

Fostering critical thinking: Designing problem-based learning student worksheet on environmental change topic

Nurul Fadilah^{a,1,*}, S. Suhartini^{b,2}, Suyitno Aloysius^{b,3}

^a Biology Education Masters Program, Faculty of Mathematics and Natural Science, Univeritas Negeri Yogyakarta, Jl. Colombo Yogyakarta No 1, Karangmalang, Catur tunggal, Sleman, Yogyakarta 55281, Indonesia

^b Department of Biology Education, Faculty of Teacher Training and Education, Univeritas Negeri Yogyakarta, Jl. Colombo Yogyakarta No 1, Karangmalang, Catur tunggal, Sleman, Yogyakarta 55281, Indonesia

¹ nurulfadilah.2023@student.uny.ac.id*; ² suhartini@uny.ac.id; ³ suyitno_al@uny.ac.id

***For correspondence:**

nurulfadilah.2023@student.uny.ac.id

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Abstract: The growing awareness of the increasingly complex environmental changes requires an educational approach that fosters critical thinking. Through the implementation of PBL, students will gain a deeper understanding and develop an attitude of environmental care, particularly towards their surroundings. This study aims to evaluate the effectiveness of PBL-based student worksheets on environmental change material to train critical thinking skills based on the completeness of learning outcomes and student responses. This research employs the 4D model of development, encompassing the stages of defining, designing, developing, and disseminating. Nonetheless, this study is confined to the third stage of development. The validation used includes material validation media validation. The data at the development stage is sourced from expert validators and subsequently analyzed using the descriptive analysis method. The validation results affirm that the developed worksheet is deemed suitable for implementation. Therefore, it is highly recommended to implement the learning process using this worksheet. Its utilization can significantly contribute to fostering student competency levels. Furthermore, disseminating its benefits widely would further amplify its positive impact across various educational settings.

Keywords: critical thinking; PBL; student worksheet

Introduction

Environmental changes have a significant impact on various aspects of life (Litovchenko et al., 2018), from humanitarian aspects to the economic (Hsiang et al., 2017) and health sectors (Eckelman & Sherman, 2016). The complexity of environmental issues leads to increased urbanization, decreased natural resources, and increased pollution and deforestation (Sola, 2014). In line with that, technological developments also increase e-waste, thereby exacerbating the environmental damage that is occurring (Shrivastri & Choudhary, 2022). Responding to these conditions, environmental education plays an important role in increasing students' awareness so that they are responsible and able to avoid the global environmental crisis (Litovchenko et al., 2018; Sola, 2014). By campaigning for environmental awareness and sustainable practices, students and the community can work together to mitigate the negative impacts of environmental change so as to create a healthier living environment for everyone (Heide & Moser, 2013; Karataş, 2013).

Education that promotes critical thinking is essential in addressing complex environmental challenges because of the need for informed decision making and active engagement in environmental issues (Kavanagh et al., 2021; Mujiningtyas et al., 2023). Critical thinking skills enable someone to be able to analyze various complex problems, evaluate problems from various perspectives, and make decisions

based on a logical basis (Chakra, 2016; Scott, 2015; Wall, 2015), including environmental problems. By integrating critical environmental education into the curriculum, students can develop a deep understanding of environmental issues, facilitate them in meaningful environmental learning, and increase their opportunities to contribute to creating a sustainable environment (Kopnina, 2015; Sobari et al., 2022). Learning in this manner will nurture a generation of global citizens who are environmentally conscious and proactive.

In line with empowering critical thinking skills, the problem-based learning model is able to provide significant relevance in increasing students' understanding of environmental issues (Llach & Bastida, 2023). Previous research shows that the application of PBL has a positive impact on students' environmental literacy (Febriasari & Supriatna, 2017; Suryawati et al., 2020; Wajdi et al., 2022). This learning model not only improves thinking skills (Magsino, 2014; Sada et al., 2016) but also empowers students' positive attitudes towards environmental issues (Dewi & Novianti, 2023) and leads to increased awareness and responsible behavior for the environment (Fettahlıođlu & Aydođdu, 2020). PBL is also in line with the interdisciplinary nature of addressing environmental challenges (Li et al., 2022), emphasizing practical application and sustainable development.

