RESEARCH ARTICLE

Validity of project-based teaching module to empower students' environmental caring character

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Abstract: Environmental problems caused by waste and exploitation of natural resources can be exacerbated by a lack of awareness and concern for the environment. One of the contributing factors is the lack of utilization of learning resources and environmental-based media in education. This study aims to develop and validate a teaching module based on the PjBL (Project-based Learning) model to increase students' environmental awareness, especially on the topic of environmental change. By using the 4D Model, this study uses quantitative descriptive analysis involving validation by two experts. The validation values for learning plan, learning media, and students' worksheet were 3.48, 3.52, and 3.45, respectively. The results of the recapitulation of validity data show a total score of 3.48 with a valid category. It was concluded that teaching modules based on project to improve environmental character are worthy of being applied in Biology learning at school.

Keywords: environmental care character; environmental change; PjBL; teaching module

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Article history:
Received: 10 May 2024
Revised: 27 June 2024
Accepted: 30 June 2024
Published: 31 July 2024

10.22219/jpbi.v10i2.33527

p-ISSN: 2442-3750
e-ISSN: 2537-6204

How to cite:
Hartanto, W., Purnomo, T., & Yakub, P. (2024). Validity of project-based teaching module to empower students' environmental caring character. *JPBI (Journal Pendidikan Biologi Indonesia), 10*(2), 640-651. https://doi.org/10.22219/jpbi.v10i2.33527

Introduction

The environment is where humans carry out their life activities (Beyene, 2022, 2023). There are interrelated interactions between human activities and the environment (Galvani et al., 2016; Singh, 2024). The lack of human awareness and concern for waste and the exploitation of natural resources has led to various environmental problems. Likewise, the learning environment in schools involves interactions between school residents and environmental sustainability (Onat & Yirmibeşoğlu, 2022; Zbašnik-Senegačnik & Koprivec, 2023). In Indonesia, environmental learning is part of the Senior High School curriculum, particularly in Geography and Biology subjects. Environmental learning in high school covers various aspects, including waste management, natural resource management, climate change, renewable energy, nature conservation, and biodiversity. Students are also taught about the importance of maintaining and preserving the environment, as well as about ways to preserve the environment.

Santo Thomas Aquino Catholic High School is a school in Tulungagung Regency that won the title of Adiwiyata Mandiri School at the National Level in 2020. An Adiwiyata School is a school that cares for and has the character of loving the environment (Fazira & Ramadan, 2023; Kuswati et al., 2024; Syauqi et al., 2023; Zaliyanti & Azani, 2024). This connection with Adiwiyata is rooted in environmental care character education (Adawiah & Anggraini, 2023; Saadah et al., 2023; Sunarto, 2023), which aims to shape students' environmental awareness and preservation efforts for present and future generations. Some of the main aspects of the policy launched by the school are about sanitation and drainage cleanliness, waste management, tree and plant maintenance, water and energy conservation, and the application of Environmentally Friendly Behavior in the surrounding community.

Observations of students at Senior High Schools in Tulungagung show that the application of Biology concepts, as well as the knowledge and participation of school residents, do not fully reflect the title of Adiwiyata Independent School at the National Level. This is evidenced by 50% of students lack knowledge of Adiwiyata. Similarly, in biology lesson, only 25% of students have been given insight into

environmental care attitudes. While from the aspect of school community participation, about 50% of students are involved in environmental-based activities. Despite achieving a high score in the Green School and environmental cleanliness aspect, student participation remains low. Furthermore, environmental learning tools prepared by teachers have not effectively developed students' environmental behavior values. Available teaching materials are limited to books and worksheets, which often do not illustrate the necessary environmental behaviors to improve the environment. There are still few books that integrate environmental behavior. The limitations of available environmental-themed teaching materials that can facilitate changes in students' environmental behavior are thought to be the cause of environmental learning implemented through formal education in schools is less than optimal.

