The Effect of Problem-Based Learning Model Integrated Dual Coding Theory On Numeracy Literacy Learning Outcomes Of Growth and Development of Living Things Material

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ABSTRACT

This study aims to obtain information on the effect of Problem Based Learning (PBL) model integrated with Dual Coding Theory (DCT) on learning outcomes of numeracy literacy on the material of growth and development of living things. The subjects of this study were students of SMAN 4 Kendari class XI.J and XI.M. The research design used quasi-experiment with nonequivalent control group design. Sampling using probility sampling technique. Indicators of numeracy literacy learning outcomes measured are, analyzing data or information, explaining, and drawing conclusions. Data analysis techniques using descriptive analysis and inferential analysis. The results of descriptive analysis showed that the average increase in numeracy literacy learning outcomes of students taught using the PBL model integrated DCT (treatment class) obtained a result of 84.1 and the PBL model (control class) obtained an average value of 74.9. The results of hypothesis testing show that t count = 4.237 > t table = 1.690 which means that there is a significant effect of the PBL model integrated with DCT on the numeracy literacy learning outcomes of students on the material of growth and development of living things.

Introduction

The learning independence curriculum emphasizes the importance of improving learners' abilities in reasoning and problem-solving through learning. One strategy is to train learners to develop their literacy and numeracy skills. This ability is very important for learners to have to face job competition in the global era (NSW Government, 2016). Numeracy literacy is the ability to use numbers from data to draw conclusions and apply them in everyday life. Literacy includes the knowledge and skills learners need to access, understand, analyze, and evaluate information, make meaning, express thoughts and emotions, convey ideas and opinions, interact with others, and participate in activities at school and in learners lives outside school (Han et al., 2017). Mastery of numeracy literacy is very important because it is a basic ability that provides the basis for learning other more complex skills (Arifin, et al., 2023). Success in any field of learning relies on the ability to use numeracy literacy significantly, as it has a very close link to problem solving (Lestary & Ghullam, 2022).

Based on the results of the national assessment 2022 as outlined in the 2023 education report card, it shows that only about 49.26% of high school students have literacy skills above the minimum, and 41.14% have numeracy skills below the minimum (Kemendikbud, 2023). In addition, the results of PISA in 2022, the numeracy literacy achievement of Indonesian students was ranked 68th out of 81 participants with a score of 366 (OECD, 2023). When compared to the numeracy literacy results in 2018, Indonesia ranked 73rd out of 79 participants with a score of 379 (OECD, 2018). From this data, it is clear that the numeracy literacy ranking in Indonesia has increased by 5 levels. However, the increase in rank was not accompanied by the score obtained where it can be seen that Indonesia's score fell from 379 to 366. The increase in the PISA ranking in 2022, even though the score dropped by 13 points, is still relatively low compared to other countries, whose average decrease is as much as 18 points .

The emphasis on the application of PBL learning in the independent curriculum is one of the efforts to improve students' numeracy literacy skills. The advantages of the PBL learning model, according to Ati & Setiawan (2020) are applying contextual learning, presenting authentic problems in students' daily lives, identifying problems and finding the best solution to minimize the problem. In addition, PBL leads students to be able to communicate the findings of the best solution to the problem that has been solved. The PBL learning model encourages authentic problems to be the focus of learning, with the aim that students can solve related problems, thus students are trained to have high numeracy literacy and critical thinking (Masliah, et al., 2023).

The reality in the field shows that the application of PBL has not been maximized in training students' numeracy literacy skills. So far, students in presenting the results of their work from problem-solving activities generally still tend to read on cellphones or laptops. It seems that students do not master the material they present. A solution is needed by innovating learning from PBL applied so far, so that students are expected not only to read but also should be able to understand what they read and communicate well the material they present. The solution is to implement PBL integrated with DCT.

DCT (dual coding theory) is a theory that describes how information can be stored in human memory through two different types of codes or representations, namely verbal codes and visual codes. This theory was put forward by Allan Paivio in his book entitled Imagery and Text A Dual Coding Theory of Reading and writing. Paivio argues that the use of both types of representations in information processing results in better memory performance (Mark & Allan, 2009). DCT is a method that provides learners with oral and visual materials at the same time. Cognitive psychologists have identified the most effective learning strategies for improving long-term memory and dual encoding. Learning materials can be represented visually in various ways such as graphic organizers, flow charts, diagrams, cartoon strips, editable timelines, and infographics (Main, 2021).

