DEVELOPMENT OF ELECTRONIC STUDENT WORKSHEET (E-WORKSHEET) BASED ON PROJECT BASED LEARNING (PJBL) TO TRAIN STUDENT'S CRITICAL THINKING SKILLS ON BIOTECHNOLOGY TOPIC OF 10th GRADE IN SENIOR HIGH SCHOOL

Pengembangan Lembar Kerja Peserta Didik Elektronik (E-LKPD) Berbasis Project Based Learning (PjBL) untuk Melatihkan Keterampilan Berpikir Kritis pada Materi Bioteknologi Peserta Didik Kelas X SMA

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Abstract

The Ministry of Education, Culture, Research and Technology (Kemendikburistek) has issued the latest policy regarding the Merdeka Curriculum. The Merdeka Curriculum seeks to answer the education issues in the context of the Industrial Revolution 4.0. Which, in its realization, students need critical thinking skills. PISA statistical data shows students' critical thinking skills are still relatively low. Innovative teaching material and the right learning model are required. This research was conducted to develop an E-Worksheet based on Project Based Learning regarding validity, practicality and effectivity to train critical thinking skills. This research involved 20 students in 10th grade in SMA Negeri 1 Taman, Sidoarjo. The results showed that the validity of the E-Worksheet was obtained with an average percentage value of overall validity of 98.81% with a very valid category. The practicality of E-Worksheet was reviewed in two ways: the results of observations of E-Worksheet implementation, which obtained an average percentage of 95% with a with a very practical category and the results of the response questionnaire, which obtained an average percentage of 97% with a very practical category. The effectivity of the E-Worksheet was reviewed based on the learning outcomes score. The data obtained results from working on pre-test and post-test questions, which received a percentage of completeness of 100% and got an N-gain score of 0.79 with a very effective category, demonstrating the high confidence in the effectivity of E-Worksheet.

Keywords: Secondary Education, Electronic Student Worksheet, Project Based Learning, Biotechnology, Critical Thinking Skills.

Abstrak

Kemendikburistek telah menerbitkan kebijakan terbaru terkait Kurikulum Merdeka. Kurikulum Merdeka berusaha untuk menjawab isu-isu yang dihadapi pendidikan dalam konteks revolusi industri 4.0 yang mana dalam perwujudannya peserta didik memerlukan keterampilan berpikir kritis. Namun dilihat dari data statistik PISA, nyatanya keterampilan berpikir kritis yang dimiliki peserta didik masih cenderung rendah. Oleh karena itu diperlukan sebuah inovasi bahan ajar dan model pembelajaran yang tepat. Penelitian ini bertujuan untuk mengembangkan E-LKPD berbasis Project Based Learning (PjBL) untuk melatih keterampilan berpikir kritis yang valid, praktis, dan efektif. Sasaran uji coba terbatas adalah 20 peserta didik kelas X SMA Negeri 1 Taman, Sidoarjo. Hasil penelitian menunjukkan validitas E-LKPD memperoleh nilai rata-rata persentase validitas keseluruhan sebesar 98,81% dengan kategori sangat valid. Kepraktisan E-LKPD ditinjau dua hal yaitu hasil observasi keterlaksanaan E-LKPD yang memperoleh rata-rata persentase sebesar 95% dengan kategori sangat praktis dan hasil angket respon yang memperoleh rata-rata persentase sebesar 97% dengan kategori sangat praktis. Efektifitas E-LKPD ditinjau berdasarkan skor hasil belajar. Data yang didapat merupakan hasil pengerjaan soal pre-test dan post-test yang memperoleh persentase ketuntasan sebesar 100% dan mendapat skor N-gain sebesar 0,79 dengan kategori sangat efektif.

