Using Projects-Based Learning in Improving Students' Critical Thinking Skills to Recycle Waste Cooking Oil

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ABSTRACT: To deal era of Industrial Revolution 4.0 (IR 4.0), students need to be equipped with 21st century skills, one of which is critical thinking skills. Related to this, the research has been conducted which aims to describe the effectiveness of project-based learning in improving students' critical thinking skills. This study was a quasi-experimental study using the matching only pretest-posttest control group design. As long as project-based learning takes place, students ask key questions, gather information needed to solve problems, consider the credibility of information sources, make inferences, decide actions to solve problems, and interact with others. Through this process, students have succeeded in making solid soap products from used cooking oil to overcome the problems caused by used cooking oil. The results showed that the average n-gain in the experimental and control classes was 0.47 (medium category) and 0.15 (low category) respectively. Based on this, project-based learning is effective in improving students' critical thinking skills through a process of solving ill-structured problems such as used cooking oil.

Keywords: critical thinking skills, waste cooking oil, project-based learning

INTRODUCTION

IR 4.0 was first introduced in Germany when the Hannover Fair was held in 2011 due to the development of digitalization and robotics [1-3]. IR 4.0 has influence in various aspects of human life. In this era, there was intense competition in the labor market so that only qualified human resources could win the competition [1,4].

Evidence suggests that education is among the most important factor for prepare quality human resources [5-6]. To deal with challenges of IR 4.0 students need to be trained in global community skills, that is communication, creativity and innovation, critical thinking and problem solving, and collaboration [7].

Students can have the skills needed in the era of IR 4.0, that is by providing ill-structured problems in learning at school. One of them is the problem of used cooking oil. Cooking oil that is used more than three times is very harmful to health [8-11]. In addition, used cooking oil if dumped directly into the environment can cause pollution [8,11-12].

Students are expected to solve the problem of used cooking oil by processing it into a product. To accommodate this, the appropriate learning process is a project-based learning (Pjbl) model. Pjbl is a learning model that requires students to integrate their knowing and learning outcomes to complete a real topic through a project. [13-15]. Pjbl makes students able to develop ideas to create native solutions, find on hand resources, present results of information investigations and check out their own findings. Pjbl also supports the principles of constructivist, trained student to collaboration with others, and have the independent and active complicity [13,16-17].

According to Lucas [18] the first stage of Pjbl is (1) determining essential question; (2) design a plan for the project; (3) create a schedule; (4) monitor the students and the progress of the project; (5) assess the outcome and; (6) evaluate the students experience during project learning are believed to be able to improve students' critical thinking skills. Previous studies have reported that the Pjbl model is effective in improving critical thinking skills in seed plant material [19], creative thinking skills [20], student learning outcomes [21-22], learning motivation, creativity, critical thinking skills, and cognitive abilities of students [23], student learning activities and achievements on the subject matter of acid and base solutions [24], and learning achievement, science process skills and student analytical thinking [14].

In fact, the majority of school learning is included in chemistry learning studying structured problems.

This causes the lack of new knowledge that will be obtained and the low ability to solve problems by students. Even though, chemistry learning can actually be done by studying the phenomena that exist in real life, so that students can play an active role in resolving the ill-structured problems given by the teacher with regard to chemical concepts [25]. This article will present new evidence for the effectiveness of Pjbl models in improving critical thinking skills of student.

METHODS

This study was done at SMAN 14 Bandar Lampung using a quasi-experimental method with matching only pretest-posttest control group design [26] which can be seen in Table 1 below.

TABLE 1. The Matching-only pretest-posttest control group design

Research Class	Treatment			
Experiment	M	O	X	O
Control	M	O	C	O

Information:
M = matching, which means that in this design a sample is matched
O = the experimental and control classes are given pretest or posttest
X = in the experimental class Pjbl model is applied
C = in the control class conventional learning is applied

With purposive sampling technique obtained two sample classes, namely the experimental class at XI MIPA 6 and the control class at XI MIPA 4. The instrument used was in the form of an open description question to measure students' critical thinking skills.

$$x_{pre/post} = \frac{\text{score}}{\sum \text{max score}} \times 100 \qquad (1)$$

Information:
x = value
Σ = total

Then the average value of the pretest and posttest is calculated using the following Formula 2:

$$\overline{x_{pre/post}} = \frac{\sum x_{pre/post}}{n} \qquad (2)$$

Information:
$\overline{x}$ = average value
n = number of students

The average value of the pretest obtained, then analyzed using the two average similarity test. While the average value of the posttest was analyzed using the two average difference test. The tests were carried out using Mann Whitney U test with SPSS version 25.

The effectiveness of Pjbl models in improving critical thinking skills of student is analyzed based on n-gain values. The results of the calculation of n-gain averages are interpreted based on criteria of high, medium, or low according to Hake [27].