In learners' numeracy literacy, DCT can be applied by presenting mathematical information through text and visual representations, such as graphs, diagrams, or illustrations. By providing information through two modes (text and visual representation), learners have a greater chance of developing their numeracy literacy more effectively. Based on a study conducted by Liu, et al. (2020) revealed that visual aids such as pictures should be presented to help learners be more positive in learning words, which will greatly affect their studies. In DCT, learners are expected to be accustomed to explaining an image or data displayed according to their thoughts without having to read. Results from Hayikaleng (2019) and a study conducted by Aryanto (2021) revealed that the DCT method can improve learners' recall and reading comprehension skills.

PBL and DCT models have the potential to provide a more effective and in-depth learning experience in numeracy literacy. Both approaches have unique characteristics that can complement each other to improve students' understanding and learning outcomes. So one of the efforts

in improving literacy learning outcomes is by combining the PBL learning model with the DCT method. The main purpose of this study is to obtain answers to the problem of how far the effect of Problem-Based Learning Model integrated with Dual Coding Theory on Numeracy Literacy Learning Outcomes of Growing and Developing Living Things at SMAN 4 Kendari.

Method

The subjects of this study were students of SMAN 4 Kendari class XI.J and XI.M. The research design used quasi-experiment with nonequivalent control group design. Sampling using probility sampling technique. Indicators of numeracy literacy learning outcomes measured are, analyzing data or information, explaining, and drawing conclusions. Design of the research is described in Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Treatment Class	O_1	X_1	O_3
Control Class	O_2	X_2	O_4

Source : (Cohen, L., Lawrence, M., & Keith, 2018)

Description:

X_1 : Treatment group taught with integrated PBL model dual coding theory

X_2 : Control group that learns with PBL model

O_1 : group pretest score

O_2 : Posttest score of group

O_3 : group pretest score

O_4: Control group posttest score

The instrument used in this study is a multiple choice test instrument of 20 items in accordance with the numeracy literacy indicators studied based on Han, et al. (2017) namely, processing/analyzing data explaining/interpreting the results of data then and making decisions/making conclusions from the material of growth and development of living things. The test instrument used was previously validated by three experts, namely two expert lecturers and one biology teacher.

The data obtained from this study were analyzed using descriptive analysis and inferential analysis. Descriptive analysis is used to describe the state of the sample in the form of average (X), variance (S2), standard deviation (S), maximum value (Max), minimum value (Min) and N-Gain. The N-Gain test analysis was conducted to determine the magnitude of the increase in students' numeracy literacy learning outcomes using the average N-Gain value. This test is done by calculating the difference between pretest and posttest scores in experimental and control classes. The formula used in N-Gain testing is as follows:

$$N - Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Maksimal - Skor\ Pretest}$$

(Novita, et al., 2019)

The inferential analysis carried out is to test the hypothesis with the t test. The steps of the t test are data normality test, data homogeneity test, determining the hypothesis to be tested, and determining the T_{count} and T_{table} values. Hypothesis testing decision making is done with the test criteria if $t_{count} > t_{table}$ then H_1 is accepted and H_0 is rejected.

Results and Discussion

The results showed that the DCT integrated PBL model had a significant effect on improving students' numeracy literacy learning outcomes compared to using the PBL model alone. This result can be seen from the N-Gain graph where the learning outcomes of numeracy literacy in the material of growth and development of living things using the DCT integrated PBL model have an N-Gain value of 0.69 higher than the PBL model which has an N-Gain value of 0.45.