Kata kunci: *Pendidikan Menengah, LKPD Elektronik, Project Based Learning, Bioteknologi, Keterampilan Berpikis, Kritis.*

INTRODUCTION

The latest policy of the Merdeka Curriculum has been published by the Ministry of Education, Culture, Research and Technology (Kemendikburistek) as an option for educational institutions to rebuild learning between 2022 and 2024 after the COVID-19 pandemic. The Merdeka Curriculum aims to address difficulties related to education in the context of the 4.0 Industrial Revolution, where it is recognized that students require the ability to think critically, solve problems creatively and innovatively, work effectively, and communicate effectively (Risdianto, 2019). This goal aligns with the skills needed by 21st-century learners, namely critical thinking skills, solutive, creativity, and innovation (Permendikbud, 2016). Critical thinking skills are 21st-century competencies that are very important in the lives of learners (Rizal, 2017). Implementing the Merdeka Curriculum can lead to a more engaging and practical learning experience for students, preparing them for the challenges of the 21st century.

Assessment (PISA), Indonesia has fallen in rank over the last 10 years. 2009, 2012, 2015, and 2018, the country was ranked 501, 501, 493, and 498 in consecutive years (OECD, 2019). The statistical data shows that critical thinking abilities among Indonesian students are still comparatively low (Sa'adah, 2020). According to Facione (2013), The five indications of critical thinking abilities are interpretation, analysis, explanation, inference, and evaluation. The acquisition of 21st-century skills shifts from the instructor to the student centre (Sari et al., 2022). This assertion is consistent with Prasetyo's (2021) assertion that learner-centred learning activities can be used to train critical thinking abilities. These views suggest that the selection of learning models should focus on refining students' capabilities, particularly their critical thinking abilities. The Project Based Learning (PjBL) model is the suitable one.

Projects and activities are the basis of the learning process in the PjBL model (Kemendikbud, 2015: 4). The PjBL model can help students meet the needs of 21st-century skills (Riyadi & Rahayu, 2017) and can support students in training critical thinking skills (Ratnasari et al., 2014). Baidowi et al. (2016) stated that the PjBL model has advantages, including helping to organize the process of creating a result, educating a sense of responsibility in managing information, and producing a product. According to research by Hamidah and Citra (2021), the PjBL model was effective and succeeded in growing students' learning outcomes and interests. In addition, the results of Pratiwi and Setyaningsih's research (2020) stated that the PjBL model was more able to train and display critical thinking skills than other learning models. The steps of the PjBL model, according to Lestari et al. (2016), include (1) Start with the essential question, (2) project planning, (3) project schedule planning, (4) monitoring project progress, (5) assessing project results, and (6) evaluating the experience.

In addition to selecting learning models, the determinant of academic performance success is the accuracy and suitability in the application of teaching materials and learning media (Nurhayati, 2020). Therefore, an innovative teaching material is needed to facilitate the learning process optimally. Student Worksheets are one of several teaching materials that can support the learning process and train students' critical thinking skills. However, most schools still apply general student worksheets, which only contain a summary of the material and are less meaningful, causing students to be less motivated. Non-electronic-based student worksheets still have many areas for improvement. One weakness that can be a barrier to learning motivation and the development of various student skills is the low interaction in the worksheet (Elfina & Ike, 2020). Developing innovative teaching materials to achieve student competence in the learning process is necessary. According to Anggraini (2022), the percentage of smartphone and laptop usage is relatively high. One alternative innovation to make teaching materials that are by 21st-century learning is to make electronic-based worksheets. Electronic-based student worksheets include an attractive appearance, practical use, and a variety of multimedia components that can be used to fulfil and complete learner competencies in the learning process.

Suitability is needed in selecting and applying teaching materials and learning models to achieve the competencies of the Merdeka Curriculum. One of the materials in the field of science that is suitable for training students' critical thinking skills by utilizing the project learning model is Biotechnology. Biotechnology is science learning that directly involves students with real life and the surrounding environment. Therefore, learning with Biotechnology material can optimally train critical thinking skills by teaching students to solve problems through real experiences during the learning process.

In the 2013 curriculum, Basic Competency (KD) 3.10 and Basic Competency (KD) 4.10 of Biotechnology material guide students in applying the knowledge gained and producing a product using the concept of

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Biotechnology material (Permendikbud, 2016). Basic Competency (KD) and Basic Competency (KD) are consistent with the Learning Outcomes (CP) and The Learning Objective Flow (ATP) of Merdeka Curriculum in Biotechnology content. Students are expected to be able to produce a Biotechnology product. In implementing the project, students will be taught about research methods using biotechnology material. Based on this description, innovative teaching materials are needed to provide innovations in developing an E-Worksheet based on the Project Based Learning (PjBL) model, which aims to train critical thinking skills in biotechnology material.

