Introduction

Indicators of the low quality of education can be seen from the strategies, methods, models and teaching methods implemented in learning activities. In general, the learning process at the secondary school level tends to use conventional learning such as lectures, assignments, using textbooks which are more dominated by teachers in the learning process. One of the innovative teaching models that can be implemented in science learning is problem-based learning (PBL) (Suhirman et al., 2021). Problem-based learning is a student-centred approach and requires prior general knowledge. Students are more active in obtaining information from various sources. Since it was first implemented until now, problem-based learning has become one of the methods that has received considerable attention in Indonesia, especially in the world of secondary and higher education (Suhirman, et al., 2020), and is a solution to improve the quality of learning in the fields of science, technology, engineering, and mathematics (STEM) (Hidayatulloh, et al., 2020).

Until now, to promote higher order thinking and problem solving for students in authentic learning situations, problem-based learning has been used, and it has been adopted in various educational and learning contexts (Yew & Goh, 2016). Along with the development of learning practices using PBL in various
learning settings there has been an increasing number of studies examining its effectiveness in developing students’ thinking skills (Suhirman, et al., 2020). Previous studies have even investigated the effect of PBL in the learning curriculum (Dochy, et al., 2003), and the most popular is the implementation of PBL which leads to more optimal learning outcomes (Dolmans, et al., 2005). The result is that the application of PBL is able to improve and develop knowledge, competence, problem-solving and communication skills (Delaney, et al., 2017). In PBL, students work together in groups to find and solve problems. In this context, it prioritizes the suitability of learning with things found in everyday life (Nuswowati, et al., 2017). This is in line with the implementation of the 2013 Curriculum (K-13) in Indonesia which recommends learning to be carried out with a scientific approach through PBL.

PBL is a learning model designed in a learning procedure that begins with a specific problem (De Witte & Rogge, 2016). PBL requires students to develop knowledge independently or work together in study groups to find solutions to an authentic problem. Problems that are complex, contextual and ill-structured will provide opportunities for students to develop their thinking skills and develop their creativity in digging up various information, developing various possible solutions, and creating various sources to solve problems (Tsai & Chiang, 2013). Proponents of PBL claim to have been able to improve the quality of the learning process and are more effective at acquiring long-term knowledge when compared to conventional learning (Strobel & van Barneveld, 2009). This is further researched to develop creative thinking skills (Elizabeth & Sigahitong, 2018; Mirawati, et al., 2017).

Creative thinking is one of the 21st century thinking skills in addition to critical thinking, communication skills, collaboration, and problem solving (Prayogi, et al., 2018a, 2018b, 2019; Prayogi & Verawati, 2020; Verawati, Hikmawati, et al., 2019; Verawati, Prayogi, et al., 2019; Verawati & Hikmawati, 2019; Wahyudi, et al., 2018, 2019a, 2019b). An indication of educational progress in some developed countries is when students are able to think creatively (Warton, et al., 2018). Creativity is shaped by a person’s cognitive ability to solve problems and generate new ideas that is rarely thought of by others (Boltz, et al., 2015). Students’ creative thinking abilities can develop with a stimulus, and this is usually facilitated by the teacher in the learning process with effective learning designs (Clinton & Hokanson, 2012). In this study we explored the effect of the PBL model on students’ creative thinking ability.

Method

The type of research used is quasi-experimental. A quantitative approach in a quasi-experimental approach is used to determine the effect of the independent variable (treatment) on the dependent variable (outcome) under controlled conditions. The research sample consisted of 70 students (n = 70) from one of the secondary schools in the city of Mataram, West Nusa Tenggara, Indonesia. The sample was divided into two classes, each of 35 students as the experimental group and 35 students as the control group. The experimental group was given learning treatment using the PBL model, while the control group was given conventional learning (lectures and questions and answers).