To enhance the effectiveness of PBL implementation, it is essential to have teaching materials in the form of student worksheets. The student serves as one of the learning tools utilized as a resource for students to conduct investigative or practical activities, either individually or in groups, based on the subject matter being studied. These sheets typically include a summary of the material, practice questions, and step-by-step instructions to guide students in completing tasks, serving as supplementary learning materials alongside textbooks.

Research on the development of PBL-based student worksheets has been conducted several times (Puspasari & Puspasari, 2019; Tussholeha et al., 2023). Studies examining the influence of PBL on students' environmental competence (Febriasari & Supriatna, 2017; Suryawati et al., 2020; Wajdi et al., 2022) and attitudes (Kuvac & Koc, 2018; Ural & Dadli, 2020) have also been reported several times. However, research aimed at developing student worksheets using the PBL model for environmental topics to enhance students' critical thinking skills in addressing environmental issues remains challenging. Therefore, the objective of this study is to develop and validate student worksheets through the PBL model for environmental change topics that can empower their critical thinking skills.

Method

In this study, the 4-D student worksheet development model was utilized. This model comprises several stages: defining, planning, developing, and disseminating (Thiagarajan et al., 1974). However, this study focused solely on the development stage and did not proceed to the dissemination stage. This decision stemmed from the fact that the tools developed were not utilized by other educational stakeholders in learning activities. Consequently, this developmental research was confined to the 3D stage. Thus, this research entails developmental research and employs the validation method as a data collection approach, without conducting trial treatments.

Several actions were undertaken during the defining stage, including curriculum analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. In the second stage (planning stage), a test was made, and decisions were made regarding the format of the student worksheets. An initial draft of the student worksheets was created, which underwent a review process incorporating feedback from the initial draft. During the development stage, revisions were made to the initial and subsequent drafts, which were then validated by two validators: biology lecturers, media experts, and material experts. The validation results were utilized to refine the worksheets further, resulting in the creation of draft III student worksheets. The development research focused on the feasibility of PBL-based environmental student worksheets in terms of construction, technical aspects, and didactic suitability. The validity of the student worksheets was assessed using a validation sheet completed by two validators, namely two media expert lectures and material experts. Data collected during the validation process were used to calculate a feasibility score, indicating the validity of the worksheets. The analysis of worksheet validity involved scoring each criterion according to the validation results obtained from the validators, as shown in Table 1.

Table 1. Likert scale criteria (Riduwan, 2013)

Score	Assessment
4	Very good
3	Good
2	Good enough
1	Not good

The percentage of validity of each component of the student worksheet assessed by each validator is

calculated using formula (1). Furthermore, the validity score interpretation criteria listed in Table 2 are used to interpret the percentage results of each requirement on the worksheets student's component. Students' worksheet will be declared feasible when the average value of money obtained from the validation of worksheet student reaches a value above or equal $\geq 70\%$

$$\text{Percentage (\%)} = \frac{\text{Total Score}}{\text{Maximum number score}} \times 100\% \quad (1)$$

Table 2. Criteria for interpreting the validity score of student worksheet on PBL (Riduwan, 2013)

Score	Assessment
87-100	Very valid
70-86,9	Valid
55-69,9	Valid enough
40-54,9	Less valid
25-39,9	Not valid

Results and Discussion

The first phase in developing a student worksheet, namely the definition stage, involves several steps. The initial stage is an analysis of teacher and student needs, where the results of the teacher need analysis are used to create innovation in the learning process, especially in the form of learning media. Based on this stage, it is necessary to develop student worksheets by adapting PBL syntax. The definition stage is carried out by adapting and analyzing the curriculum which includes Core Competencies and Basic Competencies as well as indicators on student worksheets which are prepared in accordance with the applicable curriculum provisions. The Basic Competencies chosen in this research are Basic Competencies 3.11 and 4.11 so that the topic of environmental change was chosen as main topic in the worksheet.

At the planning stage, teaching materials are selected, goal formulation is carried out, and format selection is carried out as preparation for the initial plan. Based on the analysis at the planning stage, a digital-based student worksheet using the Flipbook model is planned to be designed. This student worksheet was created using the Canva application, which will then be changed and modified in PDF format and then changed again using the help of the Heyzine application to make the student worksheet appear like a virtual book. This worksheet can be accessed using the internet via a smartphone or laptop. Another uniqueness of this worksheet is supported by the presence of images and QR codes which will load the next video and link to the YouTube page as support for understanding environmental change material.