Environmental care character is an attitude that is shown by actions to protect the natural environment. The character of caring for the environment is an attitude of caring for the environment that is manifested in the willingness to express actions that can improve and maintain environmental quality in every behavior related to the environment. This attitude is shown by actions to repair environmental damage that occurs. This character can also make the continuity of nature maintained. The character of environmental care can reflect the concern and sensitivity of students to their environment. One of the efforts to overcome these environmental problems is through character building that starts at an early age. Some indicators of environmental care character are maintaining the cleanliness and beauty of the classroom and school environment, supporting go green programs in the school environment, using environmentally friendly recycled products, and sorting waste properly (Abu et al., 2023; Buana et al., 2023; Fauzani & Aminatun, 2021). Environmental care character education is a form of development of character values.

Fostering an attitude of environmental care can be packaged with scientific learning using PjBL model. PjBL is an innovative learning model that emphasizes contextual learning through complex activities (Guo et al., 2020; Markula & Aksela, 2022; Saad & Zainudin, 2022). In this model, teachers allow to direct learning in the classroom by involving project activities (Du & Han, 2016; Kokotsaki et al., 2016). Through project work learning, students' thinking skills (Song et al., 2024), creativity (Rais & Yahya, 2021), and motivation can increase (Quinapallo-Quintana & Baldeón-Zambrano, 2024). In PjBL, the nature of environmental awareness can be developed by giving tasks to students through discussions, experiments, simulations, and project activities (López & Palacios, 2024; Yolcu, 2023). The role of the project created will provide opportunities for students to foster certain character values (Dobson & Dobson, 2021; Sari et al., 2020). Some characteristics of PjBL that can help shape environmental care attitudes include being contextual, collaborative, authentic, innovative, and evaluative. These characteristics enable students to gain real insight and knowledge, fostering a sustainable environmental care character.

Based on the results of the analysis and observations that have been described, it is necessary to conduct in-depth research at Santo Thomas Aquino Tulungagung Catholic High School, which is a school with the title of national level independent Adiwiyata and an award winner as a school with an Environmental Care and Culture Movement in Schools in 2020. Research on module development using the PjBL model in environmental education has shown great potential in increasing environmental awareness and behavior in students. Various previous studies have highlighted the importance of contextual, innovative, and evaluative approaches in PjBL to achieve optimal learning outcomes (Abilova et al., 2024; Crawford et al., 2024). However, most studies still focus on the application of PjBL in general subjects without specification on environmental education. On the other hand, several other studies have developed modules for environmental education (Fradila et al., 2021; Ignatia et al., 2020). However, these studies did not use the PjBL model as the basis for their learning model. Therefore, the purpose of this research is to develop and validate a project-based teaching module that aligns with the formation of students' environmental care character, It is hoped that there will be changes in the behavior and awareness of students to form an environmentally friendly school environmental care character so that it can clearly reflect as a National Level Independent Adiwiyata School.

Method

This type of research uses the Research and Development method. This research design applies the 4D model (define, design, develop, and disseminate) developed by Thiagarajan et al. (1974). This research was conducted at the Postgraduate Biology Education Study Program at Surabaya State University and Santo Thomas Aquino Tulungagung Catholic High School.

The first stage of this research was defined, which is divided into several steps: front end analysis, student analysis, task analysis, material analysis, and formulation of learning objectives. The next stage was the design stage, which includes instrument selection, teaching device selection, format selection, and initial design. Then, at the development stage, this stage contains expert validation and revision. This research is limited to the development process and the validity of the product in the form of a teaching module set produced.

The data collection method uses the validation method. The data used comes from instruments

developed by researchers. The instrument used is a non-test instrument. The instruments used to collect data on teaching module devices are lesson plan validation sheets, learning media validation sheets, and student worksheet validation sheets.

The validation process was carried out by two expert lecturers. This validation was carried out by expert validators who have competence in the field of biology material and content. Validation is intended to obtain suggestions and input from validators. Suggestions and input from validators will be followed up to improve the development of PjBL teaching modules based on environmental character.

The validation results were analyzed descriptively and quantitatively. The device's validity is analyzed after obtaining scores from the validator and looking for the average score for each aspect. The results of the validation data for the development of teaching modules will be determined using the Likert scale at Table 1.

