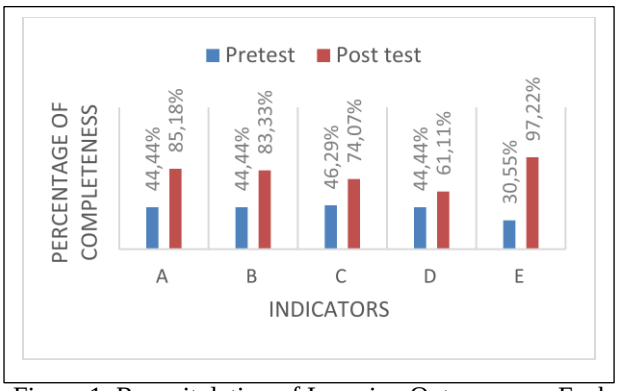


Figure 1. Recapitulation of Learning Outcomes on Each Critical Thinking Skills Indicators

Notes:
A: Analysis
B: Interpretation
C: Explanation
D: Evaluation
E: Inference

The pretest results on the analysis indicator obtained a completeness percentage of 44.44%, while the percentage of completeness of the analysis indicator on the post-test got a 85.18%. This indicated that students can solve analysis-type problems. Students could practice doing analysis questions because in Electronic Worksheets, learning activities that practice analysis activities were given the students short video presentations. Students were then asked to compile issues related to the video.

In the interpretation indicator, the percentage of completeness of learning outcomes in the pretest was 44.44%, while in the post-test, it increased and obtained a completeness percentage of 83.33%. Students could interpret data based on images on the questions presented into meaningful information. Improved interpretation skills could be caused by the Electronic Worksheets offers an article whose topics were problems in daily life so that students could more easily express the information obtained.

The pretest results on the explanation indicator obtained a completeness percentage of 46.29%, while the percentage of completeness of explanation indicator on the post-test got a percentage of 74.07%. Students could explain the differences between hypertonic and hypotonic solutions that can cause the condition of a cell changed and could explain how the processes that caused a cell changed their shape. The increased in explanation indicator was in line with the statement of Susilowati and Wisanti (2023), which stated that students could connect the information obtained and communicate it in writing into complete information.

The percentage of completeness in the evaluation indicator in the pretest was 44.44%, while the percentage of completeness in the post-test got a 61.11%. Evaluation indicators have the lowest percentage of achievement compared to other indicators. This could happen because in Electronic worksheet, activities that train evaluation critical thinking indicators, were only directed the students to carry out practicum activities that have been listed in the Electronic Worksheet and were not given the additional information or supporting information that can help students understand the activities. So that when given with test questions, students were still unable to understand the questions and the answers were not correct.

The last indicator of critical thinking skills trained in this research wa inference. The pretest results on the inference indicator got a completeness percentage of 30.55%, while the percentage of completeness of the inference indicator on the post-test increased to 97.22%. The inference indicator has the highest percentage of achievement compared to other indicators. This could occured because the question in the test related with an activity that have been carried out by the students during the learning process using the Electronic Worksheets. Hence, students' could conclude according to the experience they have gained previously through activities in the Electronic Worksheets.

Based on the explanation that has been described, the average percentage of completeness of learning outcomes of each indicator has increased from 42.03% to 80.18%.

The effectiveness assessment was also reviewed from student responses to the developed Electronic Worksheets. Recapitulation of student's positive responses to Electronic Worksheets is presented in Table 10 below.

Table 10. Recapitulation of Student's Positive Responses to Electronic Worksheets

No	Statements	Percentage Of Positive Responses
1.	Membrane transport material in Electronic Worksheets is related to everyday's life	100
2.	Electronic Worksheets can support the implementation of student-centered learning	100
3.	Electronic Worksheets can help students developing the critical thinking skills	100
4.	Electronic Worksheets can build student's knowledge independently	100
5.	Students can check the understanding of the material with statements available on the Electronic Worksheets	94.44
6.	Electronic Worksheets can help students understand the concepts of the material taught	100
7.	Electronic Worksheets can attract students to learn membrane transport material	100
8.	The appearance of Electronic Worksheets is attractive	88.89
9.	The way of presenting Electronic Worksheets attracts the interest and attention of students to read	94.44
10.	The features on the Electronic Worksheets are interesting	100
11.	Illustrations (images, tables, videos, and animations) on Electronic Worksheets can support students's understanding of membrane transport materials	100
12.	The letters used in this Electronic Worksheets are clearly legible and comfortable to read	94.44
13.	The language used is easy to understand	100
14.	The sentences used are easy to understand	100
15.	The terms used are easy to understand	100
Average		98.14

Based on the results of the student response questionnaire that given to 18 students, the overall average positive response of students was 98.14% and was included in the very effective category.

