Pbl-team teaching: supporting vocational students logical thinking and creative disposition

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Abstract. An analysis of labour demand informs that a dimension of the ability to think logically and creatively are needed. Many studies on the implementation of PBL have been carried out. However, no research has yet combined the PBL model and the team teaching method as a solution in learning for vocational schools. The collaboration involves mathematics teachers and at least one vocational teacher as a learning resource. An implementation of PBL-team teaching has been carried out in the technology & industry group of Vocational Schools in the district of Cirebon. This study is a quasi-experiment with a pretest-posttest control group design. It involves one medium-level and low-level school. Each sample was taken randomly in two classes experiment is PBL-Team Teaching and PBL, and one control class is the conventional model. Descriptive statistical analysis was used in this study. The result shows that the increase in mathematical logic and creative thinking ability of students who used PBL-team teaching was higher than students in PBL and conventional models. PBL-team teaching requires sufficient preparation for teachers. That is, to collaborate in teaching and transferring their knowledge. In addition to solving problems, it is necessary to prepare students' initial knowledge.

1. Introduction

There are several level dimensions of ability needed by industry. That is, the ability to think logically, to solve problems, to use technical logic and reasoning [1]. However, the ability to think critically and creatively is also essential [2–4]. For developing the industry, it needs innovating in improving the quality and competition of products. There is some literature of the ability to think logically and creatively [5–16]. It explains that the ability to think logically and creatively influences the success of students [17–19]. Wakefield & John F’s [20] illustrates the relationship between the interests of vocational and cognitive skills. They explore through the field of study. The results of the research stated the correlation between logic thinking, insight, idea, and creative thinking. Meanwhile, Russell [21] shows that mathematics is the key that allows a person to develop. Graduates who come to the industry are those who have basic mathematical skills and conceptual abilities. So, it can be embedded in practice and adopted in any workplace. However, many company leaders find that young workers cannot apply the mathematical concepts they have learned to overcome workplace problems. Therefore, it is critical to package learning in vocational schools that are suitable for industry needs.
Having the ability to think logically means that students can think in a coherent and sensible way based on objective facts obtained from a literature review of topics learned in a hierarchical manner from general things to more specific things [22–24]. Creativity is a product of creative thinking through good and right ways [25–27]. The results of this study concluded that learning by filing the problem yet improve four aspects of the ability to think creatively students, especially flexibility in solving the problem. But for aspects of understanding to problem information, novelty and fluency in answering questions has increased [28].

Research on PBL in Vocational High Schools has been carried out [29]. But no research has yet combined the PBL model, and the team teaching method as collaboration involves mathematics teachers and at least one vocational teacher as a learning resource. In general, people will interpret learning resources as in the form of textbooks or reading books. But Sadiman, et al. classify learning resources into people, messages, materials, tools, techniques, and environments [30]. However, the integration of cognitive knowledge and vocational skills is needed by vocational students [31, 32].

Goetz conducted observations for 1 year at NCTM and found that 2 teachers who collaborated collaboratively in learning were said to be effective [33]. According to Asmani, the purpose of implementing team teaching is to streamline the teaching and learning process [34].

PBL-team teaching is carried out following PBL learning steps with team teaching methods. PBL-team teaching in learning mathematics in vocational schools involves one mathematics teacher and at least one vocational teacher. Team teaching method is a method of teaching conducted by more than one teacher [33–35]. PBL learning steps enable vocational students to get real problems according to the vocational program they choose. The representation or stimulation of the problem is made narrative referring to contextual, real, and authentic problems.

2. Method
This research is a quasi-experimental study, with the design of the pretest-posttest control group. In its implementation, this study uses three groups of students. A first group is a group of students who get learning using the PBL model with the team teaching (as experimental-1) method, a second is a group of students who use the PBL (as experimental-2) model, and the third is the group that uses conventional learning models (as control). The three groups come from two schools that have different levels, that is, the middle and low school level. The initial ability of students is grouped into upper, middle, and lower.

The instrument used in the study is a test of logical and creative thinking that has construct and content validation. The question of logical thinking tests used corresponds to geometric material for 15-year-old students. Test questions refer to geometry competencies based on the high school curriculum. The type of test in this study is subjective in the form of descriptions but in each question contains a hint. The objective is the students can use their logical abilities to the fullest. Through the problem in the form of an essay, it will focus to the technique or method of students in solving problems that aim to know the thinking process, see the steps of work, and the accuracy of students in answering questions. Descriptive statistical analysis was used in this study.

