**International Journal of Evaluation and Research in Education (IJERE)**
Vol. 11, No. 3, September 2022, pp. 1049~1057
ISSN: 2252-8822, DOI: 10.11591/ijere.v11i3.22140 

# The effectiveness of problem-based learning with environmental-based comic in enhancing students environmental literacy

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**Article Info**

***Article history:***

Received May 16, 2021
Revised Jun 14, 2021
Accepted Jul 2, 2022

***Keywords:***

Environmental-based comic
Environmental literacy
Problem-based learning
University student

**ABSTRACT**

Environmental literacy is an attitude and behavior that must be possessed by a student in protecting the environment. Therefore, it is necessary to carry out a plan and action to empower environmental literacy through education. This study aimed to determine the effect of the problem-based learning with environmental-based comic (PBLEC) model in empowering students' environmental literacy in Indonesia. This type of research was a quasi-experimental posttest-pretest non-equivalent control group design study involving 97 students at the University of Muhammadiyah Makassar, South Sulawesi, Indonesia. Students' environmental literacy data was obtained by using an exam technique using an essay test instrument sheet, then the results were analyzed using descriptive statistics and one-way inferential analysis of covariance (ANCOVA). The results of statistical analysis showed that the PBLEC model has an effect on students' environmental literacy. The average score achieved by students in the class group using PBLEC is higher than students who are taught by the problem-based learning (PBL) learning process and conventional learning. Therefore, the use of the PBLEC model can be used in the learning process as an effort to grow and improve student environmental literacy.



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## 1. INTRODUCTION

Environmental literacy is one of the important elements that must be owned by students [1]. According to previous researchers [2], [3], without environmental literacy, students will find it difficult to understand and apply environmental love. In addition, the existence of environmental literacy in students can provide more value because students are the cogs who play an important role in delivering environmental change for the better [4], [5]. Environmental literacy is the ability to understand and interpret environmental conditions that have an impact on deciding all appropriate actions to maintain, restore and improve environmental conditions [6]–[8]. However, the importance of environmental literacy is not in line with the desired expectations in the field, it can be seen that students' environmental literacy is very low.

Several studies have written that the environmental literacy of students in schools is still very concerning [6], [9]–[11]. In addition, environmental literacy among students in higher education is no less concerning [12], [13]. Students often show arbitrary behavior, blind hearts, and blind eyes in protecting the

environment during field activities [14], [15]. The impact of ignorance that is carried out directly or indirectly has an impact on natural imbalances, causing pollution, flooding, abrasion, climate change, depletion of natural resources, waste disposal, and the extinction of biodiversity [16]–[18]. In addition, impacts such as deforestation, acidification of seawater, depletion of the ozone layer, acid rain, and other environmental problems also occur due to lack of care [19], [20]. Currently, it appears that environmental damage has touched a fundamental aspect as a result of errors in viewing the relationship between humans and the environment [21], [22]. When the root causes of basic problems in the environment are not addressed as well and as early as possible, bigger environmental problems will lurk for humans in the future [23]–[25].

The low environmental literacy of students, especially in Indonesia because during the learning process, lecturers only teach concepts without providing examples and appropriate behavior [16]–[19]. According to Jamaluddin *et al*. [26], showing appropriate behavior in learning can shape the caring attitude of students. Therefore, the existing problems show that students' knowledge, competence, and environmental attitudes have not been honed to the maximum [27]. To face the challenges of environmental literacy degradation, students need a strong literacy design and development; and have a high commitment [1]. Maintaining and establishing good environmental literacy can be done by implementing environmental education so that students have the knowledge, skills, values, and attitudes in solving existing environmental problems [4], [28].

In addition, environmental education helps students to be able to limit activities that can cause environmental damage to be worse [29], [30]. Environmental education for students can form and develop their awareness and ethics in understanding the relationship between humans and their environment, especially in the era of the industrial revolution 4.0 [8]. This statement is in line with Ardoin [27], that scientific progress in the industrial revolution 4.0 era should be accompanied by the formation of good student attitudes. Therefore, students with low environmental literacy can grow and develop well if they get the right treatment during the learning process. One that can empower the formation of environmental literacy is problem-based learning (PBL) [31], [32].

