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# THE DEVELOPMENT OF SCIENTIFIC LITERACY-BASED E-WORKSHEET ON *BRYOPHYTES* AND *PTERIDOPHYTES* SUB-MATERIALS TO TRAIN STUDENTS' CRITICAL THINKING

## Pengembangan E-Worksheet Berbasis Literasi Sains pada Sub-materi Lumut dan Paku-pakuan untuk Melatih Kemampuan Berpikir Kritis Peserta Didik

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**Abstract**

Critical thinking is one of the most needed skills for students in the 21st century. Critical thinking skills can be trained by activities with scientific literacy base in the class. The aim for this research is develop scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials to train students' critical thinking which is proper to use in class based on validity, practicality, and effectiveness. This research use 4D developing research consist of define, design, develop, and disseminate. Research trials have been done in SMA Muhammadiyah 1 Taman and involved 26 students of class X-3. The research variables consist of validity of expert validators results, practicality of student activities and student responses, and efficacy of student outcomes to know their critical thinking levels and their completeness. The collected data were analyzed using a quantitative descriptive techniques. The E-Worksheet validity was obtained by two validators in percentage of 92.96% with very valid categorized. The E-Worksheet practicality on implementation test get 93% score with very practical categorized and student responses questionnaire get 85% score with practical categorized. The effectiveness was obtained by pre-test and post-test on n-gain score was 0.64 with medium categorized and achievement of critical thinking indicators which the inferring was 85%, advanced clarification was 75%, and strategies and tactics was 78%. Based on the results, the E-Worksheet based on scientific literacy is proper based on validity, practicality, and effectiveness to train students' critical thinking.
**Keywords :** E-Worksheet, Scientific Literacy, Critical Thinking.

**Abstrak**

*Berpikir kritis merupakan salah satu kemampuan yang sangat dibutuhkan peserta didik pada abad ke-21. Kemampuan berpikir kritis dapat dilatih melalui kegiatan berbasis literasi sains dalam pembelajaran. Penelitian ini bertujuan untuk menghasilkan E-LKPD berbasis literasi sains pada sub-materi tumbuhan lumut dan tumbuhan paku untuk melatih kemampuan berpikir kritis peserta didik yang valid, praktis, dan efektif. Penelitian menggunakan metode 4D terdiri dari define, design, develop, dan disseminate. Uji coba dilakukan di SMA Muhammadiyah 1 Taman dan melibatkan 26 peserta didik kelas X-3. Variabel penelitian mencakup hasil validitas, kegiatan peserta didik, respons peserta didik, dan hasil belajar dari pre-test dan post-test untuk mengetahui kemampuan berpikir kritis dan ketuntasannya. Indikator berpikir kritis yang diukur berupa inferring, advanced clarification, dan strategies and tactics. Hasil validitas E-LKPD sebesar 92,69% kategori sangat valid. Hasil kepraktisan berdasarkan keterlaksanaan sebesar 93% dengan kategori sangat praktis dan respons peserta didik sebesar 85% dengan kategori praktis. Hasil keefektifan E-LKPD dengan n-gain sebesar 0,68 kategori sedang dan ketercapaian indikator berpikir kritis inferring 83%, advanced clarification 75%, dan strategies and tactics 78%. E-LKPD berbasis literasi sains dinyatakan layak digunakan dari segi validitas, kepraktisan, dan keefektifan untuk melatih kemampuan berpikir kritis peserta didik.*
***Kata Kunci :*** *E-LKPD, Literasi Sains, Berpikir Kritis.*

## INTRODUCTION

Self-quality can be improved by using 4C abilities: Communication, Collaboration, Critical Thinking, and Creativity) in the current global era, as contained in the US-based Partnership for 21st Century Skills (P21) (Zubaidah, 2016). Education can be the place for training and developing the 4C abilities. Critical thinking is one of education demands that should be mastered by students in the 21st century. According to Prameswari et al. (2018), critical thinking is a thinking process that begins by analyzing a problem and then determining a solution to the problem until the appropriate conclusion is produced.

The latest report by the OECD regarding PISA 2018, Indonesia is ranked 74th, or the bottom 6th, and science ability with an average score of 396, is ranked 71st. Learning activities at school can affect students' critical thinking skills at a low level, because teachers do not provide orientation to higher-level thinking activities and are limited to understanding the concepts of the material presented, so teachers are expected to be able to train critical thinking skills. The Merdeka Curriculum expects students to be trained in their abilities, including critical thinking, communication, collaboration, and creativity. The ability to think critically is not natural but needs to be trained in learning by evaluating and testing ideas (Murawski, 2022). Students' critical thinking abilities can be trained in various ways, one of which is applying scientific literacy in learning.