Table 1. Likert scale criteria

Scale Value	Assessment Criteria
4	Very valid
3	Valid
2	Less valid
1	Invalid

The average calculation uses Formula (1). These interpretation criteria are divided into several types, as listed in Table 2 (Ratumanan & Laurens, 2011). A teaching module can be declared valid and suitable for use if the minimum level of validity achieved is good enough. If the level of validity achieved is below good enough, then a revision needs to be made until a valid teaching module is obtained.

$$average\ score = \frac{The\ sum\ of\ the\ scores\ for\ each\ criterian\ of\ alll\ validators}{Number\ of\ validators} \quad (1)$$

Table 2. Likert scale interpretation criteria

Score	Assessment Criteria
3.6 ≤ P ≤ 4.0	Very valid
2.6 ≤ P ≤ 3.5	Valid
1.6 ≤ P ≤ 2.5	Less valid
1 ≤ P ≤ 1.5	Invalid

Results and Discussion

This research uses a 4D model that produces project-based teaching module products that play a role in shaping the environmental care character of students at Santo Thomas Aquino Tulungagung Catholic High School. This teaching module is equipped with various features and materials that are in accordance with the latest curriculum and applied to students for 4 face-to-face meetings. In this teaching module, it is also equipped with a learning activity guide consisting of 4 learning modules that will be handled by students. This module is also equipped with Learner Worksheets (*Lembar Kerja Peserta Didik* - LKPD) which have a function to help students be more practical in understanding the material studied. At the end of the learning process, students are given a bill to make a waste recycling product into a useful item and has a use value which is accompanied by a cognitive assessment (pre-test and post-test) and an assessment of their final project. It is hoped that with the final project, students can apply their environmental care character well and this module is also designed in accordance with project-based learning steps which include project assessment, project planning, project supervision, and presentation of the final product.

This teaching module consists of lesson plans/learning instructions, learning media as teaching materials (consisting of learning module 1, learning module 2, learning module 3, and learning module 4), and learner worksheets (consisting of worksheets 1 to 4) (Figure 1 and Figure 2). The description of the display of the teaching module device can be seen in Table 3. This teaching module is also equipped with assessment instruments and rubrics for the learning objectives.

This teaching module consists of several components that have been determined by the central government. Some of these parts are module identity, core components, and cover. The main part is the cover of the teaching module, the learning activities section, and the learning assessment. Inside the module there is also a student worksheet that contains learning activities that will be carried out by students. This teaching module was developed with the characteristics of the PjBL learning model and links it to environmental caring character.

With a teaching module, teachers can plan learning activities in a structured and planned manner and ensure that learning objectives can be achieved effectively. The teaching module developed by the

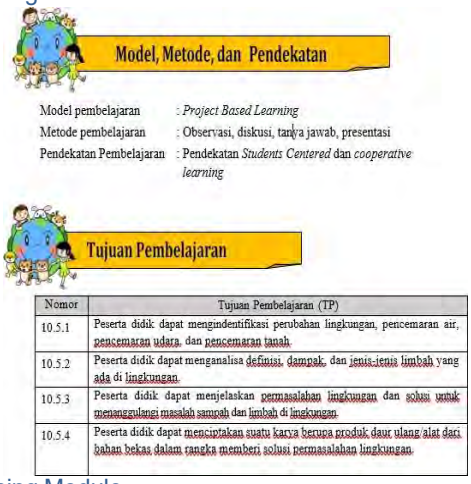
researchers includes topics of the environmental change with validation results as shown in Table 4. Based on the results of the validation of the teaching module carried out by the validators, the average result of the overall validation score is 3.48 which is categorized as valid. So that the final results of this validation indicate that this teaching module can be used in the learning process. The results of validation from the content aspect of this teaching module obtained an average score of 3.4 from the two validators, which these results indicate that in this teaching module the preparation format is in accordance with existing rules and regulations. The learning activities designed also meet the eligibility requirements to be applied in learning and use supporting teaching materials that are also feasible. In terms of language feasibility, the average result of the two validators is 3.75, which indicates that the language writing in this teaching module is very feasible if used in the learning process. Educators can make good learning plans according to students' conditions as preparation before learning.