METHOD

This type of research was development research. Researchers will develop E-Worksheets based on the Project Based Learning (PjBL) model to train critical thinking skills on biotechnology material that are feasible based on various validity, practicality, and effectivity criteria. This research uses the 4-D (define, design, develop and disseminate) development model.

The research was conducted from February to June 2023. The development stage was conducted from February to April 2023. Validators carried out the validation stage from May to June 2023. The trial phase to test the practicality and effectivity was conducted in June 2023. The research was conducted at SMA Negeri 1 Taman, Sidoarjo and involved the 20 students of 10th grade.

Descriptive and quantitative analysis of the E-Worksheet validation data was conducted by averaging the scores provided by the three validators. Three validators carried out the validation stage: two expert lecturers from the UNESA Biology Department and one high school Biology teacher. Data obtained from validators were scores from each predetermined criterion (Table 1).

Table 1. Likert Scale

Score	Category
1	Less Good
2	Moderately Good
3	Good
4	Very Good

(Adopted From Riduwan, 2013)

The average E-Worksheet validation calculation results are then interpreted according to the validity interpretation criteria (Table 2).

Table 2. Validity Interpretation Criteria

Percentage Range (%)	Category
$P \leqslant 55.91$	Not Valid
$55.91 < P \leqslant 63.79$	Less Valid
$63.79 < P \leqslant 71.67$	Moderately Valid
$71.67 < P \leqslant 79.55$	Valid
$P > 79.55$	Very Valid

(Adopted From Muhtar, 2021)

Based on the validity assessment category, the E-Worksheet was declared valid if the average value obtained was $\geq 71.67\%$ with a minimum valid category.

Observers carry out the observation stage of students using the E-Worksheet in accordance with the activity criteria listed in the E-Worksheet. The data obtained from the observer are scores from each activity criterion in the E-Worksheet that have been determined (Table 3).

Table 3. Likert Scale

Score	Category
1	Yes
0	No

(Adopted From Riduwan, 2012)

The results of the observers' scores are then analyzed to determine the E-Worksheet's practicality. The calculation of the percentage of practicality obtained is then interpreted in accordance with the observation interpretation criteria table (Table 4).

Table 4. Observation Interpretation Criteria

Percentage Range (%)	Category
$P \leqslant 55.91$	Not Practical
$55.91 < P \leqslant 63.79$	Less Practical
$63.79 < P \leqslant 71.67$	Moderatory Practical
$71.67 < P \leqslant 79.55$	Practical
$P > 79.55$	Very Practical

(Adopted From Muhtar, 2021)

Based on the criteria for assessing the students' activities by the observer, the E- Worksheet was declared valid if an average value obtained is $\geq 71.67\%$ with a minimum practical category.

The results of the student responses questionnaire were analyzed using a quantitative descriptive method. The response questionnaire sheet prepared by the researcher refers to the Likert Scale (Table 3). The analysis of student responses data was then calculated in percentages for each aspect of the assessment. The student responses interpretation criteria table then interprets the results of the percentage calculation to determine the level of practicality of the E- Worksheet (Table 5).

Table 5. Student Responses Interpretation Criteria

Percentage Range (%)	Category
$P \leqslant 55.91$	Not Practical
$55.91 < P \leqslant 63.79$	Less Practical
$63.79 < P \leqslant 71.67$	Moderatory Practical
$71.67 < P \leqslant 79.55$	Practical
$P > 79.55$	Very Practical

(Adopted From Muhtar, 2021)

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Based on the student response criteria, the E- Worksheet was declared valid if an average value obtained is ≥71.67% with a minimum practical category.

Effectivity was calculated based on students' cognitive learning outcomes. The data was obtained by working on pre-test and post-test questions. Learning outcomes are declared complete if they reach the MCC ≥75. The scores from the pre-test and post-test were then analyzed using the N-gain score method. The N-gain score results are then interpreted by the N-gain score criteria table (Table 6).