Critical thinking is included to Higher Order Thinking skills that must be trained continuously. Students' critical thinking skills can be trained using scientific literacy-based E-Worksheet. It was supported by the research results of scientific literacy activities Zahroh & Yuliani (2021) that scientific literacy-based E-Worksheet can practically and effectively train students' critical thinking skills. Scientific literacy can be applying science concept and having ability in science process to make decision which is dealing with other people, societies, and environtments.

Critical thinking abilities can be trained using scientific literacy activities. Scientific literacy activities have positive relation if it connected to measured critical thinking abilities scientific literacy activities. The researcher intend to examine three sritical thinking indicators which is connected to scientific literacy competencies. The first scientific literacy competencies are explaining scientific phenomena and evaluating which are related to making further explanations (advanced clarification). The second scientific literacy competency is designing scientific investigations, which is related to arranging strategies and tactics (strategies and tactics). The third scientific literacy competency is interpreting data and scientific evidence related to making decisions (inferring).

The researcher is developing scientific literacy-based E-Worksheet to train students' critical thinking skills using materials, features, content, and designs different from existing research, namely, using *Bryophythes* and *Pteridophytes* sub-materials. This research utilizes live worksheet media, which has several features, such as images and videos that can be accessed directly, filling in the blanks, and choosing the correct answer. Several studies are related to E-Worksheet using live worksheets to improve critical thinking skills, there are research by Teresa et al. (2022), which showed that the use of live worksheets trains students' critical thinking skills with high effectiveness. Research by Ningtyas & Rahayu (2022) also showed that students can train their critical thinking skills using E-Worksheet with an increase in all critical thinking indicators from students, including inference, interpretation, analysis and evaluation.

Initial survey was conducted by researcher using liveworksheet cite with *Bryophythes* and *Pteridophytes* keywords and it have various difference. Researcher intend to give different contents and models with the previous one using scientific literacy-based activities. The scientific literacy-based E-Worksheet is adapted to the Merdeka Curriculum, which contains activity instructions, features used in the E-Worksheet, Learning Outcomes, criteria for achieving learning objectives, primary material, and scientific literacy activities. Based on the background, this research aims to develop scientific literacy-based E-Worksheet on sub-materials of *Bryophythes* and *Pteridophytes* that are valid and practical to train students' critical thinking skills.

## METHODS

This research uses research and development types. This types of research can be used to produce products that can be tested for practicality in use (Purnama, 2016). Developing a product can be done with some steps, which are assessment or needs analyzing, developing product, evaluating, and disseminating if it needed. This research uses a 4D development model: Define, Design, Develop, and Disseminate. The 4D development model was chosen because it follows the research objectives. It produced an scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials that is valid, practical, and effective to train students' critical thinking skills.

The define stage explains the needs of students. This stage formulates the boundaries used to develop scientific literacy-based E-Worksheet. This stage is carried out with five main steps of analysis: front-end analysis, curriculum analysis, student analysis, concept analysis, and task analysis (Thiagarajan et al., 1974).

The design stage is carried out according to the analysis results at the Define stage. This stage consist of criterion-test construction, media selection, format selection, and initial design.

The develop stage consist of two stages: assessing or validating the suitability of the media being developed (expert appraisal) and conducting trials on predetermined targets (developmental testing) (Thiagarajan et al., 1974). This stage starts from the initial preparation of draft one until the final draft is produced. The develop stage aims to produce a final draft, which goes through several processes: reviewing the E-Worksheet draft, revisions, research proposal seminars, validity testing by material and education expert lecturers, and research trials.

The disseminate stage is the final stage of the 4D development method. The distribution stage starts from the packaging stage in the form of a thesis and publishing articles via the BioEdu website. Apart from that, distribution is also done by opening the privacy of scientific literacy-based E-Worksheet workbooks in live worksheets so teachers and other students can use them.

Variable Operational Definition

The validity of the E-Worksheet is assessed by two validators using a validity assessment instrument to determine the accuracy of the scientific literacy-based E-Worksheet, which was developed for further research trials. The practicality is assessed from student responses questionnaire instrument, filled in via Google Form by students after using the E-Worksheet and the implementation assessment instrument. The E-Worksheet effectiveness is assessed from students results from pre-test and post-test which are done by students individually.