PBL is a learning process in finding a concept from the inquiry process that is able to stimulate students' high-level thinking when facing a situation that is oriented towards a real problem [33]. PBL learning focuses on the learning process that always relates to problems in everyday life, so that learning processes are able to create a meaningful learning environment [34]. According to previous studies [34], [35], the characteristics of the PBL process can have an influence on the formation of student attitudes, which can indirectly shape attitudes towards the surrounding environment. In addition, learning using environmental-based comics can also have an influence in empowering the formation of environmental literacy.

Comics is an effective tool for delivering learning content to student knowledge because learning messages are conveyed in an interesting, structured, clear, and fun way [36], [37]. In addition, comics can help students in achieving the desired learning goals [38], [39], one of which is comics with environmental nuances [40]. Environmental-based comics are comics that feature story illustrations that are closely related to environmental problems and solutions. According to previous researchers [40], [41], environmental-based comics can be useful reading for students because they are made by inserting educational elements and direct stories that provide information on the importance of the environment for humans.

Based on the description that has been explained, the problems of environmental literacy, the advantages of the PBL learning model, and environmental-based comics, it is necessary to modify a strategy in the learning process in accordance with the characteristics of Indonesian students in empowering environmental literacy. According to Saribas *et al*. [13], strong environmental knowledge must be enriched and based on the process of forming maximum environmental literacy during the learning process. Therefore, the efforts made in empowering literacy and overcoming the problem of low student environmental literacy are by integrating the PBL model with environmental-based comics, which was later named problem-based learning with environmental-based comic (PBLEC). This study aimed to determine the effect of PBLEC in empowering students' environmental literacy, so the hypothesis of this research is that the PBLEC learning model has an effect on empowering students' environmental literacy.

## 2. RESEARCH METHOD

### 2.1. Type of the study

This study is a quasi-experimental study with a posttest-pretest non-equivalent control group design [42]. There are three treatment groups in this study, namely the experimental group, positive control, and negative control. The experimental group was taught with the PBLEC model, the positive control group was taught using the PBL model, and the negative control group was taught without using special (conventional) learning. The learning model of the PBLEC, PBL, and conventional learning models is the independent variable, while environmental literacy is the dependent variable. The research design is presented in Table 1.

Table 1. Design of the study

| Pretest | Learning process | Posttest |
|---|---|---|
| O1 | PBLEC | O2 |
| O3 | PBL | O4 |
| O5 | Conventional | O6 |

### 2.2. Participants

The population of this study was all second-semester biology education students at the University of Muhammadiyah Makassar, South Sulawesi, Indonesia in the 2019/2020 academic year. Hence, the sample in this study was 97 students who programmed Environmental Knowledge courses. The PBLEC class consists of 30 students, the PBL class consists of 34 students and the conventional class consists of 33 students. The average age of students is in the age range of 17-19 years. Determination of the sample is done by random sampling. The entire sample class used is an equivalent class based on the equivalence test using the data grouping test.

### 2.3. Instrument

The environmental literacy instrument used was an essay test sheet that had been previously developed [16], [43], [44]. The environmental literacy instrument consists of 14 questions from three main indicators: i) Environmental knowledge; ii) Environmental competence; and iii) Environmental attitudes. The environmental literacy rating scale is at 4.00-3.20 (very good), 3.19-2.80 (good), 2.79-2.40 (adequate), and under 2.40 (poor). Before data collection, the instrument developed was confirmed valid with a validity value of 0.451-0.582, and reliable with a value of 0.773-0.814.

### 2.4. Data collection and data analysis

The research process was carried out for four months consisting of 16 meetings. Data were collected utilizing an essay test consisting of 14 questions. The pretest data were obtained from the test before the first meeting was conducted, while the posttest data was obtained at the 16th meeting. Data were analyzed using descriptive and inferential statistics one-way analysis of covariance (ANCOVA) with a significance level of 5%. If the data shows an effect, then it is continued with the least significance different (LSD) test. Data were analyzed using SPSS for Windows. Before the data were analyzed by ANCOVA, the prerequisite tests were carried out, namely the normality test and homogeneity test. The normality test was carried out using the one-sample Kolmogorov-Smirnov test, and the homogeneity test was carried out using Levene's test of equality of error variances.

