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# THE EFFECT OF READING, QUESTIONING, AND ANSWERING (RQA) STRATEGY WITH PROBLEM BASED LEARNING MODEL TO IMPROVE STUDENTS' HOTS SCIENCE LITERACY ABILITY ON THERMOCHEMISTRY

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## Abstract

This research aims to determine the effect of integrating the Reading, Questioning, and Answering (RQA) strategy with the Problem-Based Learning (PBL) model in improving students' Higher-Order Thinking Skills (HOTS) and science literacy in thermochemistry. The background of this research is the low science literacy and critical thinking skills of students, as evidenced by Indonesia's low scores in international assessments such as PISA and TIMSS. This study uses a quantitative method with a pre- experimental one-group pretest-posttest design on 11th-grade science students. The research instrument is a 20-item multiple-choice test validated to measure three HOTS cognitive levels (Analyzing, Evaluating, Creating) and nine science literacy indicators. The results showed a significant improvement in learning outcomes ($p < 0.001$), with the average pretest score of 34.84 increasing to 68.87 in the posttest. The Normalized gain (N-Gain) value is 0.52, falling into the moderate category. The analysis also showed a significant increase in students' understanding; for example, the ability to distinguish scientifically investigable questions increased from 0% to 70.97%. Despite improvements in analytical and evaluative skills, students continue to struggle with mathematical calculations related to quantitative data. In general, the combination of RQA and PBL methods is effective in helping students understand the material through independent reading and questioning before class, thereby enhancing their readiness to critically address real-world problems in the classroom.
**Keywords:** RQA strategy, PBL model, HOTS literacy

## INTRODUCTION

Education in the 21st century learning places greater emphasis on students' abilities to formulate problems, explore, think analytically, and collaborate in solving them [1]. However, current education suffers from low student absorption due to traditional, teacher-centered methods that focus on knowledge transfer rather than skill development. To build these essential skills, teachers must shift to a student-centered learning approach [2].

Students in the 4.0 era must have basic skills or proficiency with the term 4C: Critical Thinking, Communication, Creativity, and Collaboration, as they play a critical role in equipping them to face future challenges and solve problems logically [3]. The main problem in learning in schools today is low student absorption. This is directly reflected in persistently low achievement of science literacy and HOTS, students are not yet able to analyze and apply concepts to solve problems. Students are still focused on memorization and are less skilled in applying their knowledge. So it is very important for teachers to direct students to do literacy so that they are able to think at a high level or HOTS [4].

In the learning process, teachers have not used a supportive learning model in explaining the material, and students already think that chemistry lessons are abstract and difficult to understand because there are many words and terms that are rarely heard. Its make students are less active in the learning process, they tend to be passive [5]. To solve these problems, the application of Reading-Questioning-Answering (RQA) strategy with the Problem Based Learning model will be carried out in the learning process to improve students' literacy and critical thinking skills.

The RQA strategy emphasizes students' activeness in discovering knowledge based on their

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learning experiences. The reading stage trains seriousness in understanding the material and finding substantive information, which ultimately trains analytical and critical thinking skills. Next, the stage of formulating questions in writing is useful for digging up information and testing previous ideas, thus improving the ability to explain. The last stage is to answer the questions that have been made, where students build relationships between concepts and manage their thought processes through research, experiments, or discussions to strengthen understanding [6]. Then, the problem-based learning model (PBL) is effective in improving the quality of learning if all stages are followed correctly. This model not only empowers but also hones and tests students' critical thinking skills through hands-on experience so as to encourage them to learn actively, creatively, and critically. PBL integrates the 4C principle and is considered to be able to meet the demands of 21st century education. By encouraging students to solve problems and look for solutions, which makes them achieve an understanding of the problems and solutions they find [7].

Based on the aforementioned problems, a strategic instructional intervention is required to overcome students' difficulties in understanding thermochemistry. Therefore, this research implements the Reading, Questioning, Answering (RQA) learning strategy combined with the Problem Based Learning (PBL) model to address these educational challenges. And its to determine the effect of integrating the Reading, Questioning, and Answering (RQA) strategy with the Problem-Based Learning (PBL) model in improving students' Higher-Order Thinking Skills (HOTS) and science literacy in thermochemistry.

## METHOD

This study is a quantitative research using a quasi-experimental method. The specific design used is the Pre-Experimental "One-Group Pretest-Posttest" design. This design was chosen to compare students' abilities before and after receiving the treatment. The students' initial scores were measured using a pretest ($X_1$), then the students were given a treatment consisting of learning with the RQA strategy and the PBL model (T), and finally, they took a posttest ($X_2$) to measure the improvement.

This research was conducted at one of the State Senior High School in Medan. The population consisted of all 11th-grade science students, and this research used cluster random sampling. Through this technique, the XI Borland 2 class, consisting of 31 students, was selected as the single experimental class.

The data collection instrument was a written test in a multiple-choice format with five answer options (A, B, C, D, E). To determine the quality of the questions, analyzed with :

1. Difficulty Level (*P*): Indicates the percentage of students who answered correctly. Ideal questions fall into the moderate (index 0.31 - 0.70) and difficult (0.21 - 0.30) categories to properly measure HOTS.
2. Discriminating Power (*D*): Assesses the ability of a question to differentiate between high-ability and low-ability students. A good discriminating power index ranges from 0.20 to 0.80.
3. Distractor Effectiveness: Incorrect answer options are considered functional if they are chosen by at least 5% of the students.
4. Validity : Item validity was calculated using Pearson correlation. With $\alpha = 0.05$ and $N = 30$, the $r_{table}$ value is 0.361. A question is valid if $r_{count} > 0.361$.
5. Reliability Tests : Test reliability was calculated using the Kuder-Richardson 20 (KR-20) formula.