The student response questionnaire contained 15 closed questions, as listed in Table 10. Eleven questions received a positive response percentage of 100%, while the other four received less than 100%. The lowest percentage of student responses was in the Electronic Worksheets performance, 88.89%. However, most of the student's still stated that the developed Electronic Worksheets was interesting. An attractive worksheets was essential to increase student's interest in learning. Student's motivation could increase if learning resources are designed attractively (Nurrita, 2018). One of the questions that received a percentage of positive responses of 100% in Table 10 was whether Electronic Worksheets could help develop student's critical thinking skills. This indicated that Electronic Worksheets based on scientific approach could facilitate students in understanding the material and could train student's critical thinking skills. Based on the explanation above, the developed Electronic Worksheets was very effective in terms of the results of student responses.

CLOSING

Conclusion

Based on the results of the research, it can be concluded that the Electronic Worksheets based on scientific approach topic that has been developed is valid, practical, and effective to be used to train critical thinking skills on membrane transport material with a validity score of 3.69 with a very valid category percentage, practicality aspect got an average percentage of 93.28% in the very practical category and the effectiveness in terms of learning outcomes got a post-test completeness score of 83.33% in the very effective category, the N-gain score is 0.69 in the moderate category, and the average completeness of each critical thinking indicator is 80.18%, while the aspect of effectiveness in terms of student responses, got an average percentage of 98.14% which was included in the very effective category.

Suggestion

Researcher suggest that the time allocation must be optimized especially with the implementation of the 5M scientific approach. In activities that train critical thinking indicators evaluation in Electronic Worksheet, supporting information or data should be given so that students can understand the activities carried out properly. Activities on Electronic Worksheet should be more up to date so that learning process is more interesting. In addition, similar research on other learning materials must be done so that students can continue to be trained in critical thinking skills.

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REFERENCES

Abidin, Y. 2013. *Desain Sistem Pembelajaran dalam Konteks Kurikulum*. Bandung: Rafika Aditama.

Bohori, M., Putra, A., and Razi, P. 2015. Pengaruh Lembar Kegiatan Siswa Berorientasi Pendekatan Saintifik dalam Pembelajaran Fisika terhadap Pencapaian Kompetensi Siswa. *Pillar of Physics Education*, 5, 161–168.

Ennis, R. H. 2011. *The Nature of Critical Thinking: An Outline of Critical Thinking Disposition and Abilities*, (Online), (https://education.illinois.edu/docs/default-source/faculty-documents/robert ennis/thenatureofcriticalthinking_51711_000.pdf, diakses 30 Januari 2023).

Facione, P. A. 2011. *Critical Thinking: What It Is and Why It Counts. Insight Assessment*, (Online), (https://www.insightassessment.com/CT-Resources/Teaching-For-and-About-Critical-Thinking/Critical-Thinking-What-It-Is-and-Why-It-Counts/Critical-Thinking-What-It-Is-and-Why-It-Counts-PDF, diakses 2 Februari 2023).

Fikriyah, A., Tjandrakirana, T., and Agustini, R. 2020. Enhancement of Students Critical Thinking Skill in Fungi Concepts Based on Science, Technology, and Society Learning Approach. *Jurnal Inovasi Pembelajaran Biologi (JIPB)*, 1(2), 44–49.

Fransiska, D., Yeni, L. F., and Titin, T. 2021. Pengembangan LKPD Berbasis Multimedia Interaktif pada Materi Kingdom Monera. *Journal of Biology Learning*, 3(1), 9-17

Hadi, A. M. 2021. Penggunaan LKPD untuk Meningkatkan Hasil Belajar Peserta Didik pada Materi Matriks. *DIDAKTIKA : Jurnal Pemikiran Pendidikan*, 27(2), 153-164.

Hake, R. 1999. *Analyzing Change Gain Scores*. Indiana: Indiana University.

Hendratmoko, T. Kuswandi, D. and Setyosari, P. 2017. Tujuan Pembelajaran Berlandaskan Konsep Pendidikan Jiwa Merdeka Ki Hajar Dewantara. *Jurnal Inovasi dan Teknologi Pembelajaran*, 3(2), 152–157.

Iswantini, W and Purnomo, T. 2017. Validitas Lembar Kegiatan Siswa Berbasis Inkuiri pada Materi Pencemaran Lingkungan untuk Melatihkan Literasi Sains Siswa pada Kelas X SMA. *BioEdu*, 6(3), 344–352.