Next, achievement indicators will be formulated in basic competency 3.11, namely analyzing data on environmental changes, their causes, and their impact on life, as well as in basic competency 4.11, namely formulating ideas to solve the problem of changes in the surrounding environment. Creating a student worksheet involves choosing a format that consists of three main parts: the beginning, the content, and the end. The initial part includes the cover, book identity, instructions for use, basic competencies, indicators and learning objectives. The content section contains material and images related to the topic of environmental change as well as problem-based learning steps. At the end of the book there is a final assignment that will be given to students. The next step is to create a product design using the Canva application, followed by the final step, namely creating an expert assessment instrument for validator data.

In accordance with applicable regulations in the application and development of worksheets students, it includes an introduction, instructions for using worksheets students, concept maps, learning outcomes (or *tujuan pembelajaran* in Bahasa Indonesia), learning objectives framework (or *alur tujuan pembelajaran* in Bahasa Indonesia) and the presence of process skills, then the content of the material, student assignments, and a cover that contains a bibliography.

At the development stage, student worksheets are validated by experts and revised. At the development stage, several steps were taken, namely the stage of creating a worksheet using the Canva application which was then converted into PDF format and using the Heyzine application. The uniqueness of the worksheets that developed in this research lies in their FlipBook model, which aims to replicate the feeling of turning pages in a physical book. The worksheets is made using the Canva application, will then be converted and converted into PDF format and then will be converted again using the help of the Heyzine application to make the worksheets look like a virtual book. Accessible via internet connection using smartphones or laptops, these interactive worksheets include visuals and QR codes that link to additional videos on environmental change. Table 3 presents the display and features found on the students' worksheet.

Next, the feasibility test stage was carried out by 2 experts, namely a media expert and a material expert.

In the student worksheet developed in this research, a validity assessment was conducted to determine the feasibility of the material and the effectiveness of the worksheets. The assessment utilized validation from media and material experts. The assessment used is validation from media in [Table 4](#) and material experts are presented in [Table 5](#). Judging from the feasibility aspect of validation by media experts, the total percentage in the display aspect is 91.3% and in the implementation aspect it reaches 97%. The validation results indicate an average feasibility score of 84% for content, 85% for language aspects, and 85% for presentation aspects. Hence, the development of worksheets, aimed at enhancing critical thinking skills regarding environmental change material, can be deemed feasible. All aspects achieved scores above seventy percent, demonstrating their validity.

Table 3. Display and features on the students' worksheet

No	Display and Features	Description
1		<p>Main cover The main cover of the worksheets students contains the title, phase, author's name, images related to environmental change material, and student identity form.</p>
2		<p>Second Page The second page contains instructions for using the worksheets for students and a concept map to provide direction and imagery related to the material to be studied in the worksheets students.</p>
3		<p>Third Page The third page contains Learning Outcomes, ATP, and Process Skills following the independent curriculum.</p>
4		<p>Material Page On the page containing the material, there are learning objectives and content of the material as well as images that support the material to make students understand better with the help of visual images.</p>
5		<p>Assignment Sheet Page On the assignment sheet there are questions related to the material, discussion results column, QR code for additional material, and student identity column.</p>

The resulting product in this research is a problem-based learning worksheet for students, that is proven to be able to train critical thinking in students in environmental change topic. Starting with discussions on environmental pollution material, the worksheet progresses to exploring the various factors contributing to environmental change and strategies for addressing these challenges, especially in coastal areas. The produced student worksheets have been structured to adhere to the PBL syntax, which applies several links to skills in critical thinking of students.

Table 4. Media validation results on students' worksheets

No	Assessed aspect	Assesment point	Percentage
Display aspect			
1	Appropriateness of image layout	4	87%
2	Appropriateness of Background selection	4	87%
3	Appropriateness of Color Proportion	3	82%
4	Appropriateness of Font Selection	3	80%
5	Appropriateness in the use of font size	4	87%
6	Accuracy of image size	4	87%
7	Clarity of Writing Order in learning media	3	80%
8	Image display quality	3	78%
9	Image clarity	3	78%
10	The suitability of the images presented with the content of the material discussed	3	80%
Average Feasibility of Display Aspects			91,3%
Implementability Aspect			
11	Ease of use of learning media	3	78%
12	Ease of accessing learning media	4	80%
13	Clarity of the flow displayed on the learning media	4	80%
14	Ease of using teaching media	4	87%
15	Suitability of learning media with the target use	3	80%
16	Safety of media use (display with health)	3	80%
Average Feasibility of Implementation Aspect			97%

