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Looking at the effect of TaRL-integrated CBL on students' scientific literacy skills: What we can learn?

Annisa Ibrahim*, Ervan Johan Wicaksana, Fitri Astriawati
Universitas Jambi, Jl. Jambi-Muara Bulian, KM. 15, Mendalo Darat, Jambi Luar Kota, Muaro Jambi, Indonesia
*Corresponding e-mail: annisaibrahim22@gmail.co.id

Abstract

In the 21st century, scientific literacy is essential for students to face the complexity of global problems that require scientific understanding in decision-making. PISA data shows Indonesia's low scientific literacy. In 2018, it ranked 74th out of 79 countries with a score of 396 (40% of students only reached level 1), and in 2022, it dropped to 69th out of 81 countries with a score of 383 (34% of students at the elementary level). Less than 1% of Indonesian students reached levels 5-6 in both periods. Efforts to optimize scientific literacy were carried out by implementing a case-based learning (CBL) model integrated with the teaching at the right level (TaRL) approach. A quasi-experimental study was conducted at SMAN 1 Kota Jambi with the topic of the immune system using a non-randomized pretest-posttest control group design. The sample was selected using purposive sampling in grade XI, consisting of an experimental class (CBL-TaRL, n=36) and a control class (CBL, n=36). The results showed that the average score of the experimental class increased from 54.17 to 85.28, while the control class increased from 50.69 to 68.61. The one-way ANCOVA test showed a significant difference [$F(1,69)=27.560$, $p<0.001$, $\eta p^2=0.28$] with a large effect size. Students taught using CBL-TaRL had a higher increase in scientific literacy, especially in the aspects of analyzing scientific phenomena (36%) and designing scientific investigations (34%).

Keywords: case-based learning model, science literacy skills, teaching at the right level

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INTRODUCTION

In the 21st century, science and technology have advanced rapidly, including the development of scientific concept understanding in learning (Sutrisna, 2021). This is related to learning demands that emphasize skills such as 4C (critical thinking, creativity, communication, and collaboration). These skills need to be based on scientific concept understanding, such as science literacy, to support students' abilities in facing the demands of the 21st century (Bagus et al., 2022). The importance of science literacy in education is to ensure that every decision made by students is based on scientific evidence relevant to everyday life so that they do not make wrong decision.

Science literacy is the ability to use scientific knowledge based on four dimensions, such as the context knowledge dimension, the competency dimension, the knowledge dimension, and the attitude dimension, according to PISA (Programme for International Student Assessment) (OECD, 2023). Individuals with science literacy skills tend to have a high cognitive level and are able to meet learning demands such as critical and creative thinking. However, in reality, the result of PISA conducted by the OECD (Organization for economic Co-operation and development) (OECD, 2019), show that in 2018, Indonesia ranked 74th out of 79 countries with a score of 396, where 40% of students were only able to reach level 1 or below. In 2022, Indonesia ranked 69th out of 81 countries with a score of 383, with 34% of students at the basic level. Almost no Indonesian students (less than 1%) reached levels 5-6 in both periods, indicating a lack of development of gifted students in science. This data shows that Indonesia's science literacy skills are still classified as low. This indicates that students lack critical thinking skills in desicion making, have difficulty developing analytical skills, and are unable to meet the various demands of the 21st century (Huryah et al., 2017).

Based on preliminary observations in the form of interviews conducted with one of the biology teachers at SMA Negeri 1 Kota Jambi, the results of the interviews with biology teachers stated that students only focused on the theoretical understanding of the learning material and still needed to improve their skills in evaluating phenomena in the environment, drawing conclusions based on scientific data, and designing investigations related to biology learning. Furthermore, the selection of the body's defense system material in this study was based on several considerations. First, the results of interviews with teachers showed that students had significant difficulties in understanding abstract concepts in this material, such as specific and non-specific immune response mechanisms, the role of antigens and antibodies, and the process of phagocytosis. Second, students had difficulty relating theoretical concepts to health phenomena they encountered in their daily lives, such as the wound healing process, allergic reactions, the mechanism of vaccines, and the importance of maintaining the immune system during a pandemic. Third, the characteristics of the immune system material, which is rich in real-life cases, allow for the optimal application of the CBL model, where students can analyze various phenomena such as cases of autoimmune diseases, immune system failure, or the effectiveness of immunization. Fourth, this material has varying levels of complexity, ranging from basic concepts (lymphoid organs) to advanced concepts (adaptive immune mechanisms), making it suitable for the application of the TaRL approach, which accommodates the diversity of students' cognitive levels.

Case Based Learning (CBL) is a learning model that uses real cases as a context for learning, where students analyze complex situations, identify problems, and develop solutions based on their knowledge (Arasti et al., 2024). This model encourages active learning through discussion, critical analysis, and evidence-based decision making. However, biology teachers explained that the CBL model has not been optimally implemented in biology learning due to time constraints in identifying students according to their individual abilities. This contributes to low science literacy among students. The learning model used should be able to facilitate students in developing their ability to analyze and draw conclusions from scientific phenomena. To optimize the application of the learning model, it needs to be integrated with a learning approach that is able to meet students' needs, such as the Teaching at the Right Level (TaRL) approach.