### 2.5. Learning procedures

The learning process in the PBLEC model, the PBL model, and conventional learning receive different treatments during the learning process. The learning process was carried out for 16 meetings in each class. The learning process in the three models is presented in Table 2.

Table 2. Learning process on the three models

| Model | Activities |
|---|---|
| PBLEC | **Introduction**<br>1. Problem orientation<br>a. Lecturer carry out an appreciation process to students about learning materials according to environmental-based comics. **<br>b. Lecturer explain the learning objectives to be achieved<br>c. Lecturer motivate students to be actively involved in the learning process using environmental-based comics. **<br>**Core activities**<br>2. Organizing problems<br>a. Lecturer help students identify problems regarding the lessons studied using environmental-based comics. **<br>b. Lecturer direct students to formulate problems from the problem identification process from environmental-based comics. **<br>3. Guiding individual/group investigations<br>a. Lecturer encourage students to collect information that fits the topic of the problem using environmental-based comics. **<br>b. Lecturer encourage students to seek explanations and solutions to problems using environmental-based comics. **<br>4. Develop and present the work<br>a. Lecturer assist students in planning and preparing appropriate works that can be used in the presentation process.<br>b. Lecturer ask students to give feedback on other group presentations.<br>**Closing activities**<br>5. Analyze and evaluate the problem-solving process<br>a. Lecturer direct students to make conclusions.<br>b. Lecturer help students to reflect on the learning processes that carried out according to environmental-based comics. ** |

Table 2. Learning process on the three models (*continued*)

| Model | Activities |
|---|---|
| PBL | **Introduction** |
| | 1. Problem orientation |
| | a. Lecturers do the apperception process to students about learning materials. |
| | b. Lecturers explain the learning objectives to be achieved. |
| | c. Lecturers motivate students to be actively involved in the learning process. |
| | **Core activities** |
| | 2. Organizing problems |
| | a. Lecturer help students identify problems regarding the subject being studied. |
| | b. Lecturer direct students to formulate problems from the problem identification process. |
| | 3. Guiding individual/group investigations |
| | a. Lecturer encourage students to collect information that fits the topic of the problem. |
| | b. Lecturer encourage students to seek explanations and solutions to problems using environmental-based comics. |
| | 4. Develop and present the work |
| | a. Lecturer assist students in planning and preparing appropriate works that can be used in the presentation process. |
| | b. Lecturer asked the students to give responses to the presentations of the other groups. |
| | **Closing activity** |
| | 5. Analyze and evaluate the problem-solving process |
| | a. Lecturer direct students to make conclusions. |
| | b. Lecturer help students to reflect on the learning processes that have been carried out. |
| Conventional | **Introduction** |
| | a. Lecturer doing apperception |
| | b. Lecturer explain the learning objectives to be achieved |
| | **Core activities** |
| | a. Lecturer explain the learning materials and students listened well |
| | b. Lecturer provide opportunities for students to ask something they do not understand |
| | **Closing activities** |
| | a. Lecturer ask students to conclude the material that has been studied |
| | b. Lecturer close the lesson |

******Compulsory to use comics in the learning process

## 3. RESULTS AND DISCUSSION

### 3.1. Results

The results of the study on the average environmental literacy score of students in 16 meetings showed different results. Table 3 shows that environmental literacy scores on each indicator increased for the three PBLEC, PBL, and conventional learning models from pretest to posttest scores. The highest increase in environmental literacy in PBLEC is occurred in the first indicator with a score of 0.59, while the lowest score was environmental literacy in the third indicator with a score of 0.57. The highest score for PBL occurred in the environmental literacy of the first indicator with a score of 0.49 and the lowest score occurred in the environmental literacy of the third indicator with a score of 0.38. As for conventional learning, the highest score occurs in environmental literacy in the first indicator with a score of 0.36 and the lowest score occurs in environmental literacy in the third indicator with a score of 0.30.