Table 2. N-Gain Results of Numeracy Literacy on the Growth and Development of Living Things Using the DCT Integrated PBL Model and PBL Model

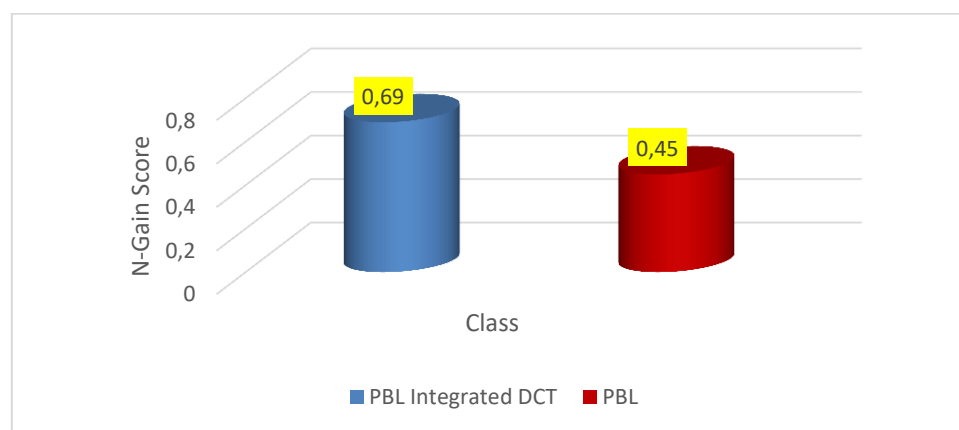| Class	Normalized N-Gain	Category
PBL Integrated DCT	0,69	Medium
PBL	0,45	Medium

Figure 1. Graph of N-Gain Results of Numeracy Literacy on the Growth and Development of Living Things Using the DCT Integrated PBL Model and PBL Model

This is most likely due to the combination of PBL and DCT models utilizing the strengths of problem-based learning and dual utilization of visual and verbal representations in strengthening understanding and retention of information. In addition, the effect of increasing students' numeracy literacy learning outcomes is most likely also due to the DCT method helping students in understanding and remembering numeracy literacy concepts which in this study are in the form of pictures, graphs and experimental data learned through the PBL model. Learners are required to be able to understand what they get deeper and explain what they have gotten in the presentation session. In the presentation session, students display the results of problem solving that have been obtained with pictures and also key words which are then further explained. Samburskiy (2020) states that utilizing the power of the human brain to process information visually and verbally can increase memory retention and understanding. In this model, learners are faced with real problems that require deep understanding using various forms of information representation (text, images, graphics, and tables). Integrating DCT with PBL allows learners not only to receive verbal information, but also to visualize and analyze problems and present them. Mastery of the material on the growth and development of living things can be seen in

the presentation; learners show a richer and deeper understanding.

The results of the study of several researchers also found that, using pictures, graphs, experimental data and words to understand information, students can more easily connect numeracy concepts with their applications in everyday life, thereby increasing students' ability to analyze and use numeracy information (Aprilia, et al., 2021). In line with the findings of Wulandari (2023) who revealed that the strategy of using image media can improve student learning outcomes in other words, the strategy can be used as a strategy in teaching biology to improve student understanding in the lesson. In addition, Riswo (2017) stated that pictures, graphs and charts provide opportunities for students to discuss in looking at pictures, graphs and charts to get problem solving which can then be communicated. Khoirunisa et al. (2023) also explained the advantages of using the DCT method, namely students get references and motivation to learn by using symbols and words in understanding information. DCT, which focuses on using symbols and words to understand information, can help learners understand the concept of numeracy literacy well. The PBL model, which is based on solving real problems, makes it possible to apply numeracy concepts in relevant and diverse contexts, so that learners can develop broader and more effective numeracy literacy skills in analyzing and using numeracy information (Maharyati, 2022). In line with that, Abdullah & Zaenal (2023) stated, the use of PBL models actually has a positive impact in helping to improve students' numeracy literacy skills, but sometimes in its application it often only focuses on complex problem solving and critical thinking skills in general.

The results of the *N-Gain* analysis of each indicator of numeracy literacy learning outcomes studied on the material of growth and development of living things found that of the three indicators, namely analyzing information, explaining and making conclusions showed that the explanation indicator had a high category. These results can be seen in Figure 3 where the three indicators of numeracy literacy using the PBL model integrated with DCT show that the highest indicator is the explanation indicator which is 0.78 with a high category, while the indicators of analyzing information and making conclusions get N-Gain scores of 0.63 and 0.69 respectively in the medium category. In the PBL model, the N-Gain results obtained by each indicator are analyzing information 0.44, explaining 0.47, and making conclusions 0.43 in the medium category.