The TaRL approach is a learning approach that aims to ensure that learning materials are delivered according to the students' level of understanding. This approach has three main stages: assessment (assessment of students' initial abilities), grouping (grouping students based on cognitive level), and catch up (learning tailored to the abilities of each group, Paiticen et al. (2024), which informs that the TaRL approach divides students into small groups based on their cognitive level so that they can develop systematic thinking and scientific reasoning skills. The TaRL approach can be implemented based on learning planning in accordance with the principle of differentiation, which is to meet the diverse needs of students based on content, process, and product (Minasari & Susanti, 2023). The TaRL-integrated CBL model facilitates learning because it uses real-life cases adapted to students' cognitive levels and abilities (Padli et al., 2024). Therefore, the TaRL-integrated CBL model can be an appropriate solution for implementing differentiated learning to optimize students' science literacy in biology learning.

RESEARCH METHOD

This research is a quasi-experiment using a non-randomized pretest-posttest control group design (Leedy & Ormrod, 2021). The choice of a quasi-experimental design was based on the researcher's limitations in conducting full randomization of the research subjects because the research subjects were classes that had been formed naturally at school. Ethical considerations in education prevented the researcher from freely randomizing individuals from existing classes. This study involved two groups: one experimental group that applied the TaRL integrated CBL model and one control group that only applied the CBL model. The control group served as a reference in analyzing the changes that occurred due to the difference in treatment with the experimental group. This type of research can accurately test hypotheses related to cause and effect causal (Harahap et al., 2021). The purpose of this study is to measure the cause and effect of the independent variable (x), namely the application of the integrated CBL model TaRL, on the dependent variable (y), namely science literacy skills in biology learning. The research design is shown in Table 1.

Table 1. Research design

Sample Collection	Group	Pretest	Treatment	Posttest
Non-random	Experiment	O_1	CBL-TaRL	O_2
Non-random	Control	O_3	CBL	O_4

In an effort to control confounding factors, researchers took several control measures: (1) ensuring that both classes were taught by the same teacher, (2) using identical learning materials, (3) conducting lessons during the same time period, and (4) using equivalent classroom facilities. Thus, differences in results can be attributed more to the treatment given.

Population and sample

The population in this study was grade XI phase F students who studied biology at SMAN 1 Kota Jambi in the 2024/2025 academic year. Then, from the class population, two homogeneous classes were selected, each of which was used as an experimental class to implement the integrated TaRL CBL model in differentiated learning and a control class to implement learning using the Case Based Learning (CBL) model with a contextual approach. The distribution of the grade XI phase F student population is shown in Table 2.

Table 2. Population of Grade XI Phase F at SMAN 1 Kota Jambi

Class/Phase	Number of Student
XI F.1	36
XI F.2	36
XI F.5	36
XI F.6	36
XI F.7	36
XI F.9	36
Total	216

Sampling technique

Purposive sampling was used to select two classes with similar characteristics, such as the number of students and average scores. This technique was chosen to consider the normality and homogeneity of the students' cognitive assessment results in each class in biology learning. The classes used as samples had to meet the normality and homogeneity tests, both of which could be performed using SPSS software version 27. The results obtained from the normality and homogeneity tests showed that four classes met the assumptions of both tests, and then a draw was conducted to determine two classes as the experimental and control classes. The research sample is shown in Table 3.

Table 3. Research sample

Group	Class	Number of Students
Control	F6	36
Experiment	F5	36

Research instrument, data collection, and data analysis

In this study, data collection was divided into three stages (interviews, tests, and data analysis). The initial stage consisted of interviews with biology teachers in grade XI, which served as the first step to determine the actual conditions at the research location (Sugiyono, 2020). Then, essay tests in the form of pre-tests and post -tests were used in accordance with science literacy indicators. These tests were used to compare students' initial abilities before and after the intervention. Subsequently, the data findings were analyzed. The science literacy indicators used were based on OECD (2023).

Table 4. Indicators of competency aspects

No.	Science Literacy Competency Aspect	Science Literacy Indicators
1	Analyzing phenomena scientifically	Analyzing scientific phenomena in accordance with existing knowledge. Proving a phenomenon using scientific reasoning appropriately.
2	Designing and evaluating scientific investigation designs and interpreting data.	Designing elements of scientific investigation. Analyzing scientific evidence based on findings and drawing conclusion.
3	Researching, evaluating, and using scientific information in decision making	Summarizing information from the internet and drawing conclusion in accordance with scientific studies. Evaluating phenomena that pose risk to decision making.