Table 6. Gain Score Criteria

N-gain	Category
g > 0.7	High
0.7 < g > 0.3	Medium
g < 0.3	Low

(Adopted From Fibriyanti, 2012)

Based on the gain-score criteria, the E- Worksheet was declared valid if an average value obtained a gain-score ≥0.31 with a minimum medium category.

RESULT AND DISCUSSION

The result of this development research is the final product of E-Worksheet based on Project Based Learning (PjBL) to train student's critical thinking skills on Biotechnology topic of 10th grade in senior high school. The final product of E-Worksheet must have eligibility standards, which include validity, practicality, and effectivity.

Validity of Student E-Worksheet

The validity of E-Worksheet was reviewed based on the validity score by three validators. The following is a recapitulation of data from the E-Worksheet validation results in Table 7.

Table 7. Validity Result of E-Worksheet

Aspects Assessed	Average Validity Value (%)	Category
Systematics Presentation	96.67%	Very Valid
Content	98.61	Very Valid
Suitability of PjBL Model Stages	100%	Very Valid
Achievement of Critical Thinking Skills Aspects	98.81%	Very Valid
Linguistics	100%	Very Valid
Average	98.82%	Very Valid

Based on the results of the validity test that has been carried out, the recapitulation results are presented in Table 7. The table shows that the percentage value of presentation validity is 96.67%, content validity is 98.61%, the validity of the suitability of the stages of the PjBL model is 100%, the validity of the achievement of critical thinking aspects is 98.81%, and the validity of

language is 100%. The five percentage values in each aspect of the validity assessment were categorized as very valid. Based on these results, the average percentage value of overall validity was 98.81% and included in the very valid category. Several suggestions from validators related to changing the E-Worksheet cover, including changing the cover design to describe the topic of Biotechnology material better and changing the composition of layout elements (title, logo, author, and illustrations) to make it more appropriate. The statement of Fadli et al. (2017) explains that good and effective media development is media whose use of letters is manageable so that the writing can be read well.

The validator's advice to improve typography is crucial for the E-Worksheet's readability and user-friendliness. This advice aligns with the findings of Christi, C.D.Y., and Lestari, N.A. (2019), which emphasize the importance of clear, concise language in enhancing understanding. The validator also suggested incorporating additional features to guide students in drawing accurate conclusions. This strategy aligns with Irawan's (2017) view that a well-crafted conclusion is essential for presenting relevant, logical, and reasonable outcomes.

Practicality of Student E-Worksheet

The practicality of the E-Worksheet was based on the results of observations of its implementation and student response questionnaires. The practicality of the E-Worksheet was reviewed based on the results of observations of its implementation by observers. Observers were tasked with observing the activities of students in each group working on the E-Worksheet. The following is a recapitulation of the data from the observation of the E-Worksheet implementation presented in Table 8.

Table 8. Result of Observations on the implementation of E-Worksheet

No	Aspects Assessed	Implementation (%)
1.	Students can read and understand the general instructions listed in the E-Worksheet.	100
2.	Students can read and understand the features listed in the the E-Worksheet.	100
3.	Students can read and understand the learning outcomes, indicators, and objectives listed in the the E-Worksheet.	100
No	Aspects Assessed	Implementation (%)
4.	Students can analyze problems in the surrounding environment after reading an article.	90
5.	Students can analyze problems in	90

	the surrounding environment after observing videos.	
6.	After reviewing articles and observing videos, students are able to generate ideas/hypotheses to solve problems in the surrounding environment.	90
7.	Students can design a project to make conventional biotechnology products.	100
8.	Students can design a project to make conventional biotechnology products using the scientific method.	95
9.	Students can design a project activity schedule according to the predetermined time.	100
10.	Students can carry out the project activity process according to the design that has been made.	90
11.	Students can collect data by testing product results (organoleptic test).	90
12.	According to the literature review, students can analyze the results of product data (organoleptic test).	90
13.	Students can make conclusions and associate data results to answer problem formulations.	90
14.	Students can make a simple report with a predetermined format.	100
15.	Students can evaluate the results of project work by answering the questions provided.	100
	Average	95

The average percentage of E-worksheet implementation that 20 students have carried out is 95% and categorized as very practical. Based on these results, the six aspects of E-Worksheet implementation have the lowest percentage of 90%. One aspect also gets a percentage of 95%. Then, seven aspects of E-Worksheet implementation get the highest percentage of 100%.