Table 3. N-Gain Results of Each Indicator of Numeracy Literacy on the Growth and Development of Living Things Using the DCT Integrated PBL Model and PBL Model

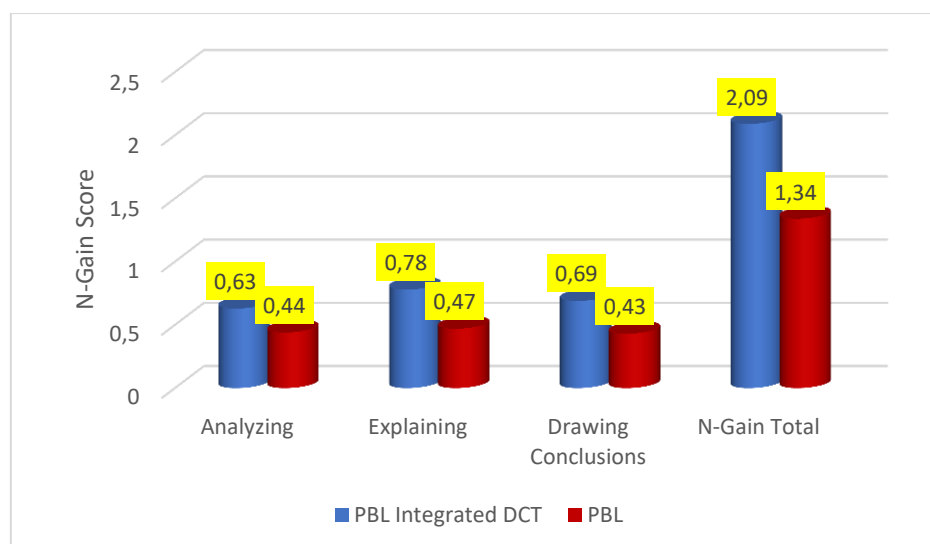| Indicator	Model PBL Terintegrasi DCT		Model PBL	
	Normalized N-Gain	Category	Normalized N-Gain	Category
Analyzing	0,63	Medium	0,44	Medium
Explainng	0,78	High	0,47	Medium
Drawing Conclusions	0,68	Medium	0,43	Medium

Figure 2.Graph of N-Gain Results of numeracy literacy indicators on the material of growth and development of living things using PBL integrated DCT model and PBL Model

The increase in the explanation indicator is because DCT uses a combination of visual and verbal to build a stronger mental representation. In the research conducted by Kanellopoulou, et al. (2019) stated that learners can learn more effectively if presented with words and images than words alone. PBL integrated with DCL allows learners to use visualization and symbolism to understand more complex concepts to explain the solution of the problem in more detail and accurately (Pajriah & Budiman, 2017). The PBL model integrated with DCT is implemented by using problems that combine text and visuals on the material of the growth and development of living things. The PBL model integrated with DCT can be used simultaneously to improve students' numeracy literacy skills. In PBL, the problems given to learners are designed to include visual elements that support learners' numeracy literacy understanding. For example, problems involving data analysis are accompanied by tables, graphs and diagrams that learners need to interpret. DCT helps learners understand numeracy concepts better, while PBL allows learners to apply numeracy concepts in relevant and diverse contexts, and improve their ability to analyze and use numeracy information. This study has limitations, namely only limited to the material of the growth and development of living things with three face-to-face meetings. It is important to conduct research in a planned and widespread manner on all materials that allow learners to get used to, so that their numeracy-literacy skills improve.

Conclusion

Based on the results of the above research, it can be concluded that the application of the DCT integrated PBL model significantly improves the learning outcomes of students' numeracy literacy in the material on the growth and development of living things in class XI at SMAN 4 Kendari. Integrating PBL and DCT can be an option in improving students' numeracy literacy learning outcomes in other materials. Therefore, similar research needs to be well planned and expanded on all appropriate learning materials.

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