Kemendikbudristek BSKAP. 2022. Salinan Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 008/H/KR/2022 Tentang Capaian Pembelajaran pada Pendidikan Anak Usia Dini Jenjang Pendidikan Dasar dan Jenjang Pendidikan Menengah pada Kurikulum Merdeka. In *Kemendikbudristek BSKAP RI* (Issue 021).

Kusumah, R. G. T. 2019. Peningkatan Kemampuan Berfikir Kritis Mahasiswa Tadris IPA melalui Media Projek. *IJIS Edu : Indonesian Journal of Integrated Science Education*, 1(1), 71–89.

Lestari, L., Alberida, H., and Rahmi, Y. L. 2018. Validitas dan Praktikalitas Lembar Kerja Peserta Didik (LKPD) Materi Kingdom Plantae Berbasis Pendekatan Saintifik untuk Peserta Didik Kelas X SMA/MA. *Jurnal Eksakta Pendidikan (Jep)*, 2(2), 170-177.

Mahjatia, N., Susilowati, E., and Miriam, S. 2021. Pengembangan LKPD Berbasis STEM untuk Melatihkan Keterampilan Proses Sains Siswa melalui Inkuiri Terbimbing. *Jurnal Ilmiah Pendidikan Fisika*, 4(3), 139-150.

Mursitaningrum, R.S., Yuliani, and Yakub, P. 2019. Keefektifan LKPD Berbasis Guided Discovery untuk Melatihkan Keterampilan Proses Sains Terintegrasi pada Materi Fotosintesis. *Jurnal Bio Edu (Berkala Ilmiah Pendidikan Biologi)*, 8(3), 510 – 522.

Nurrita, T. 2018. Pengembangan Media Pembelajaran untuk Meningkatkan Hasil Belajar Siswa. *MISYKAT: Jurnal Ilmu-Ilmu Al-Quran, Hadist, Syari'ah Dan Tarbiyah*, 3(1), 171-187.

Oktavianty, E., Silitonga, H. T. M., and Fatimah, S. 2020. Peningkatan Keterampilan Berpikir Kritis Peserta Didik Melalui Penerapan Pendekatan Saintifik. *Jurnal Inovasi Dan Pembelajaran Fisika*, 7(2), 183–189.

Pratama, C., Kaspul, and Arsyad, M. 2020. Pengembangan Media Pembelajaran Interaktif Berbasis Aplikasi Android pada Konsep Sistem Pernapasan Manusia Jenjang SMA. *Jurnal Program Studi Pendidikan Biologi*, 10(2), 16–23.

Ramlawati, Liliasari, Martoprawiro, Muhamad A., and Wulan, A, R. 2014. The Effect of Electronic Portfolio Assessment Model to Increase of Students' Generic Science Skill in Practical Inorganic Chemistry. *Journal of Education and Learning*, 8(3), 179-186.

Riduwan. 2013. *Skala Pengukuran Variabel-Variabel Penelitian*. Bandung: Alfabeta.

Roswati, E., Hernawan, E., and Ardiansyah, R. 2019. Hubungan Keterampilan Berpikir Kritis dengan Hasil Belajar Peserta Didik pada Sub Konsep Psikotropika. *Prosiding Seminar Nasional Biologi dan Pembelajarannya (SN-Biosfer)*, 262-268.

Sihafudin, A., and Trimulyono, G. 2020. Validitas dan Keefektifan LKPD Pembuatan *Virgin Coconut Oil* Keterampilan Proses Sains pada Materi Bioteknologi.

Bioedu: Berkala Ilmiah Pendidikan Biologi, 9(1), 73–79.

Susilowati, D., and Wisanti. 2023. Pengembangan E-LKPD Keanekaragaman Hayati Berbasis Learning Cyle 5E (LC5E) untuk Melatih Berpikir Kritis. *Bioedu: Berkala Ilmiah Pendidikan Biologi*, 12(2), 343-355.

Umbaryati. 2016. Pentingnya LKPD pada Pendekatan Scientific Pembelajaran Matematika. *PRISMA: Prosiding Seminar Nasional Matematika*, 217–225.

Wati, R. T., and Yuliani, Y. 2020. Pengembangan Lembar Kegiatan Peserta Didik (LKPD) Berbasis Problem Based Learning (PBL) Submateri Transpor Membran untuk Melatihkan Keterampilan Berpikir Kritis". *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, 9(2), 340–349.

Wuri, O. R., and Mulyaningsih, S. 2014. Penerapan Pendekatan Saintifik pada Pembelajaran Fisika Materi Kalor terhadap Keterampilan Berpikir Kritis Siswa Kelas X SMA. *Jurnal Inovasi Pendidikan Fisika (JIPF)*, 3(3), 91–95.