Figure 1. Teaching Module Package (a) Teaching module cover page; (b) Teaching module content page; (c) Learning module cover page 1; (d) Learning module cover page 2; (e) Learning module cover page 3; (f) Learning module cover page 4.

Creative and innovative learning presented by the teacher will take place well and successfully if the teacher can choose the right learning media and teaching materials to use. In the learning process on the topic of environmental change, a learning module is prepared that will be used by students to help facilitate the process of understanding and building their environmental care character. This learning module consists of 4 parts, each of which is interrelated and continuous based on the PjBL model. The selection of a PjBL model because this model can guide students to find a problem in the environment that can ultimately be given a solution in the form of making products to solve these environmental problems. This project discusses environmental change and pollution that occurs around students and is equipped with a work guide and existing features with the aim that students more easily understand the material and problems that occur today. This learning module is also equipped with practice questions to measure the ability and cognitive of students. At the end of the learning module, assignments are also given to sharpen students' understanding of the sub topics being discussed. The learning module as learning media developed by the researchers includes topics of the environmental

change with validation results as shown in Table 5.
Based on the results of the validation of the learning module / teaching material media carried out by the validators as in Table 5, it can be obtained that the average result of the two validators is 3.52 which is categorized as valid. This validation result indicates that this teaching module can be used in the learning process. Judging from the aspect of the feasibility of the content of this learning module, it obtained an average score of 3.46, including the identity and writing format of the learning module. These results indicate that the content of this module is in accordance with the PjBL syntax and contains environmental material. In terms of display feasibility aspect, the average score is as follows 3.7 which includes the suitability of the cover with the content and completeness of the media used so that it can be concluded that the appearance of this learning module is attractive and quite complete. Based on the aspect of language feasibility, an average score of 3.5 was also obtained, indicating that this learning module is easy to understand.

Table 3. Description of the display of the teaching module device

No.	Appearance	Information
Learning Plan		
1.		The learning plan in this teaching module consists of general information, learning outcome elements, Pancasila learner profile, facilities and infrastructure, learning models and methods used, learning objectives to be achieved, prerequisite knowledge, meaningful knowledge, triggering questions, learning activities, reflection, and learning assessment. The content in this teaching module is in accordance with the standard provisions of the government and the independent curriculum.
Learning Module		
2.		Learning modules 1 and 2 are prepared as newteaching materials used by students to help achieve learning objectives. Thismodule is project-based and equipped with guidelines, material with *QR codes*, worksheets, as well as assignments and practice questions that are expected to help students understand the character and spirit of environmental care. This module discusses environmental change and waste.
3.		Learning modules 3 and 4 discuss efforts/solutions in overcoming existing environmental problems. Learning modules 3 and 4 are equipped with project-based syntax which will guide students to work on a recycled work/product at the end of learning. It is expected that with the completion of this module, students' environmental awareness character will be formed.
Learner Worksheet		

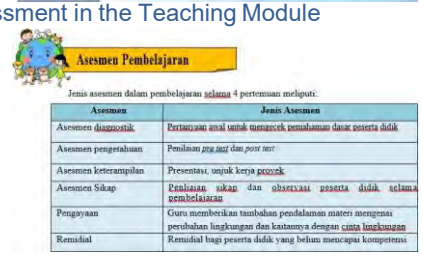
No.	Appearance	Information
4.		The 4 learner worksheets were used in 4 meetings in the classroom. This worksheet is equipped with a video link to the material and also a barcode scan to facilitate students. This learner worksheet consists of learning instructions that students will do, it also contains a guide to working on projects that are equipped with formative assessments at the end of learning.
Assessment in the Teaching Module		
5.		Learning assessments consist of diagnostic assessments, cognitive, attitudinal and skills assessments, as well as pre and posttests at the end of the lesson. Project assessments are also given during the final project process.