Data Collection Method

Several instruments are used in collecting data for this research, consist of validity of expert validators sheets, student responses questionnaire, achievement of implementation sheet, and questions of pre-test and post-test. The validity test is used to determine the validity of scientific literacy-based E-Worksheet from the five points of presentation aspect, nine points of content aspect, and one point of language aspect.

Student responses and achievement of implementation are used to measure the practicality of E-Worksheet. The achievement of implementation is used to know students' activeness and participation in class. Achievement of implementation is used to assess each students by the observers. Student response questionnaire is get from students response in Google Form consist of 10 questions with yes or no answers. The questionnaire questions assess the E-Worksheet from its ascpects of presentation, content, and language based on students experience.

The achievement of effectiveness are from pre-test, post-test, and results of E-Worksheet. Pre-test and post-test questions were validated by the validators before it tested to students. Results of pre-test and post-test were get from individually test of five essay questions, while E-Worksheet was done as a group.

Data Analysis Method

The collected data is analyzed by processing it to obtain an interpretation of the data to simplify the discussion process until a conclusion is reached. After getting the E-Worksheet validity assessment data, the data is calculated using the following formula.

$$\text{Percentage Validity Score} = \frac{\sum \text{score}}{\text{Maximal score}} \times 100\% \quad \text{.....(1)}$$

Based on the percentage results, the values are interpreted into validity criteria, as seen in the following table.

Table 1. Validity Achievement Criteria

| Intervals (%) | Criteria |
|---|---|
| 0 – 48 | Invalid |
| 49 – 61 | Less Valid |
| 62 – 74 | Valid Enough |
| 75 – 87 | Valid |
| 88 – 100 | Very Valid |

(Riduwan & Sunarto, 2013)

The assessment of the practicality of scientific literacy-based E-Worksheet consists of two assessments: a student response questionnaire and an implementation. The questionnaire scores are totaled and calculated using the formula below.

$$\text{Questionnaire Percentage (\%)} = \frac{Total\ Score}{Total\ Respondents} \times 100 \text{..(2)}$$

Implementation analysis was carried out to determine the level of implementation of the use of E-Worksheet in learning. The data obtained from each student can be calculated using the following formula.

$$\text{Implementation (\%)} = \frac{\sum "yes"\ answer(s)}{\sum "no"\ answer(s)} \times 100\% \quad (3)$$

The final results are interpreted into the following table of practicality criteria below.

BioEdu
Berkala Ilmiah Pendidikan Biologi
Vol. 13 No. 2 Tahun 2024 Hal: 415-422
https://ejournal.unesa.ac.id/index.php/bioedu

Table 2. Practicality Achievement Criteria

| Intervals (%) | Criteria |
|---|---|
| ≤ 25 – 40 | Not Practical |
| 41 – 55 | Less Practical |
| 56 – 70 | Practical Enough |
| 71 – 85 | Practical |
| 86 – 100 | Very Practical |

(Riduwan & Sunarto, 2013)

Scientific literacy-based E-Worksheet is practical if the final results of the assessment are ≥ 71%.

The effectifity of E-Worksheet is get from students' results of pre-test and post-test. Grades that are get will be calculated of its completeness percentage. The data from each critical thinking indicators can be calculated using the following formula.

$$\text{Indicators Completeness (\%)} = \frac{\sum each\ indicators\ score}{\sum maximal\ score} \times 10 \quad (4)$$

E-Worksheet is effective if the final score of indicators completeness will be >61% (Riduwan & Sunarto, 2013). The difference of pre-test and post-test are calculated to know its increase. The increasing score can be calculated using n-gain formula.

$$n - gain = \frac{posttest\ score - pretest\ score}{ideal\ score - pretest\ score} \quad \ldots\ldots (5)$$

The final results are interpreted into the following table of n-gain criteria below.

Table 3. Effectiveness Criteria using N-gain Score

| Intervals | Criteria |
|---|---|
| <g> < 0.30 | Low |
| 0.70 > <g> ≥ 0.30 | Middle |
| <g> ≥ 0.70 | High |

(Hake, 1999)

## RESULTS AND DISCUSSION

The research aims to produce scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials that are valid, practical, and effective to train students' critical thinking. E-Worksheet refers to the 4D development model: define, design, develop, and disseminate.