The practicality of E-Worksheet is also reviewed based on the student response score. The following is a recapitulation of the data from the questionnaire results of students' responses to E-Worksheet presented in Table 9.

Table 9. Result of Student Responses on the implementation of E-Worksheet

No	Aspects Assessed	Responses (%)	
1.	The title of the E-Worksheet is written in clear and easy-to-understand sentences.	100	0
2.	Articles contained in the E-Worksheet can be accessed clearly and easily.	100	0
3.	Videos contained in E-Worksheet can be accessed clearly and easily.	95	5
4.	Images contained in E-Worksheet can be seen clearly and easily.	100	0
5.	Biotechnology material on E-Worksheet is written in clear and easy-to-understand sentences.	100	0
6.	Biotechnology material on E-Worksheet is related to daily life.	90	10

No	Aspects Assessed	Responses (%)	
7.	The features contained in the E-Worksheet are interesting.	95	5
8.	The features contained in the E-Worksheet can help students in working on projects.	90	10
9.	The questions contained in each feature are written in clear and easy-to-understand sentences.	100	0
10.	Google Forms and Google Sheets can be accessed easily on each feature.	95	5
11.	E-Worksheet can attract students' interest in learning Biotechnology material.	100	0
12.	E-Worksheet can support the implementation of learner-centered learning.	100	0
13.	E-Worksheet can help students develop critical thinking skills.	95	5
14.	The appearance of the E-Worksheet is attractive.	95	5
15.	The letters used in the E Worksheet are legible and comfortable to read.	100	0
No	Aspects Assessed	Responses (%)	
	Average	97	3

The average percentage of students' responses to the E- Worksheet developed is 97% and categorized as very practical. Based on these results, it is shown that the two questions have the lowest percentage of 90%. Then, five questions have a rate of 95% and eight questions have the highest percentage of 100%. This learning model builds, spurs, and evokes the participation process and the process of finding experiences that are different from before. So that students are expected to be able to reflect on these experiences critically and actively. Active in learning here does not mean that students only dare to express an opinion, question, and solution. However, students also have a basis for the questions, opinions, and solutions submitted. This ability is then called critical thinking skills (Azizah et al., 2018).

Effectivity of Student E-Worksheet

The effectivity of E-Worksheet was based on the score of students' cognitive learning outcomes. Questions from both the Pre-Test and Post-Test were used to measure the cognitive learning results of the students. After completing learning activities utilizing E-Worksheet, students complete five multiple-choice questions and five description questions to gauge how complete their learning outcomes were, as well as how complete each indicator of critical thinking skills was. The following is a recapitulation of student learning outcomes data based on Pre-test and Post-test scores in Table 10.

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Table 10. Recapitulation of Student Learning Outcomes Based on Pre-Test and Post-Test Values.

Students	Pre-Test	Post-Test	N-Gain	Category
1	56.67	93.34	0.85	High
2	36.67	83.34	0.74	High
3	33.34	86.67	0.80	High
4	46.67	90	0.81	High
5	46.67	86.67	0.75	High
6	46.67	86.67	0.75	High
7	46.67	93.34	0.88	High
8	60	93.34	0.83	High
9	43.34	86.67	0.76	High
10	56.67	96.67	0.92	High
11	36.67	76.67	0.63	Medium
12	50	93.34	0.87	High
13	36.67	93.34	0.89	High
14	36.67	86.67	0.79	High
15	53.34	90	0.79	High
16	30	76.67	0.67	Medium
Students	Pre-Test	Post-Test	N-Gain	Category
17	36.67	83.34	0.74	High
18	30	83.34	0.76	High
19	43.34	86.67	0.76	High
20	43.34	90	0.82	High
Average	43.50	87.84	0.79	High

Table 10 summarizes student learning outcomes consisting of Pre-test and Post-test scores. The pre-test results show that 100% of the 20 SMA Negeri 1 Taman, Sidoarjo students experienced learning disabilities, with an average score of 43.50. This is because the value achieved does not meet the predetermined MCC ≥75. The highest score achieved by students in the Pre-test was 56.67, while the lowest score achieved by students in the Pre-test was 30. After determining students' initial knowledge obtained from the pre-test score, learning biotechnology material was carried out by applying the developed E-Worksheet.