The research instrument consisted of an essay test with 12 questions compiled based on science literacy indicators, which were then validated through validity, reliability, difficulty level, and discrimination tests. The validity of the questions through the Pearson correlation test showed that only 10 questions were valid with a Pearson correlation value ≥ sign value. The reliability test using Cronbach's Alpha showed that the reliability of the science literacy ability questions (a = 0.848) was high. The difficulty level test showed that the questions used to measure science literacy ability were in the 0.31-0.70 interval, indicating that the questions used had a moderate level of difficulty. The results of the discrimination power test showed that item number 3 met the criteria and could be used, 2 items met the criteria and could be used, and 5 items met the criteria and could be used.

Data analysis

The Ancova test was used to determine the extent of the influence of the integrated TaRL CBL model on science literacy skills. The Ancova test can be performed using the SPSS for Windows application. According to (Yennita et al., 2024), the assumptions that must be met in a one-way Ancova test include: (1) The dependent variable is a scale or ratio. (2) The independent variable is a scale or ratio with categorical data that groups the data into at least two groups that are not related. (3) Independent observations. (4) No significant outliers are visible. (5) Residual data is normally distributed. (6) One group has homogeneous variance with another group. (7) There must be a linear relationship between the covariate and the dependent variable. (8) Homogeneity of regression curvature.

The results of the One Way ANCOVA test assumptions inform us that the dependent variable in this study is interval data, namely science literacy scores. The independent variables are nominal/categorical data from the control class and the experimental class. This study was conducted independently of observations. No student science literacy scores were found to be very low or very high or to have a score range that was very different from their group. Based on this explanation, the first, second, third, and fourth assumptions have been met. The Shapiro-Wilk test results indicate that the science literacy data residuals are normally distributed [W(72) = 0.989, p = 0.778], so it can be concluded that the fifth assumption of the One Way ANCOVA test is met, as shown in Table 5.

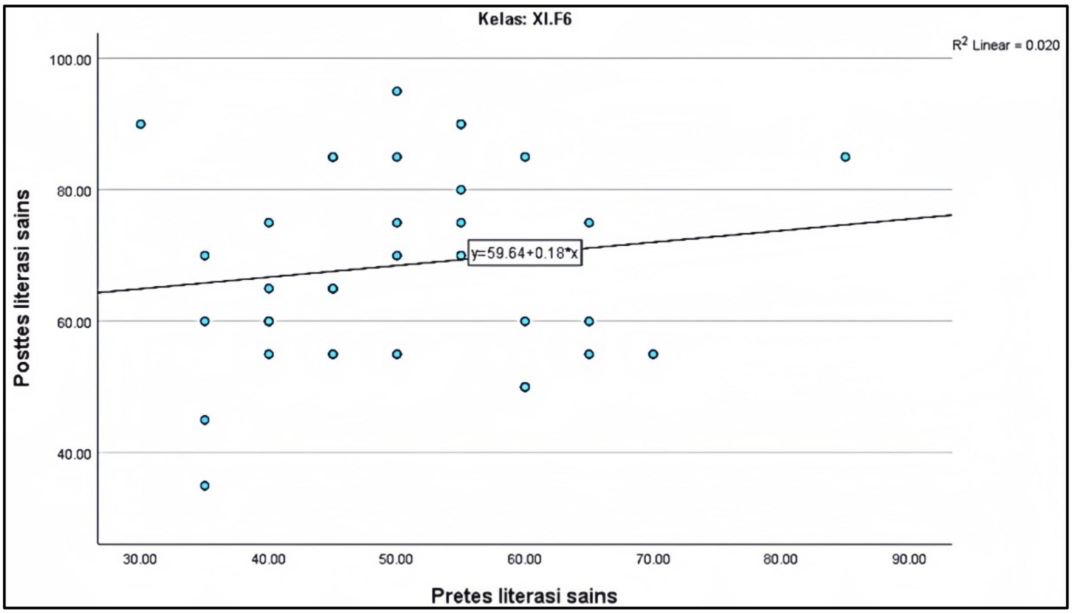
Table 5. Test of normality of posttest science literacy data residuals

Description	Shapiro-Wilk			Description
	Statistic	df	Sig	
Residual Science Literacy Data	0.989	72	0.778	Normal