Table 4 shows that based on the results of the ANCOVA test on the learning model, the significance value obtained is $p=0.000$ ($p<0.05$) which indicates that the PBLEC, PBL, and conventional learning models have a significant effect on student environmental literacy. The LSD test was conducted to see the significant difference in the three learning models. The PBLEC model is significantly different from the PBL model and conventional learning as seen from the difference in notation between the three learning models. Based on the corrected mean of student environmental literacy in the PBLEC, PBL, and conventional learning models, they are 3.17, 2.94, and 2.73, respectively. The PBLEC model provides a better contribution in influencing the growth and improvement of student environmental literacy. The results of the LSD test on student environmental literacy are presented in Table 5.

Table 3. Increasing student environmental literacy scores on the three learning models

| Indicator | Model | Pretest | Posttest | N-Gain | Criteria |
|---|---|---|---|---|---|
| Environmental knowledge | PBLEC | 2.12 | 3.22 | 0.59 | Medium |
| | PBL | 2.09 | 3.02 | 0.49 | Medium |
| | conventional | 2.05 | 2.75 | 0.36 | Medium |
| Environmental competence | PBLEC | 2.02 | 3.17 | 0.58 | Medium |
| | PBL | 2.02 | 2.98 | 0.48 | Medium |
| | conventional | 2.06 | 2.72 | 0.34 | Medium |
| Environmental attitude | PBLEC | 2.04 | 3.15 | 0.57 | Medium |
| | PBL | 2.11 | 2.85 | 0.38 | Medium |
| | conventional | 2.12 | 2.68 | 0.30 | Medium |

Table 4. ANCOVA results on student environmental literacy

| Source | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Corrected model | 3.488[a] | 3 | 1.163 | 40.876 | .000 |
| Intercept | 6.348 | 1 | 6.348 | 223.173 | .000 |
| Pretest | .165 | 1 | .165 | 5.791 | .018 |
| Model | 3.364 | 2 | 1.682 | 59.143 | .000 |
| Error | 2.645 | 93 | .028 | | |
| Total | 847.682 | 97 | | | |
| Corrected total | 6.133 | 96 | | | |

Table 5. LSD Test results on environmental literacy in the three learning models

| Model | Pretest | Posttest | Deviation | Increase (%) | Mean score | LSD notation |
|---|---|---|---|---|---|---|
| PBLEC | 2.06 | 3.18 | 1.12 | 54.36 | 3.17 | a |
| PBL | 2.07 | 2.95 | 0.88 | 42.51 | 2.94 | b |
| Conventional | 2.08 | 2.72 | 0.68 | 30.76 | 2.73 | c |

### 3.2. Discussion

Environmental literacy must be owned by a student as an agent of change in maintaining a better environment. The results showed that the PBLEC model had a higher environmental literacy score than the PBL and conventional learning models. This can be seen from the increase in the pretest to posttest scores and the corrected mean scores of students' environmental literacy. The high environmental literacy score in PBLEC is due to the characteristics of the model in the learning process which has been designed by relying on the advantages of the PBL model and the advantages of environmental-based comics. According to Hanipah *et al*. [31], the PBL learning process can shape knowledge and attitudes that have an impact on students' ability to understand themselves and their surroundings, so they can understand environmental problems. In addition, the ability of comics in the form of visuals that are designed attractively and uniquely can attract students' knowledge and attitudes about the importance of protecting the environment [39].

There are five main processes in PBLEC in shaping student environmental literacy during the learning process, namely problem orientation, problem organization, group investigation process, work development, and presentation and evaluation. The five main processes are supported by environmental-based comics that stimulate students' environmental knowledge and attitudes. At the problem orientation stage, lecturers make apperceptions that are very closely related to students' daily lives by relying on environmental-based comics, especially in the scope of environmental problems. The problem orientation process indirectly forms students' awareness of what attitudes need to be done and what knowledge needs to be built in overcoming existing problems. According to Perusse and Baaken [45], the process of associating problems with everyday life in the learning process when problem orientation is very effective in shaping students' awareness and knowledge. This is in line with [46], [47], that when learning presents contextual problems, students' logical power is more open so that it stimulates students' cognitive development in understanding and interpreting the material being studied by connecting with their environment. Learning that begins with environmental problems can educate students to behave in caring for the environment [48], [49]. In addition, instilling awareness and concern for the environment during the problem orientation process is the right and strategic step in conducting education about the importance of environmental literacy [16], [50].