RESULT AND DISCUSSION

The results of this study were in the form of pretest and posttest scores related to students' critical thinking skills. The mean values of pretest and posttest in both the experimental and control classes are presented in Figure 1.

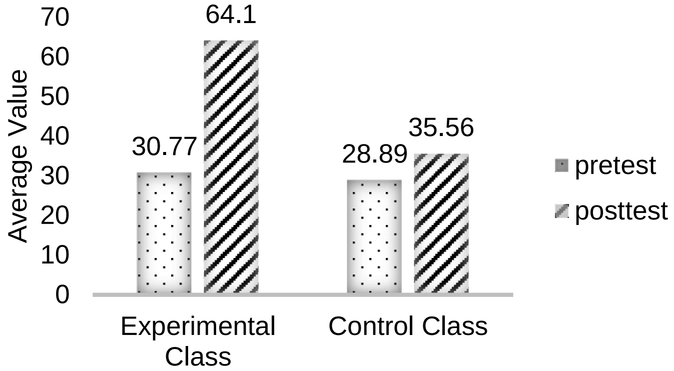

FIGURE 1. Average pretest and posttest critical thinking skills in the experimental and control classes

Based on Figure 1. the mean value of the pretest of critical thinking skills of students in the experimental class and controls did not differ significantly. This is supported by the two average similarity test results as presented in Table 2.

TABLE 2. The Two average similarity test result

	Pretest
Mann-Whitney U	314.000
Wilcoxon W	665.000
Z	-1.648
Asymp. Sig. (2-tailed)	.099

Based on the results of the two average similarity test obtained asympt sig (2-tailed)> 0.05, which means that the average pretest value of the students' critical thinking skills in the experimental class is the same as in the control class. After being given treatment evidently, the average posttest score of the experimental class is more excellent than the control class. The results of the two average difference test are presented in Table 3. The following:

TABLE 3. The Two average difference test result

	Posttest
Mann-Whitney U	164.500
Wilcoxon W	629.500
Z	-3.852
Asymp. Sig. (2-tailed)	.000

Based on results the two averages difference test obtained of Asymp sig (2-tailed) < 0.05 which means that the average posttest value of students' critical thinking skills applied to learn with Pjbl models is higher than with conventional learning. The results of n-gain calculations both experimental and control classes are presented in Figure 2.

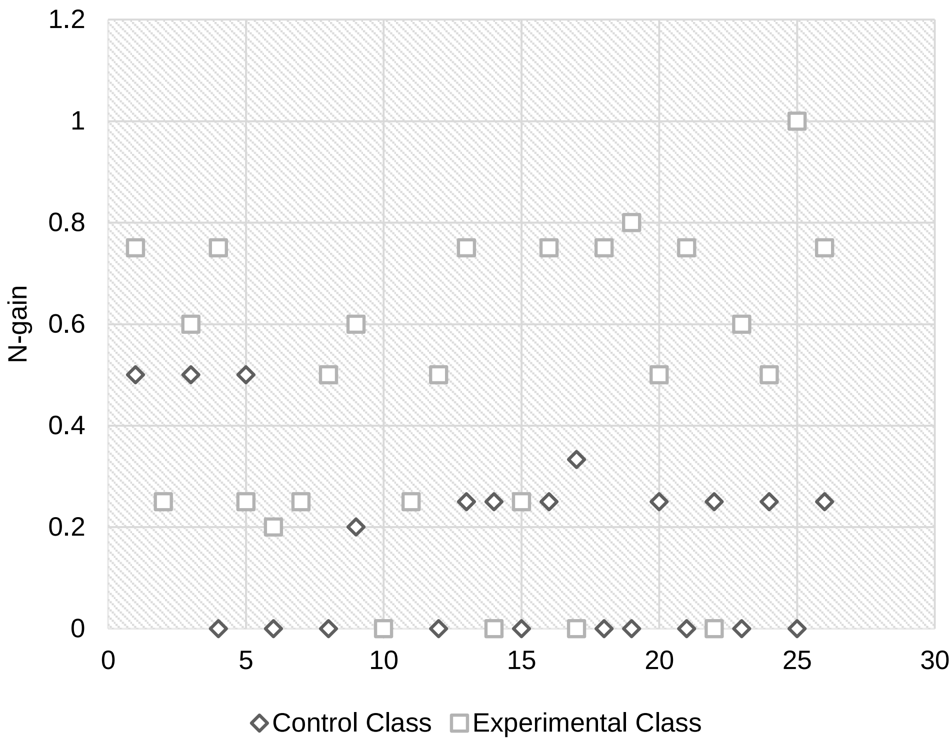

FIGURE 2. N-gain critical thinking skills in the experimental and control classes

Based on Figure 2., the average n-gain of the experimental class is 0.47 with the medium category. On the other hand, the control class has a mean n-gain of 0.15 with a low category. The difference in n-gain in the experimental and control classes can be explained based on student activities at each stage of learning.