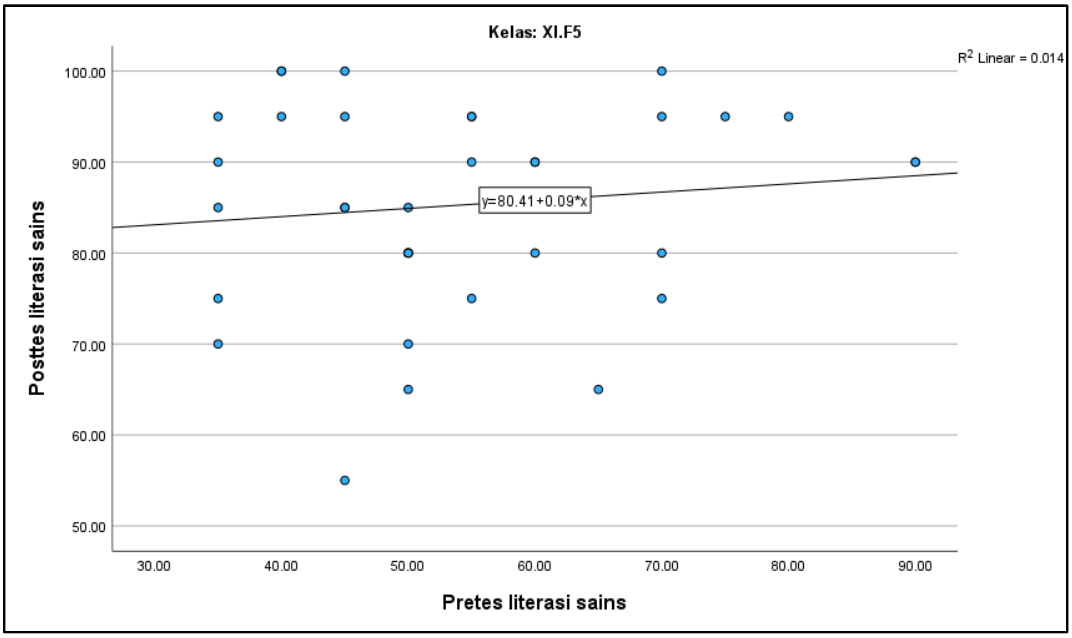
Table 6. Results of the science literacy homogenity test

Description	Levene's Test				Description
	F	df1	df2	Sig	
Science Literacy Data	2.718	1	70	0.104	Homogeneous

In the next assumption, Levene's Test results in Table 6 indicate that the variance of science literacy data between one class and another is homogeneous (F(1,70) = 2.718, p = 0.104], so the sixth assumption of the One-Way ANCOVA test is fulfilled. The Scatter Plot in Figure 1 informs us that the pre-test data (covariate) is linear to the post-test science literacy data (dependent variable), thus fulfilling the seventh assumption of the One-Way ANCOVA test.



(a)



(b)

Figure 1. Linearity between the covariate and the dependent variable in the control class (a) and the experimental class (b)

The next assumption to be met is homogeneity of regression slopes in both classes, as shown in Table 7.

Table 7. Results of the homogeneity of regression slopes test

Description	Test of Between-Subject Effect					Description
	TYPE III Sum of Squares	df	Mean Square	F	Sig.	
Science Literacy Pretest Class	22.759	1	22.759	0.133	0.717	Homogeneous
Error	116.619	68	171.499			

Based on Table 7, the test results show that the regression slope of the pretest data with the posttest data on science literacy between the experimental class and the control class is homogeneous [F(1,68)= 0.133. P= 0.717], concluding that the eighth One Way ANCOVA test is fulfilled.

RESULTS AND DISCUSSION

The research conducted at SMAN 1 Kota Jambi involved two classes as control and experimental classes during three meetings. This study only measured aspects of competence in science literacy using material on the body's defense system in its application. The results obtained from the research are as follows.

Description of science literacy ability data

The science literacy skill data consists of the pretest and posttest scores for the control and experimental classes in Table 8.

Table 8. Science literacy scores

Description	Control Class		Experiment Class	
	Pretest	Posttest	Pretest	Posttest
Total	36	36	36	36
Mean	50.69	68.61	54.17	85.28
Standard Deviation	11.78	14.57	15.00	11.27
Minimum	30.00	35.00	35.00	55.00
Maximum	85.00	95.00	90.00	100.00

Based on Table 8, there were 36 students in the control class and 36 students in the experimental class. The average pretest score in the control class was 50.69, while the average pretest score in the experimental class was 54.17.

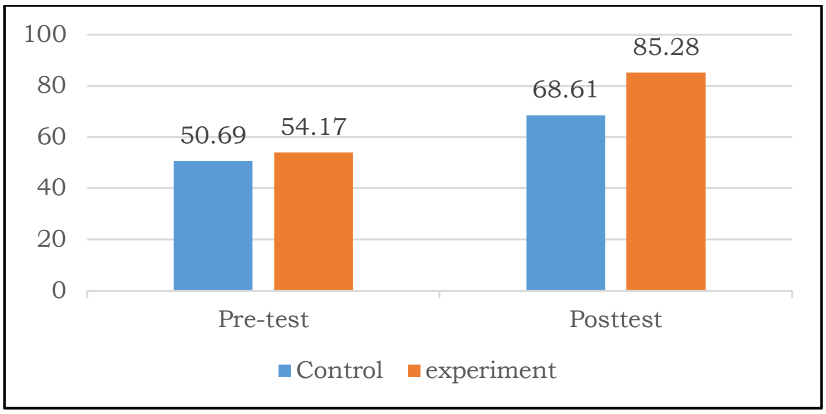


Figure 2. Comparison of control and experimental class scores

The average posttest score in the control class was 68.61, while the average posttest score in the experimental class was 85.28. The comparison of science literacy scores is shown in Figure 2.