Then, after learning about Biotechnology using an E-Worksheet, students will be asked to take further tests to get the post-test value. Based on the results of the post-test, it was shown that 100% of students were declared complete with an average Post-test score of 87.84. the maximum score that students received on the post-test was 96.67, and the lowest score that they received was 76.67. After acquiring the pre-test and post-test values representing student learning outcomes, the N-gain score will be calculated and analysed. N-gain analysis aims to ascertain how much student learning outcomes have increased. Table 10 demonstrates that, with an average N-gain score of 0.79, 100% of students saw improved learning outcomes. The "High" category is obtained by applying the N-gain score criteria table to the average N-gain score values.

This result is in line with Mudjiono (2009), who states that each learner has different initial abilities, and each learning activity will be attempted so that each learner can complete and achieve learning indicators by the predetermined Minimum Completeness Criteria (MCC). In addition, applying the E-Worksheet-based PjBL model in science learning can also facilitate and provide for students from all kinds of abilities and backgrounds (Hilkka et al., 2013).

There are five critical thinking indicators in learning by applying E-Worksheet. The following is a recapitulation of data on the completeness of each indicator based on the pre-test and post-test scores presented in Table 11.

Table 11: Recapitulation of Completeness of Each Critical Thinking Indicator Based on Pre-Test and Post-Test Values

Indicators of Critical Thinking Skill	Pre-Test	Post-Test	N-Gain	Category
Interpretation	45	90.84	0.83	High
Analysis	60	89.17	0.73	High
Inference	35	87.5	0.81	High
Explanation	31.67	80	0.71	High
Evaluation	45.84	91.67	0.85	High
Average	43.50	87.84	0.79	High

Table 11 summarizes the completeness of each indicator of students' critical thinking based on pre-test and post-test scores. The average result of the completeness of each critical thinking indicator on the pre-test score is 43.50%, with the lowest percentage found in the explanation indicator at 31.67% and the highest percentage found in the analysis indicator at 60%. The average result of the completeness of each critical thinking indicator on the post-test score is 87.84%, with the lowest percentage found in the explanation indicator at 80% and the highest in the evaluation indicator at 91.67%.

Based on the percentage of each indicator, the calculation and analysis of the N-gain score are then carried out. N-gain analysis aims to determine the magnitude of the increase in each indicator of students' critical thinking. The average N-gain score is 0.79, with the category "High." Learning completeness is influenced by the development of the E-Worksheet. This result is because this learning model provides practice in abstract and absolute terms. During learning, students are expected to find a problem, analyze it, share responses, and share a solution aligned with each indicator of critical thinking skills (Natty et al., 2019).

CLOSING

Conclusion

E-Worksheet based on Project Based Learning (PjBL) model for teaching critical thinking skills on biotechnology material generated creates an E-Worksheet that is practicable based on validity, practicality, and effectivity, according to the results of data analysis and research debate. The validity of the E-Worksheet was obtained with an average percentage of overall validity of 98.81% with a very valid category. The practicality of E-Worksheet based on the results of observations of E-Worksheet implementation was obtained an average percentage of 95% and categorized as very practical and practicality based on the results of student response questionnaires, which was obtained an average percentage of 97% and categorized as very practical. The effectivity of the E-Worksheet based on the cognitive learning outcomes score was obtained with an average percentage of 100% completeness with an average N-gain score of 0.79 with a very effective category. The effectivity of the E-Worksheet was also reviewed based on the completion score of each indicator of students' critical thinking, namely obtaining an average value on the Pre-Test value of 43.50%, with the lowest percentage found in the explanation indicator and the highest percentage found in the analysis indicator. The Post-Test value is 87.84%, with the lowest percentage found in the explanation indicator and the highest in the evaluation indicator. The average N-gain score is 0.79, with a very effective category.

Suggestion

The research should be conducted with a greater capacity. According to the research results, it should be more carefully planned in terms of the allocation of time, resources, and materials as learning media. Also, comparable studies on additional educational resources need to be conducted to provide students with ongoing instruction in critical thinking.

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