Stage 1 determination of essential questions

At this stage, students are faced with a problem related to used cooking oil presented in the discourse. Based on the discourse, students are asked to write the main questions. Following are some statements were written by students.

Student 1: What is the harmful content contained in used cooking oil for health?

Student 2: What is meant by used cooking oil?

Seeing a few students is not appropriate in writing the main questions, the teacher directs how to determine the main questions that are in accordance with the discourse. The result is that students are able to correct the main question.

Student 1: what products can be made using used cooking oil?

Student 2: what products can be made using used cooking oil?

Stage 2. Design a plan for the project

At this stage there are three activities, namely determining information, finding information and determining product design. Students in groups are given two days to determine and seek information. During determining and seeking information, students must include sources of information/references. During the activity, students periodically report the results of assignments to the teacher. The teacher evaluates the assignment and gives direction when there is less relevant information and obtained from non-credible sources. For these suggestions, students make improvements and obtain information, among others: (1) composition of cooking oil and used cooking oil; 2) substance in used cooking oil which is harmful to health; (3) the impact of used cooking oil on health; (4) the impact of used cooking oil on the environment; (5) products made by other people using used cooking oil as raw material and; (6) tools, materials and procedures for products that have been made by other people using used cooking oil as much as possible, at a source that has high credibility. Furthermore, based on information on used cooking oil products by other people, students determine the product design that allows them to make used cooking oil and put forward the reasons for choosing it in writing.

In the classroom, each group communicates the product design of used cooking oil. All groups together with the teacher discuss to agree and choose a product design that will be made taking into account the ease of manufacture, cost and time of manufacture. Based on the results of the discussion, it was agreed that the chosen product design would be solid soap.

Stage 3. Create a schedule

Students for one day are asked to make a timeline and determine the deadline for making products in groups and consult with teachers outside the class. The teacher directs students in determining what activities should be done in making products and also in determining the time in each of these activities.

Based on the timeline, students design the project in groups for one week. Students are assigned to make project objectives, make procedures, and modify the tools and materials used in making solid soap. Then consult the teacher. Based on the direction given by the teacher, students improve the project design. Students are asked to make 3 solid soaps, by varying the volume of NaOH solution, which is 5 mL, 10 mL, and 15 mL.

Stage 4. Monitor the students and the progress of the project

After the project design is correct, for four days students make solid soap in groups outside the classroom. During the production of the product, students consult the teacher about the obstacles they experience. Based on field notes, when consulted, they said the following:

Student 1: “Used cooking oil filter to separate from dirt and activated carbon does not work well, when using filter paper takes a long time, but when using cloth, activated carbon does not separate well”.

The teacher directs students to solutions that can overcome the problem.

Teacher: “Choose a cloth filter that has more pores that can filter dirt and activated carbon well”.

Students are asked to document activities during making solid soap. Students are also asked to determine which soap has the best density and produce the most foam in the variation of the volume of NaOH solution used.

Stage 5. Asses the outcome

Students were asked to make a report about making solid soap for 4 days. Reports that have been made are then given to the teacher. Students in groups communicate their products in front of the class. Teachers and students from other groups provide feedback, in the form of responses or questions.

Stage 6. Evaluate the students experience during project learning

As long as project-based learning takes place, students are able to apply new ideas to use tools in their home environment to replace laboratory equipment. For example, changing a beaker with a glass cup that is thick enough to dissolve NaOH. In addition, students also use deodorizers that are different from those used by others in making solid soap from used cooking oil.

Students are trained to be able to make the main questions. Students must also gather information needed to overcome the problem of used cooking oil. In addition, in seeking information, students are trained to choose credible information sources, so that the information they obtain can be trusted. When students determine the product to be made from used cooking oil, it means that students have been able to decide actions to overcome the problem of used cooking oil. Students also determine the volume of NaOH solution which is best used to obtain solid soap with good density and has the most foam, can train students to make inferences. Students are also able to communicate the results of their projects to others. With learning like this, students' critical thinking skills based on the Ennis [28] framework can improve satisfactorily.

CONCLUSION

Based on the average value of the pretest, posttest, and n-gain it can be concluded that project-based learning is effective in improving students' critical thinking skills. As long as project-based learning takes place, students collaborate with others and the teacher in finding solutions to overcome problems caused by used cooking oil.

It makes students have active and independent involvement in learning, which through in-depth investigation activities, students can make solid soap to overcome the problem at the end of project-based learning.

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