The science literacy ability measured was in terms of competency. To determine the comparative effect of applying the TaRL-integrated Case Based Learning (CBL) model and applying CBL alone on science competency, the average scores of students in each aspect were calculated. The results of the calculation are shown in Table 9.

Table 9. Achievement of science literacy aspects

Science Literacy Competency Aspect	Learning Model	Pretest	Posttest	Improvement
Analyzing phenomena scientifically	CBL-TaRL	62.4%	98%	36%
	CBL	59.2%	81.6%	22.4%
Designing and evaluating scientific investigation designs and interpreting data	CBL-TaRL	64%	98%	34%
	CBL	57.6%	79.6%	22%
Researching, evaluating, and using scientific information in decision making	CBL-TaRL	14.8%	24.6%	9.8%
	CBL	14.6%	18.2%	3.6%

Based on Table 9, the lowest improvement in the aspect of researching, evaluating, and using scientific information in decision making was 3.60% in the CBL model, while the highest improvement in the aspect of analyzing phenomena scientifically was in the integrated CBL TaRL model. The distribution of science literacy achievement is shown in Figure 3.

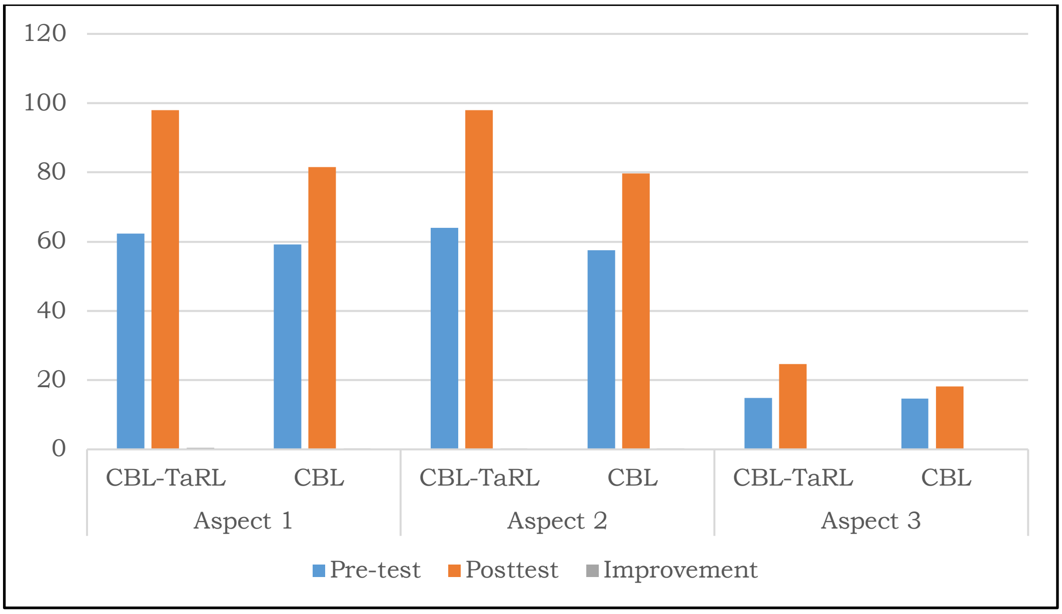


Figure 3. Comparison of science literacy achievement

Science literacy scores in the experimental class with the application of the TaRL-integrated Case-Based Learning (CBL) model with student grouping based on low, medium, and high cognitive levels are shown in Table 10.

Table 10. TaRL science literacy scores

Competency Aspect	TaRL Group	Pretest	Posttest	Improvement
Analyzing phenomena scientifically	Low (A)	52.80	77.08	24.28%
	Moderate (B)	55.56	83.33	27.77%
	High (C)	53.13	92.71	39.58%
Designing and evaluating scientific investigation designs and interpreting data	Low (A)	52.80	83.33	31.00%
	Moderate (B)	54.86	84.72	29.86%
	High (C)	58.33	86.46	28.13%
Researching, evaluating, and using scientific information in decision making	Low (A)	54.17	83.33	29.16%
	Moderate (B)	45.83	87.50	42.00%
	High (C)	58.33	83.33	25.00%

Science literacy scores in the application of the TaRL approach in the experimental class were grouped based on low, medium, and high cognitive levels. The highest increase in the first aspect was in group C with 39.58%, in the second aspect the highest increase was in group A with 31%, and in the third aspect the highest increase was in group B with 42%. The distribution of TaRL group scores is shown in Figure 4.