The scientific literacy based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials was developed with aim to train students' critical thinking skills. E-Worksheet is consist of cover, features introduction, activities instruction, learning outcomes, criteria for achieving learning objectives, activities for students through features, and bibliography displayed in 28 total pages. Main features consist of Bio-presume, Bio-elucidation, and Bio-strategem with addition feature Bio-tip.

E-Worksheet was presented in *Liveworksheet* site. Scientific literacy based E-worksheet utilize features of *Liveworksheet*, such as filling the blank square, pairing suitable pictures, choosing the right answer, and playing Youtube videos. Pictures, font, and colour combination were well adapted to make it easier for students. Materials were delivered with three parts, "Bagian 1-Tumbuhan Lumut", "Bagian 2-Tumbuhan Paku", and "Bagian 3-Kegiatan Lanjutan" which is the comparison of *Bryophythes* and *Pteridophytes*. Features in this E-Worksheet are in the table below.

Table 4. Features of E-Worksheet

| Features | Description |
|---|---|
| Bio-presume | a. Interpreting data and scientific evidence activities.<br>b. Train inferring critical thinking skills. |
| Bio-elucidation | a. Explaining scientific phenomenon and evaluating.<br>b. Train advanced clarification critical thinking skills. |
| Bio-strategem | a. Designing scientific research activities.<br>b. Train *strategies and tactics* critical thinking skills. |
| Bio-tip | a. Glossaries of biological terms that are used.<br>b. Completed with picture of its terms. |

Here is the example of E-Worksheet presentation.

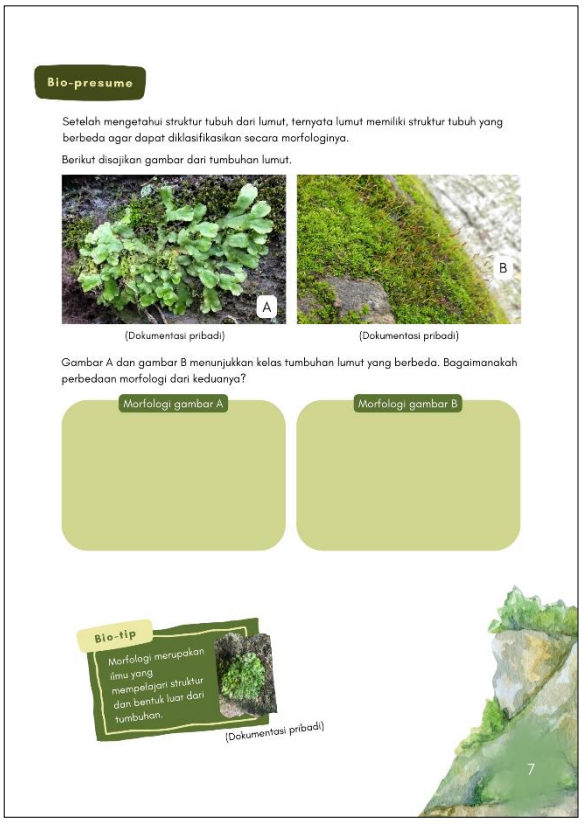


Figure 1. Example of E-Worksheet Presentation

The validity of E-Worksheet is carried out to determine its feasibility before being tested on students. The validity test was carried out by two validators consisting of education expert lecturers and material expert lecturers using validity assessment instruments.

The aspects assessed in the E-Worksheet validity test consist of presentation, content, and language, presented in the following table.

Table 5. Validity Test Results

| No. | Criteria | Results | | Average (%) |
|---|---|---|---|---|
| | | V1 | V2 | |
| Presentation | | | | |
| 1. | E-Worksheet image and color display quality | 4 | 4 | 100 |
| 2. | The proportion of font size and color is appropriate for its use | 4 | 4 | 100 |
| 3. | Instructions for using the features that will be used | 3 | 4 | 87.5 |
| 4. | Videos are easy to access; suitable with topics; audio and display are clear. | 4 | 4 | 100 |
| 5. | Bibliography is listed; support topics; in accordance with APA 7th edition. | 4 | 4 | 100 |
| Average / Category | | 97.5 / Very Valid | | |
| Content | | | | |
| 1. | Suitability of the topic presented with the subject matter. | 3 | 3 | 75 |
| 2. | Suitability of Learning Achievements, Learning Objectives, and Criteria for Achieving Learning Objectives with the activities. | 4 | 4 | 100 |
| 3. | Critical thinking skills to make decisions (inferring). | 3 | 3 | 75 |
| 4. | Critical thinking skills to make further explanations (advanced clarification) | 4 | 4 | 100 |
| 5. | Critical thinking skills to organize strategy and tactics (strategies and tactics). | 4 | 4 | 100 |
| 6. | Bio-presume feature. | 3 | 4 | 87.5 |
| 7. | Bio-elucidation feature. | 4 | 4 | 100 |
| 8. | Bio-strategem feature. | 4 | 4 | 100 |
| 9. | Bio-tip feature. | 4 | 4 | 100 |
| Average / Category | | 93.06 / Very Valid | | |
| Language | | | | |
| 1. | Linguistic structures are clear and straightforward; in accordance with EYD; not strange language. | 4 | 3 | 8.75 |
| Average / Category | | 87.5 / Very Valid | | |
| Average of All Aspects | | 3.71 | | 92.69 |
| Category | | Very Valid | | |