3. Results and discussion
The result of the study shows the ability to logically & creative thinking in students at school is at medium and low levels for all groups. In general, based on the students' initial ability, school level, and the use of learning models, the average logical thinking ability of students who get PBL-Team teaching learning is higher than PBL and conventional. Descriptive statistics concerning students’ gain mathematics logically and creative thinking ability can be seen in the following Table 1.
Table 1. Description of gains a student’s mathematical thinking dan creative ability

| Description | N   | Minimum | Maximum | Mean  | Std. Deviation |
|-------------|-----|---------|---------|-------|----------------|
| GAIN_LOGIS_PBLT | 71  | .23     | 1.00    | .7004 | .18534         |
| GAIN_LOGIS_PBL  | 77  | .00     | 1.00    | .6647 | .22508         |
| GAIN_LOGIS_Kv   | 77  | .04     | .64     | .2360 | .14846         |
| GAIN_KREATIF_PBLT | 71  | .11     | .91     | .4803 | .16981         |
| GAIN_KREATIF_PBL | 77  | -3.83   | 5.67    | .4710 | 1.12609        |
| GAIN_KREATIF_Kv | 77  | -.26    | .73     | .2166 | .19865         |

The picture of improving logical thinking skills based on the use of learning models, school levels, and mathematical initial abilities is shown in Figures 1, 2, and 3. While the picture of increasing creative thinking skills in Figures 4, 5, 6.

**Figure 1.** The average increase in the ability to think logically based on the use of the Learning Model.

**Figure 2.** An average increase in Logical Thinking ability based on school level & use of learning models.

Figure 1 illustrates that the use of PBL-Team teaching models contributes to a higher capacity increase when compared to PBL and Kv models. From a logical thinking ability according to the use of the learning model, the average score of students who got learning with the PBL-TT model increased by 0.70 (moderate). Students who got the PBL model increased by 0.66 (moderate) and students who received conventional learning increased by 0.24 (low). Based on school level, logical thinking ability is depicted in Figure 2. At the middle school level, the overall PBL-Team teaching model provides a higher capacity improvement compared to PBL and Kv models. However, this is not the case in low schools. the overall ability of students who use PBL models is slightly better than students who use PBL-Team teaching and Kv models.
If viewed from the level of initial ability of students, overall Figure 3 provides an illustration that increasing logical thinking ability is higher for students with high levels. Based on the initial ability, the overall average score of students' logical thinking ability increased by 0.49 (moderate) for low-level students and 0.65 (moderate) for high-level students. It shows that the score will be higher for students with better initial abilities. When viewed as a whole, increasing the ability to think logically through the use of the PBL-Team teaching model is relatively higher for high-level students. Whereas for students at the medium level, the difference in improvement was not too much difference between students who used PBL-TT models and students who used PBL models.

As well as the ability to think logically, Figure 4 illustrates the overall ability to think creatively using the learning model and the results show that the average increase in creative thinking skills of students who use PBL-Teaching models is better than the group of students who use PBL and Konvensional models. But if viewed from the school level, Figure 5 illustrates that the increase in the average creative thinking ability of students at medium level schools using the PBL-Team teaching model is better than PBL and Kv while at the low school level PBL contributes the best in improving thinking skills creative.
The description of the data of increasing creative thinking ability in general shows that the average increase in students' creative thinking skills using PBL-TT models is 0.48 and PBL is 0.47. The increase of a students' creative thinking skills in PBL-TT and PBL classes are both at a moderate level. The increase of a students' creative thinking skills using conventional models is 0.22 (low). Based on the school level, it appears that PBL-TT provides an increase of 0.51 at medium level schools. Whereas for low-level schools, the biggest increase occurred in the class that received the PBL model which is 0.46. They are both in the medium category. From the scores of creative thinking abilities based on students' initial abilities, overall increased by 0.35 (moderate) for low-level students, 0.47 (moderate) for medium-level students, and 0.29 (low) for high-level students.

![Figure 6](image)

**Figure 6.** The average score of Gain on creative thinking skills based on MIA and the use of learning models

From Figure 6, the highest increase in creative thinking abilities is achieved by students with moderate levels. Some research results on PBL, show that increased ability does not interact with initial abilities [36–38]. Overall, the use of PBL-Team teaching relatively provides a higher increase for students at high levels. Whereas for students with moderate and low levels, the most significant increase occurred in students who received PBL models.

4. **Conclusion**

Overall description, the improvement of students' logical and creative thinking abilities who receive PBL-TT and PBL models is not much different. In general, the higher the level of initial ability, the higher the student's ability to increase. These results provide an explanation that the creativity of students develops not based on initial abilities. Provision of the right stimulus, able to make low-level students have increased creativity over students at high levels. However, the use of PBL-TT models can improve students' overall creative thinking ability both regarding their initial abilities and school level.

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