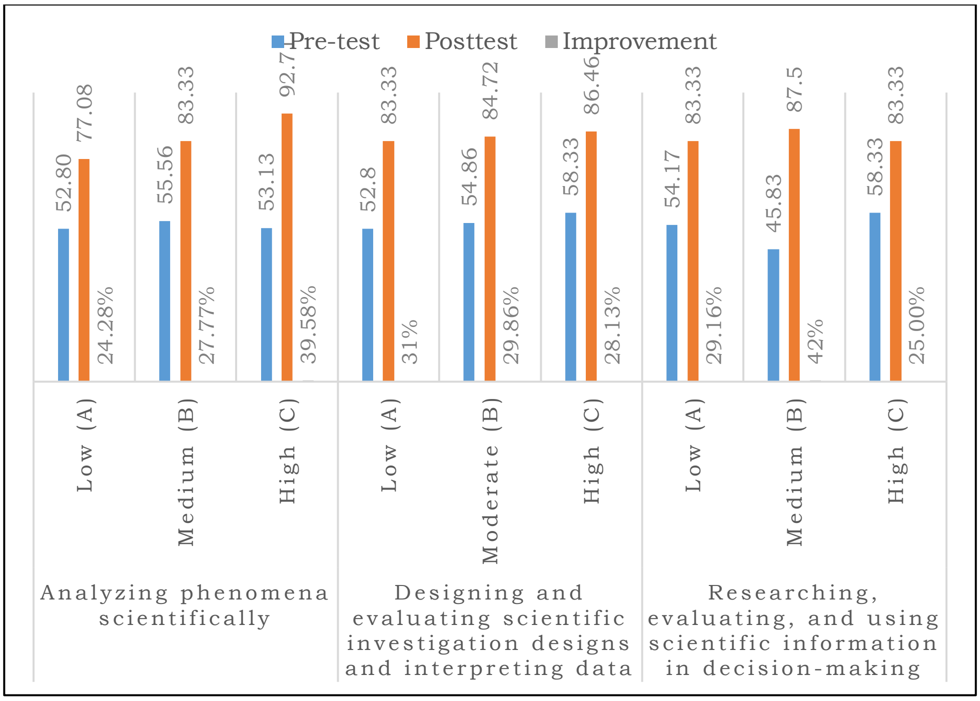


Figure 4. TaRL group scores

Data analysis

The one-way ANCOVA test can be used after eight assumptions are met. After the prerequisite tests have been met, the science literacy data can be analyzed using the One-Way ANCOVA test. The test results are shown in Table 11.

Tabel 11. One-Way ANCOVA Test

Description	Test of Between-Subject Effect						
	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Description
Class	4667.177	1	4667.177	27.560	<0.001	0.28	Highly influencing
Error	11684.668	69	169.343				

The results in Table 11 indicate that there is a significant difference in science literacy between the control class and the experimental class, controlling for the students' initial science literacy [F(1,69)= 27.560, p <0.001, np2 = 0.28]. These results indicate that the application of the TaRL-integrated Case Based Learning (CBL) model has a significant and highly effective impact on improving students' science literacy skills based on the effect size value obtained (eta squared = 0.28) compared to the application of CBL alone.

Discussion

The application of the TaRL-integrated CBL model provides learning that can develop students' abilities according to their cognitive level and diversity of material according to the needs of each student. This contributes to facilitating students in carrying out case-based learning that is relevant to everyday life to practice science literacy skills such as explaining scientific phenomena, making predictions using scientific reasoning, understanding the elements of scientific inquiry, evaluating and analyzing scientific phenomena. These aspects are basic skills that need to be possessed to face the demands of the 21st century (OECD, 2023). The interconnection among the TaRL, CBL, and science literacy is presented in Table 12.

The research was conducted by at SMAN 1 Kota Jambi in the even semester of the 2024/2025 academic year. The research was conducted three times in each of the selected sample classes with the same material, namely the body's defense system. The samples used were class XI F6 as the control class and class XI F5 as the experimental class. In preparation for the research, the researcher prepared validated and suitable learning tools for use in the study.

During the research, science literacy skills were measured through a pretest before applying the learning model in both the control and experimental classes. The pretest results for the control class were 50.69 and for the experimental class were 54.17. Then, learning was conducted in three meetings, after which students were given a posttest to see the difference from the application of the TaRL approach used in learning. The post-test results obtained from the control class were 68.61 and the post-test results from the experimental class were 85.28. These results show that the post-test scores in the experimental class were much higher than those in the control class.

The application of the Case Based Learning (CBL) model with a contextual approach in the control class allowed students to be actively involved in discussions to solve the cases given during the learning process, then connect theory with practice so as to increase students' knowledge (Widyasari et al., 2023). In the research implementation, students were divided into six small groups with the same cases and assignments. Group members were selected based on their heterogeneous cognitive abilities so that each group had a diversity of cognitive levels among students.