The implementation of E-Worksheet and student response questionnaires show the level of practicality of scientific literacy based E-Worksheet. The practicality of scientific literacy-based E-Worksheet have been assessed in learning activities. Implementation was assessed by three observers who each considered each student from the two groups in learning using an implementation test sheet. Data from observations of students' activities in learning using scientific literacy-based E-Worksheet can be seen in the following table.

Table 6. Achievement of Implementation Result (n=26)

| Meeting | Implementation (%) |
|---|---|
| 1st | 93 |
| 2nd | 95 |
| Average / Category | 94 / Very Practical |

Based on Table 6, the results shows average implementation of E-Worksheet which is 94% and very practical. After working on the E-Worksheet, students provided their responses through response questionnaire to measure the practicality of the E-Worksheet that has been worked on. The result of students questionnaire is presented in the following table.

Table 7. Student Responses (n=26)

| No. | Statements | Positive Response (%) |
|---|---|---|
| 1. | The scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials is interesting to be studied. | 88 |
| 2. | Language that are used in scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials is easy to be understood. | 62 |
| 3. | The presented questions are included in training critical thinking skills questions. | 96 |
| 4. | Features are easy to use. | 88 |
| 5. | Pictures and videos can help giving explanation on *Bryophythes* and *Pteridophytes* sub-materials. | 77 |
| 6. | Text display in scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials is easy to read. | 92 |
| 7. | The scientific literacy-based E-Worksheet can increase knowledge about problems around the environment. | 100 |
| 8. | The scientific literacy-based E-Worksheet can help to make conclusion based on reviewing the results of observation activities. | 92 |
| 9. | The scientific literacy-based E-Worksheet can help to make assumptions or idea from scientific phenomenon. | 73 |
| 10. | The scientific literacy-based E-Worksheet can help to make strategies on utilization of | 81 |

| No. | Statements | Positive Response (%) |
|---|---|---|
| | *Bryophythes* and *Pteridophytes*. | |
| Average / Category | | 85 / Practical |

Based on Table 7, the results of the practicality test of E-Worksheet which was obtained through a student response questionnaire filled in by 26 people is practical with average 85%. The questionnaire contained yes and no statements. Students have been completed the response questionnaire via Google Forms after completing all learning activities.

Students result from pre-test and post-test showed the level of effectiveness of E-Worksheet. Students' critical thinking skills also can be known from its result. Students result can be seen in following table.

Table 8. Learning Outcomes Completeness (n=26)

| No. | Measured Critical Thinking Indicators | Completeness of Measured Critical Thinking Indicators (%) | |
|---|---|---|---|
| | | Pre-test | Post-test |
| 1. | Inferring | 29 | 83 |
| 2. | Advanced clarification | 30 | 75 |
| 3. | Strategies and tactics | 37 | 78 |
| Average of indicators completeness | | 32 | 79 |
| Category | | Incomplete | Complete |
| Students that are complete (%) | | 0 | 73 |
| N-gain | | 0.68 (Middle) | |

Based on Table 8, there were enhancements on critical thinking indicators value. The same matter also happened with the enhancement of students results from its completeness. Difference marks from pre-test and post-test were used to know the n-gain score. Average of n-gain score is 0,64 which is middle categorized. It can conclude that the scientific literacy-based E-Worksheet was affect students result with middle categorized.