Table 4. Teaching module validity result

No	Aspect	Validator Score	
		Rater I	Rater II
Content Appropriateness Aspect			
Format of Teaching Module			
1.	Write down the main identity of the teaching module	4	3
2.	Write down the subject description	4	3
3.	Write down elements, phases, and learning outcomes	4	3
4.	Write down the flow of learning objectives	3	3
5.	Writing down study materials	4	3
6.	Writing down learning methods	4	3
7.	Include the time allotted	4	3
8.	Includes the learner's learning experience	3	3
9.	Includes learning assessments	4	3
10.	Include learner reflection at the end	4	3
Learning Activities			
11.	Write down the learning experience that learners will have	4	3
12.	The time allocation set is in accordance with the material taught	4	3
13.	Guiding students in designing projects and schedules according to PjBL syntax.	4	3
14.	Organizing students in project development according to PjBL syntax	4	3
15.	Reporting the final product according to PjBL syntax	4	3
16.	Evaluate project learning outcomes at the end of the lesson	4	3
Supporting Learning Activities			
17.	Use of teaching materials in the form of handouts to support learning	4	3
18.	Use of learning media to support learning	4	3
Aspects of Language Appropriateness			
19.	The language used is in accordance with EYD and well organized	3	4
20.	The language used is easy to understand	4	4
Amount		**77**	**62**
Average		**3.85**	**3.1**
Category		**Very Valid**	**Valid**

(a) (b)

Figure 2 Teaching module: (a) before revision; and (b) after revision

The improvements to the learning media after the validation process show that the images in the cover of the teaching module look small and are difficult to use to see the characteristics of the environment (Figure 3). The results after revision become better for students to see.
Furthermore, student worksheet contains activities carried out by students during the learning process and products produced by students after completing these tasks or activities. Student worksheet is often used to train and measure student competence or learning outcomes. The learner worksheet developed consists of 4 activities that are used in 4 face-to-face meetings. This worksheet consists mainly of the main identity, learning objectives to be achieved, learning resources, QR Code as video material, as well as formative tests and learning reflections. Learner worksheet 1 focuses on environmental change and pollution, learner worksheet 2 discusses various kinds of waste, learner worksheet 3 discusses solutions to environmental problems, and learner worksheet 4 discusses recycled products. All worksheets are based on the PjBL model. The events approach in everyday life is very suitable to be used as a flow for preparing student worksheets so that it is easy for students to understand.

Table 5. Learning module/learning media validity results

No	Aspect	Validator Score	
		Rater I	Rater II
Content Appropriateness Aspect			
Teaching Material Identity			
1.	Writing the identity/cover of the learning module	4	3
2.	Appropriateness of the title on the learning module	4	3
3.	Includes learning outcomes and elements	4	3
4.	Write down the flow of learning objectives	4	3
5.	Include activity instructions in the learning module	4	3
Teaching Material Weight			
6.	Suitability of learning activities in the module with the independent curriculum	4	3
7.	The material presented is in accordance with the concept	4	3
8.	This module can be integrated with other learning technologies	4	2
9.	This module uses relevant, environmentally-based case studies	4	3
Learning Activities			
10.	The module guides students to be able to identify the initial problem	4	3
11.	This module guides students to design a project	4	3
12.	The module guides students to be able to create projects to	4	3

No	Aspect	Validator Score Rater I	Rater II
	address		
Characteristics of Environmental Project-Based Learning			
environmental issues			
13.	This module can shape students' environmental awareness character	4	3
Display Feasibility Aspect			
14.	The suitability of the cover with the contents of this learning module	4	3
15.	Appropriateness of writing with fonts and images	4	3
16.	Display of colors and images can attract learners' interest	4	4
17.	The media in this module is very diverse such as QR codes about videos/images that help student understanding	4	4
18.	The media used in this module are relevant to the surroundings.	4	3
Aspects of Language Appropriateness			
19.	The language used is easy for students to understand	4	4
20.	The language used is in accordance with EYD and standard writing rules	3	3
Amount		**79**	**62**
Average		**3.95**	**3.1**
Category		**Very Valid**	**Valid**