Table 12. Interconnection among TaRL, CBL, and science literacy

TaRL Approach	CBL Syntax	Science Literacy Indicators (Competency Aspects)	Interconnection
Grouping based on cognitive results from the pretest (Asessment)	Student orientation to the case	Analyzing scientific phenomena accordance with existing knowledge.	Students are directed to fulfill competency aspects by being oriented towards cases based on varied material.
		Making accurate predictions using scientific reasoning.	Case orientation will require students to make predictions based on scientific reasoning according to the material presented.
Presenting varied assignments (Grouping)	Organize student groups on cases.	Understanding the elements of scientific inquiry design.	Grouping based on cognitive level will make it easier for students to understand the competency aspects according to the cases that have been given.
Modify the difficulty level (Catch Up)	Guiding the Investigation	Analyze scientific evidence based on data findings and draw conclusions.	Students are given the opportunity to analyze scientific evidence based on reading sources, in this section the difficulty level of the case has been modified according to the cognitive level.
	Presenting the findings/discussion results.	Able to research information from the internet and draw conclusions in accordance with scientific studies.	Students are directed to be able to research the information obtained and draw conclusions so that they are able to present their findings.
	Analyze and evaluate.	Evaluate phenomena that pose a risk to decision making.	Students are given the opportunity to evaluate phenomena and analyze the decisions taken.

In terms of analyzing phenomena scientifically, the control group showed the highest increase of 22.40%. This increase occurred because in the first and second syntaxes of CBL, namely student orientation to the case and organizing student groups for learning, students were asked to summarize the meaning of the case presented. This treatment gave students the opportunity to understand cases relevant to their real lives. In this syntax, students did not experience significant difficulties, which encouraged their enthusiasm in analyzing phenomena scientifically. When students are able to analyze phenomena scientifically, they will indirectly be able to identify the cases faced (OECD, 2019).

In terms of designing and evaluating scientific investigation designs and interpreting data, there was a 22% improvement in the control class. This number was influenced by the application of the third and fourth syntaxes, namely guiding scientific investigations and presenting findings. In the learning process, groups of students were directed to answer questions related to the cases in the worksheet and then summarize them in the form of posters. This activity provided students with the opportunity to search for the information needed to complete the assignment, design the findings, and evaluate the assignment given. Scientific investigation is an important part for students to design effective and efficient work procedures in order to obtain information to be used as arguments for scientific solution (Mushlich & Sunarmi, 2025)

In terms of researching, evaluating, and using scientific information in decision-making, there was an increase of 3.60%, which was the lowest increase in the control class. In the assignment in syntax 3, students should be able to use scientific information appropriately so that they can make appropriate decisions. The low achievement in this aspect indicates the complexity of summarizing information, which requires high-level cognitive skills. In learning, students had difficulty determining the validity of scientific information from various sources, especially the internet, resulting in making inappropriate decisions in solving the case (Faiza & Wulandari, 2023). Although the CBL model should be able to provide opportunities for students to integrate knowledge with problems in cases to practice decision making (Kementerian Pendidikan Kebudayaan Riset dan Teknologi, 2023)

The measurement of science literacy in this study focused on three aspects of competence according to the PISA framework: (1) analyzing phenomena scientifically, (2) designing and evaluating scientific investigation designs and interpreting data, and (3) researching, evaluating, and using scientific information in decision-making. These aspects were implemented in the application of the TaRL Integrated Case-Based Learning (CBL) model. The stages of implementing learning using the TaRL Integrated Case-Based Learning (CBL) model in this study were as follows.

The first syntax is student orientation to the case, where the case selection is the same for all groups and is adjusted to the material being taught. In the implementation of the research, no significant obstacles were found in its implementation because students could be directed to focus on the cases presented. In this syntax, students have the opportunity to analyze scientific phenomena and practice their ability to draw the right conclusions from the cases presented. The second syntax is organizing student groups for learning. At this stage, students are grouped based on their cognitive level, which is an integration of TaRL and CBL, thus creating an optimal constructivist learning environment. The CBL model presents authentic cases that are relevant to students' lives, while TaRL ensures that each student can process these cases according to their cognitive abilities (Padli et al., 2024). Researchers accompany student groups and distribute LKPD according to the cognitive level of the students, with group A consisting of students with low cognitive abilities, group

B consisting of students with moderate cognitive abilities, and group C consisting of students with high cognitive abilities.

In terms of analyzing scientific phenomena, group A had a posttest score increase of 24.28%, group B had an increase of 27.77%, and group C had an increase of 39.58%. These variations in posttest results show that group C outperformed the other two groups. The study found that in learning, group C was often more proactive in asking questions and actively involved in solving cases. This finding shows that the application of TaRL enables students to analyze scientific phenomena according to their cognitive level. The high achievement in this aspect can be explained by the characteristics of the CBL model, which presents real cases that encourage students to analyze biological phenomena systematically. In the experimental class, the application of TaRL enabled the assignment of analysis tasks in accordance with the students' cognitive levels, so that each group could optimally develop their scientific reasoning skills. This is in line with (Adi et al., 2024).