Learning is carried out on physics material in the motion sub-material in four meetings (excluding pretest and posttest). The pretest-posttest was conducted in both groups (experimental and control) with a creative thinking ability test instrument consisting of 8 items that accommodate Torrance’s creative thinking indicators on aspects of fluency, flexibility, originality, elaboration (Mullen Raymond, 2017). Each indicator consists of two question items. Scores of students' creative thinking ability were analyzed using a multilevel scale (five scales) adapted from the scoring technique of Verawati, et al (Verawati, et al., 2021) with the lowest score -1 (minus one) and the highest +3 (plus three). Furthermore, the creative thinking scores (CRs) of each student were interpreted into categories, as presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Interpretation CRs into categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score range</td>
</tr>
<tr>
<td>CRs &gt; 17.6</td>
</tr>
<tr>
<td>11.2 ≤ CRs ≤ 17.6</td>
</tr>
<tr>
<td>4.8 ≤ CRs ≤ 11.2</td>
</tr>
<tr>
<td>1.6 ≤ CRs ≤ 4.8</td>
</tr>
<tr>
<td>CRs ≤ 1.6</td>
</tr>
</tbody>
</table>

Analysis of increasing creative thinking scores using the n-gain equation. Data on students' creative thinking abilities were analyzed descriptively by using SPSS v.23, where the normality test, homogeneity test, and analysis of variance were calculated for each group.

Result and Discussion

The results of the students' creative thinking ability test showed an increase in creative thinking ability after learning with the PBL model, as shown in Table 2 and Figure 1.
Table 2. Creative thinking test result

<table>
<thead>
<tr>
<th>Sample group</th>
<th>N</th>
<th>Pretest</th>
<th>Criteria</th>
<th>Posttest</th>
<th>Criteria</th>
<th>N-gain</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>35</td>
<td>0.41</td>
<td>Less creative</td>
<td>17.37</td>
<td>Creative</td>
<td>0.72</td>
<td>High</td>
</tr>
<tr>
<td>Control</td>
<td>35</td>
<td>0.46</td>
<td>Less creative</td>
<td>3.74</td>
<td>Less creative</td>
<td>0.14</td>
<td>Low</td>
</tr>
</tbody>
</table>

The results in Table 2 show that in the pretest the creative thinking ability score was 0.41 with less creative criteria, and this increased after learning treatment using PBL to 17.37 with creative criteria. It is different with the control group, where in the pretest and posttest students' creative thinking ability remain on the criteria of being less creative. The increase in the score of creative thinking ability in the experimental and control classes, respectively, was 0.72 (high criteria) and 0.14 (low criteria). The results in Table 1 also show explicitly that creative thinking ability can be improved with the PBL model, meanwhile with conventional learning (lectures and questions and answers) creative thinking ability cannot be improved.

Furthermore, the results of statistical tests (analysis of variance) were carried out to evaluate the differences in students' creative thinking abilities between the two groups (experimental and control), this was preceded by normality and homogeneity tests as presented in Table 3. While the results of the analysis of variance were presented in Table 4.

Table 3. The summary of the result of normality and homogeneity test

<table>
<thead>
<tr>
<th>Group of data</th>
<th>Kolmogorov-Smirnov N</th>
<th>Sig.</th>
<th>Levene’s Test N</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest of CR ability</td>
<td>70</td>
<td>0.200</td>
<td>0.000</td>
<td>0.981</td>
</tr>
<tr>
<td>Posttest of CR ability</td>
<td>70</td>
<td>0.200</td>
<td>0.960</td>
<td>0.320</td>
</tr>
</tbody>
</table>

Table 4. The results of one-way anova analysis

<table>
<thead>
<tr>
<th>Group</th>
<th>Df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1</td>
<td>1836.413</td>
<td>608.187</td>
<td>0.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>68</td>
<td>3.134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of this study have achieved the objectives that have been formulated previously. Based on the results of the study, it can be concluded that the PBL model has a more significant impact on students' creative thinking ability than conventional learning (p < 0.05). Finally, based on the results of this study, we encourage the use of the PBL model in classroom-learning, especially for the purpose of training students' creative thinking ability.

Conclusion

The results of this study have achieved the objectives that have been formulated previously. Based on the results of the study, it can be concluded that the PBL model has a more significant impact on students' creative thinking ability than conventional learning (p < 0.05). Finally, based on the results of this study, we encourage the use of the PBL model in classroom-learning, especially for the purpose of training students' creative thinking ability.
Acknowledgments

We give our highest appreciation to those who have contributed to this study, especially the research team.

References