Activities in E-Worksheet were presented variously with utilize features from Liveworksheet to make students not bored in learning. As Kurniawan et al. (2018) said that variation of learning presentation, such as hearing audio, watching video, and observating pictures will make students not bored to understand the materials. Videos in E-Worksheet get score 4 or 100% from two validators with very valid categorized, but it get the lowest score from students response questionnaire in amount 77%. The reason of the low score was from the audio of the video that have unclear quality to hear.

Videos in E-Worksheet were presented as introduction activity and on Bio-elucidation feature. The lowest students result was on Bio-elucidation acitivities which was evaluate advanced clarification in amount 75 which was under the minimum score. Video with less quality can affect students result. As Ambara et al. (2018) said that presenting video in learning process have positive impact to students result. Completeness of students result was also not maximal, which was only 73%. Therefore, video that was presented will be better if the audio quality will be improved. Application of media with well audio quality can make material delivering easier and make students remember the materials easier (Sutiono & Husna, 2022).

Validity result in content aspect shows that inferring activities get the lowest score in amount 75%. If it linked to the implementation, 89% students did the inferring activities. Although it get the lowest score from validators, students still get high score in inferring question of post-test in amount 83%. That score is 54% increasing from pre-test. It can conclude that although inferring activities get less score from validators, but students were still trained their inferring skills with get high achievement score.

Students learning process using scientific literacy-based E-Worksheet get and utilize something in the form of argumentation, idea, or description from it. It concluded from the activities in the E-Worksheet. Scientific literacy-based E-Worksheet activities consist of exploring and evaluating natural phenomenon, designing scientific literacy, and exploring and interpreting the presented scientific data. Those activities mirroring the cognitivism theory which is said that students insight of something make them be able to solve problems in their surrounding environment and thinking from students (Wisman, 2020).

Students still not maximal in assumpting or creating idea to presented problems. It can known to its interpretation on point "formulating opinion on observating image and and analyzing graphic" with score 92% and very practical categorized, but it only get 73% score from the questionnaire (point 9). This point is related to scientific literacy competency which is interpreting data and scientific evidence. Students can arrange assumption or idea, but they were feeling difficult to its composing. Its difficulty can caused by some factors, such as students were not used to arrange assumption or idea, not really understood to the concepts or materials, less critical thinking skills, misconception, or less reading. As PISA 2018 said that students critical thinking skills in Indonesia is still low and as Fuadi et al. (2020) said that less reading can make students scientific literacy in low levels.

Overall students completed the minimum score with post-test score average in amount 79. Based on that average score, it can conclude that students understood the *Bryophythes* and *Pteridophytes* sub-materials.

Students result shows relationship between completeness of post-test and their participation in class. Students participation can be known from the observers. The observer data shows that students who were not complete in their post-test were not really active during activities in E-Worksheet. Otherwise, students who were always active during activities get well result and completed. Students result completeness can be achievable if they join activities in learning participatively (Risanatul & Junaidi, 2022).

E-Worksheet validity in language aspect showed 3.5 score or 87.5% with very valid categorized. Language aspect assessed its structure consist of language clarity and straightforwardness, suitability with EYD, and not strange language. Language structure can affect students misconception levels (Perdana et al., 2018). Even the validity score was good, but it get low score from student responses, which was only 62% with practical enough categorized.

Language aspect from student questionnaire gets low score can be caused by students who were not used to reading and complaining first before they read the topics. Many Biological strange terms can also affect students' scientific literacy. It can be caused by in odd semester of Kurikulum Merdeka was still not discuss about Biodiversity. Students who less reading also known from implementation test that not all students read the features introduction, activity instruction, and short materials about *Bryophythes* in the E-Worksheet. Therefore, language that was used should be adapted with student levels. Students also should be get used to scientific literacy activities, so that they will be used to it.

## CLOSING

### Conclusion

This research produces scientific literacy-based E-Worksheet on *Bryophythes* and *Pteridophytes* sub-materials to train students' critical thinking skill that is valid, practical, and effective. The scientific literacy-based E-Worksheet was declared very valid based on presentation, content, and language aspects. The scientific literacy-based E-Worksheet is practical based on student responses and very practical based on implementation. The scientific literacy-based E-Worksheet is effective based on the completeness of critical thinking indicators that are measured and middle categorized n-gain score.

### Suggestion

The development of literacy-based E-Worksheet can be carried out again on other Biology materials and sub-materials. Other research can be conducted with other critical thinking indicators measured. Language that is used should be adapted to make students understand the materials easier. Changing audio of the video also should be done.

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