The treatment in the second syntax had an impact on improving the aspects of designing and evaluating scientific investigation and interpreting data. The division of tasks based on cognitive level allowed students to design investigations according to their abilities, so that they were more accurate in describing the elements of scientific investigation (Abdullah et al., 2025). In learning, groups of students are directed to join groups that have been determined by the teacher according to their cognitive abilities. Group A experienced the highest increase of 31%, group B 29.86%, and group C 28.13%. These findings inform us that the cognitive level of students divided based on level does not necessarily determine that low abilities will always have low increases as well. These findings are supported by Paiticen et al. (2024) who state that the TaRL approach divides students into small groups based on cognitive level so that they are able to think systematically and have better scientific reasoning skills. The TaRL approach shows higher effectiveness because tasks can be tailored to the abilities of each group.

The third syntax is guiding investigation, where assignments are differentiated based on group divisions in accordance with the characteristics of the TaRL approach. At this stage, students are directed to answer questions related to cases according to their cognitive level. In the assignment, they are required to be able to determine valid information so that they do not make wrong decisions in completing the assignment. The treatment in the third syntax affects the aspects of researching, evaluating, and using scientific information in the TaRL group. Group A had an increase of 29.16%, group B had the highest increase of 42%, and group C had the lowest increase of 25%. These results are in line with Chakrabarti et al. (2018) who stated that cognitive development is related to students' intellectual potential in thinking and problem solving. TaRL facilitates this development by providing challenges that are appropriate to each student's abilities so that students do not experience gaps with their groupmates (Erlinkha et al., 2023).

These findings add new insights and complement the research by Sutrisna, (2021) which states that the ability to evaluate scientific information is the most difficult aspect of science literacy because it requires a deep understanding of the epistemology of science and high-level critical thinking skills. Syntax 4 is presenting the findings. At this stage, everything went smoothly, and each group was able to present their findings well. Then, ending with syntax 5, the student groups reflected on the difficulties and challenges they faced during the learning process.

During the research, there were several challenges and obstacles faced, such as: (1) The preparation of learning tools took longer because students had to be grouped according to their cognitive abilities. (2) When integrating the TaRL section into the CBL syntax, it was necessary to pay attention to the suitability of the case variations given in the LKPD in accordance with the aspects of competence in science literacy. (3) In the experimental class, group A was often distracted and uncomfortable with their group members.

These obstacles can be overcome by taking the following steps: (1) Understanding the elements needed in developing learning tools and adjusting them to the model and approach used. (2) Dividing assignments according to students' cognitive levels. (3) Providing more frequent assistance to students who have difficulty understanding the assignments.

This finding provides important insight that the integration of TaRL with CBL, although effective overall, still requires specific reinforcement in the aspect of scientific information evaluation. This is in line with the results of Paiticen et al. (2024) research, which shows a gradual increase in science literacy skills with an increase of 2.9% in cycle 1 and 6.2% in cycle 2, indicating that more time is needed to develop these complex skills.

In this study, the CBL model was integrated with the TaRL approach. The Teaching at The Right Level (TaRL) approach is designed to help students develop basic skills such as literacy by grouping students based on their ability levels rather than their grade levels. Learning is tailored to the achievements, ability levels, and needs of students in order to achieve the expected learning outcomes (Banerji & Chavan, 2016).

The results of this study provide a theoretical contribution that the integration of the TaRL approach with problem-based learning models such as CBL can significantly improve the effectiveness of science learning. These findings reinforce the theories of differentiated learning and constructivism in the context of science education in Indonesia. Practically, this study shows that teachers can implement learning that accommodates student diversity without lowering learning standards. The TaRL-integrated CBL model can be an effective learning alternative to improve student science literacy, especially in facing the challenges of student heterogeneity in the classroom. These results are also in line with the research Yuli et al., (2023) which shows that TaRL can increase students' interest in learning biology, with an increase in the percentage of very high criteria to 2.9% in cycle 2, whereas previously no students had achieved this criterion in cycle 1.

CONCLUSION

The conclusions of this study are as follows. The application of the TaRL-integrated Case Based Learning model had a significant effect on students' science literacy skills, with a pretest average in the experimental class of 54.17 and an increase in the posttest average score to 85.28. The highest aspect of science literacy competence in this study was analyzing scientific phenomena, with an increase of 36% in the experimental class.

The magnitude of the effect of applying the TaRL-integrated Case Based Learning model through a parametric test in the form of One Way ANCOVA is [F(1, 69) = 27.56, p<0.001, n*p^2 = 0.28], indicating that there was a significant and highly effective influence in improving students' science literacy skills based on the effect size value obtained (Eta-squared = 0.28).

Although this study shows positive results, it should be acknowledged that quasi-experimental designs have limitations in controlling all confounding variables. These findings provide strong indications of the effectiveness of the learning model, but further validation is needed through studies with more rigorous designs and more representative samples.

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