Table 5. Material validation on students' worksheet

No	Aspects to be assessed	Assessment Point	Percentage
Content Feasibility Aspect			
1	Suitability of material with basic competencies	3	78%
2	Suitability of material with basic competencies	3	78%
3	Clarity of work instructions during the learning process using learning media	4	87%
4	Ease of understanding the material	4	87%
5	The conciseness in the presentation of the material	4	87%
6	Ease of understanding the images provided	4	87%
7	Ease of understanding the questions	4	87%
8	Suitability of exercise questions with material	4	87%
Average Content Appropriateness			84%
Language Aspect			
9	Correct use of PUEBI	3	79%
10	Sentences used are easy to understand	4	87%
11	Sentences used are in accordance with the age development of learners	4	87%
12	There are no sentences using double meaning terms	4	87%
Average Language			85%
Aspect Presentation Aspect			
13	Logical presentation of material	3	79%
14	Presentation of concept sequence	4	87%
15	Presentation of material equipped with pictures	4	87%
16	Presentation of material can attract the attention of students	4	87%
17	Presentation of learning media can guide students in exploring information independently	4	87%
Average Feasibility of Presentation Aspects			85%

The topic of environmental change was chosen in the development of the worksheet in this research because of its important relevance in the current global context. The phenomena of climate change (Selby & Hoffmann, 2014; Urry, 2015), environmental damage (Al-Mulali & Ozturk, 2015) and sustainability are crucial issues that affect human life and the ecosystem at large. Overcoming problems related to environmental change requires a deep understanding and critical thinking skills of society, especially the younger generation who will become future leaders (Kavanagh et al., 2021; Kopnina, 2015; Mujiningtyas et al., 2023; Sobari et al., 2022). Therefore, choosing the topic of environmental change provides an opportunity to equip students with the knowledge, skills and attitudes needed to later be involved in overcoming this problem.

The use of PBL-based student worksheets is an approach that can significantly improve students' critical thinking skills regarding environmental change. This statement is in line with several previous studies that report the influence of PBL on improving students' critical thinking skills (Birgili, 2015; Hussin et al., 2018; Kong et al., 2014). By considering a learning process that emphasizes problem solving and reflection, students are not only prepared to understand environmental issues, but also to develop in-depth analytical skills. In addition, this approach encourages active involvement of students in solving complex problems (Galvao et al., 2014; Yew & Goh, 2016). This learning experience allows them to broaden their perspectives and develop creative solutions to the environmental challenges they face.

In addition, the PBL model has also proven effective in facilitating student-centered and problem-oriented learning (Ali, 2019). By encouraging discussion and collaboration in solving problems, PBL-based student worksheets help create a dynamic and engaging learning environment (Prosser & Sze, 2014; Qin et al., 2016). Through this process, students not only develop a deeper understanding of environmental change, but also acquire the social and cognitive skills necessary to become responsible, critical thinking decision makers in environmental problems.

Since the researchers only focused on creating teaching materials, this research did not proceed to deliver or disseminate their work to others outside the research environment. As a result, the dissemination stage was not conducted. Therefore, further research that continues the stages carried out in this study needs to be conducted. The worksheets that have been developed need to be tested and applied in learning. Then, the effect of using this worksheet on students' critical thinking skills also needs to be measured. After that, important findings and best practices during the use of this worksheet in learning also need to be disseminated.

Conclusion

This research has developed a student worksheet by applying the PBL model syntax. This worksheet is designed to improve students' critical thinking skills when studying the topic of environmental change. The results of material and media validation inform that the worksheet developed is feasible and ready to be implemented in learning. Based on the results of the analysis in this research, the worksheet that has been developed can be continued as a worksheet in learning on the topic of environmental change. Measuring critical thinking skills after students take part in learning using this worksheet also needs to be done to confirm the benefits of the worksheet that has been developed. Dissemination of the implementation results also needs to be carried out so that the usefulness of the worksheets that have been developed can be spread more widely.

Conflicts of Interest

The highest appreciation to the campus of Universitas Negeri Yogyakarta (UNY) for facilitating this research through the institutional policy of the Directorate of Research and Development (DTI).

Author Contributions

N. Fadilah: Methodology; Writing – original draft, Writing – review and editing. Data analysis; Writing – review and editing. **S. Suhartini:** Writing – review and editing. **S. Aloysius:** Writing – review and editing

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