Figure 3. Student worksheet: (a) before revision; and (b) after revision

Table 6. Students' worksheet validity results

No	Aspect	Validator Score Rater I	Rater II
Content Appropriateness Aspect			
1.	The worksheets prepared are in accordance with the steps of PjBL	4	3
2.	This project-based worksheet complies with the curriculum standards independent	4	3
3.	These worksheets are organized according to the learning objectives.	4	3
4.	Worksheets have been prepared to shape the character of environmental care student	4	3
5.	Worksheets contain interesting displays/images and links/QR Code that is integrated with the web	4	3
6.	The writing of the worksheet has used Indonesian language	4	3
7.	This worksheet uses easy sentences student understanding	4	3
8.	This worksheet already uses sentences without multiple interpretations	3	3
Amount		**31**	**24**
Average		**3.87**	**3.0**
Category		**Very Valid**	**Valid**

Based on the validation results of the students' worksheets carried out by the two validators, an average score of 3.45 can be obtained, which means it is valid (Table 6). These results indicate that this student worksheet has been prepared based on the format and rules that apply in general. The use of language and writing in this student worksheet is also appropriate and easy for students to understand. The appearance and features in this worksheet are quite interesting and complete so that it can make it easier for students to understand the learning material.

The results of the LKPD before being revised show that the features to train the character of environmental care have not been seen in the LKPD. After the LKPD was revised, there were features of teaching problem perspectives and building environmental care characters (Figure 3). The main characteristic of this learner worksheet is that it contains environmental subjects that are realized in project work.

PjBL is able to provide a positive impact on improving student competencies (Quinapallo-Quintana & Baldeón-Zambrano, 2024; Rais & Yahya, 2021; Song et al., 2024)., including competencies and attitudes related to the environment (López & Palacios, 2024; Yolcu, 2023). By implementing PjBL, students can be directly involved in real projects that aim to solve environmental problems around them (Guo et al., 2020; Saad & Zainudin, 2022). This learning not only improves students' understanding of scientific concepts, but also develops thinking skills such as problem solving (Chiang & Lee, 2016; Karan & Brown, 2022), collaboration (Safarini, 2019), and critical thinking skills (Song et al., 2024). Through this model, student involvement in learning and their awareness and positive attitudes towards the environment can increase. Therefore, by implementing PjBL, students' academic competencies and their environmental care character can develop.

Environmental education plays an important role in forming a generation that cares and is responsible for environmental sustainability (Aggarwal, 2023; Llopiz-guerra et al., 2024). Through environmental education, students are prepared to be aware of and face various current environmental challenges, such as climate change, pollution, and loss of biodiversity (Leboreiro & Lemes, 2023; Mandrwal & Negi, 2022; Stevenson, 2022). Environmental education is not only about understanding ecological concepts, but also about developing competencies for critical thinking, problem solving, and taking appropriate action in protecting and preserving the environment. understanding of environmental change, participation in environmental-based activities, and application of environmentally friendly behavior (Fatima, 2023; Fonseca, 2023; Zharmenova et al., 2024).

Conclusion

The project-based teaching module that aims to shape the environmental care character of students is feasible and valid to be used in the learning process at school. This is supported by the results of the study which show that the validation test of the teaching module is 3.48 with a valid category, the validation of the learning module / teaching material is 3.52 with a valid category, and the validation of the student worksheet is 3.45 also with a valid category. Overall, the results of the validation test of learning devices prepared by researchers have an average score of 3.48 with a valid category. The recommendation that can be considered is that the character of caring for the environment that has been formed through the use of this learning aid is not only applied to learning certain chapters in biology subjects. This character of caring for the environment is expected to develop and become a habit for students in their daily lives.

Acknowledgment

The researcher would like to thank the expert validator in the field of biology materials, media experts, and linguists who have reviewed and provided input from the tools that researchers have developed.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

W. Hartanto: methodology; analysis; writing original draft preparation; and review and editing. T**. Purnomo:** review, editing and lecture. **P. Yakub:** review, editing and lecture.

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