In the next stage, the process of organizing problems in the form of identifying problems that occur in the field is carried out. The problem identification process carried out by students in a structured manner can form a thinking process that has an impact on their attitudes and knowledge [51]. According to Bachtiar *et al.* [34], the problem identification process is an important part of the meaningful thinking process as an effort to define the problem and create a definition that appears to be measurable and resolved. Students' awareness and concern for the environment grows naturally when there is a continuous formation through real activities carried out in each learning process [32], [52].

The next stage is group investigation. This stage as a process of finding a concept from the problems that exist is the most important part in shaping student environmental literacy. During the investigation process, there is a process of collecting data both mentally and actually. Students can understand the environmental problems they face through environmental-based comics. Students get sufficient information to create and build their ideas in solving existing problems. The processes that occur either directly or indirectly can shape student literacy, especially in environmental literacy. The effectiveness of the investigation becomes more meaningful because environmental-based comics are always an interesting source of problem-solving. Comics can provide more concrete facts that occur in the field which are packaged in a design that is more fun and interesting to read during the learning process [40], [41].

According to Puput, Ahmadi, and Rochmad [53], comics can shape the character of students so that they can understand and be sensitive to the surrounding situation better.

At the stage of developing work and presentation materials, students become better at shaping their environmental literacy by making presentation products at PBLEC. Creating a product in the learning process indicates a person's literacy ability has grown and developed well [54]. When students are accustomed to learning with concepts that are closely related to their surrounding environment, good awareness and knowledge will be formed in students, one of which is the formation of environmental literacy [5], [55], [56]. In addition, during the PBLEC learning process, the actions of the lecturer at each stage of the process become one of the keys to the formation of student environmental literacy. In learning activities, there is always social interaction between lecturers and students to generate and strengthen student environmental literacy both in the process of problem-solving, discussion, question and answer, and presentations. An active learning process such as the PBLEC learning process can shape student environmental literacy. According to several studies, when the learning process always activates students, gradually the attitudes and knowledge of students will be well-formed [52], [57], [58].

The last stage that can shape or empower students' environmental literacy in the learning process is evaluation. Evaluation is a way of seeing the extent to which students are able during the learning process. In addition, the reflection process carried out at the end of the lesson also influences students in shaping environmental literacy. According to El-Shaer and Gaber [35], reflecting on the results of the learning process is one way to grow and improve knowledge and attitudes that have an impact on students' literacy skills. In general, a significant influence on the formation of student environmental literacy in PBLEC is because the model focuses on the domain of knowledge formation and student environmental attitudes.

The learning process that pays more attention to the formation of the realm of knowledge and attitudes will have an impact on the formation of student literacy, one of which is environmental literacy [4], [22], [59]. In addition, the characteristics of the PBL model also provide more value in character building in PBLEC. According to previous researchers [33], PBL can shape a person's personality such as being creative, able to focus on a problem, confident, having a sense of responsibility, being diligent, and always having positive perceptions and attitudes in the learning process. These advantages make PBL able to shape student environmental literacy in the learning process.

The low score of environmental literacy in the PBL class and conventional class is due to the lack of interesting facts obtained during the learning process. It is in contrast to PBLEC who get interesting facts about environmental problems from environmental-based comics. However, the existence of a process of investigation, collaboration, a discussion between individuals and groups in PBL can help shape student literacy in the learning process [31], [32], [60]. The characteristics of PBL learning can empower students' environmental literacy, but it is not as good as learning outcomes that rely on PBL and PBLEC in the learning process. For conventional learning, opportunities to improve environmental literacy are not appropriate for use in learning process, because conventional learning looks passive to students so that the process of forming environmental literacy cannot be formed properly. Active activities for students during the learning process can shape student environmental literacy better and more meaningfully [2], [29], [30].

## 4. CONCLUSION

The learning process using the PBLEC has an effect on empowering students' environmental literacy. It can be seen that the average corrected PBLEC model is better than the PBL and conventional learning models. Therefore, it is recommended to apply the PBLEC model in empowering students' environmental literacy in overcoming environmental problems. However, this study has limitations. It is only revealing the formation of student environmental literacy in a limited number of samples. Therefore, further research should be involved larger sample size.

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