Data analysis techniques for this research are normality test, hypothesis test with paired t-test and next the result compared again with ngain and average percentage calculation for result of distribution question for each HOTS cognitive domain and 9 science literacy indicators to identify which aspects experienced the greatest improvement.

## RESULTS AND DISCUSSION

The empirical validation stage of the initial 34 questions resulted in 20 suitable questions. The tabulation results are presented in Figure 1.

| Question Number | Difficulty Level | Differentiation Test | Distractor | Validity | Reliability |
|---|---|---|---|---|---|
| 1 | Difficult | Bad | Qualify | Invalid | Reliable |
| 2 | Very Difficult | Bad | Not eligible | Invalid | Reliable |
| 3 | Easy | Enough | Not eligible | Invalid | Reliable |
| 4 | Currently | Not enough | Not eligible | Invalid | Reliable |
| 5 | Very easy | Not enough | Not eligible | Valid | Reliable |
| 6 | Easy | Good | Qualify | Valid | Reliable |
| 7 | Very easy | Not enough | Qualify | Valid | Reliable |
| 8 | Currently | Enough | Not eligible | Invalid | Reliable |
| 9 | Easy | Enough | Not eligible | Valid | Reliable |
| 10 | Currently | Good | Qualify | Valid | Reliable |
| 11 | Currently | Bad | Qualify | Invalid | Reliable |
| 12 | Very Difficult | Bad | Not eligible | Invalid | Reliable |
| 13 | Difficult | Bad | Not eligible | Invalid | Reliable |
| 14 | Easy | Good | Qualify | Valid | Reliable |
| 15 | Currently | Good | Qualify | Valid | Reliable |
| 16 | Currently | Good | Qualify | Valid | Reliable |
| 17 | Currently | Good | Qualify | Valid | Reliable |
| 18 | Easy | Not enough | Not eligible | Valid | Reliable |
| 19 | Currently | Good | Qualify | Valid | Reliable |
| 20 | Currently | Good | Qualify | Valid | Reliable |
| 21 | Currently | Good | Qualify | Valid | Reliable |
| 22 | Currently | Good | Qualify | Valid | Reliable |
| 23 | Very easy | Enough | Not eligible | Valid | Reliable |
| 24 | Easy | Good | Not eligible | Valid | Reliable |
| 25 | Very Difficult | Bad | Qualify | Invalid | Reliable |
| 26 | Currently | Good | Qualify | Valid | Reliable |
| 27 | Currently | Good | Qualify | Valid | Reliable |
| 28 | Easy | Good | Not eligible | Valid | Reliable |
| 29 | Very Difficult | Bad | Qualify | Invalid | Reliable |
| 30 | Difficult | Bad | Qualify | Invalid | Reliable |
| 31 | Very Difficult | Bad | Qualify | Invalid | Reliable |
| 32 | Very Difficult | Bad | Not eligible | Invalid | Reliable |
| 33 | Easy | Good | Qualify | Valid | Reliable |
| 34 | Difficult | Bad | Not eligible | Invalid | Reliable |

Figure 1. Tabulation Results

The research implementation was divided into three stages. During the Preparation Stage, the researcher developed learning tools (Learning Objective Flow and Lesson Plans). During the Implementation Stage, the experimental class students were given a pretest (20 questions) to measure their baseline ability. Then, the students were taught using the RQA strategy and PBL model over several meetings. Once the material was completed, students were given the exact same questions as a posttest to measure their learning improvement.

Based on the results of administering the 20-question test to the 31 students in the experimental class, there was a very clear difference in results before and after the treatment. The students' pretest and posttest scores are presented in Table 1.

Table 1. Data of Students Pretest and Posttest

| N | Pre | Post |
|---|---|---|
| 1 | 55 | 90 |
| 2 | 30 | 65 |
| 3 | 35 | 45 |
| 4 | 25 | 65 |
| 5 | 55 | 75 |
| 6 | 15 | 75 |
| 7 | 50 | 70 |
| 8 | 35 | 55 |
| 9 | 45 | 75 |
| 10 | 40 | 80 |
| 11 | 35 | 55 |
| 12 | 15 | 50 |
| 13 | 30 | 50 |
| 14 | 30 | 75 |
| 15 | 30 | 65 |
| 16 | 50 | 90 |
| 17 | 30 | 90 |
| 18 | 40 | 80 |
| 19 | 50 | 90 |
| 20 | 20 | 50 |
| 21 | 20 | 75 |
| 22 | 45 | 75 |
| 23 | 20 | 35 |
| 24 | 40 | 70 |
| 25 | 45 | 90 |
| 26 | 40 | 85 |
| 27 | 50 | 75 |
| 28 | 50 | 75 |
| 29 | 25 | 40 |
| 30 | 15 | 65 |
| 31 | 15 | 60 |

During the pretest, the lowest score obtained by a student was 15, and the highest score only reached 55, the class average was 34.84. This very low average score proves that before the learning intervention, students' understanding of thermochemistry was extremely deficient. Students were unfamiliar with HOTS type questions and did not grasp the basic concepts of thermochemistry. After students participated in the learning process using the RQA strategy and the PBL model, the posttest results showed a drastic improvement. The lowest score rose to 35, and the highest score reached 90. The class average score increased to 68.87. The average scores of students are presented in Table 2.

Table 2. Average Scores of Students

| Evaluation Phase | Min Score | Max Score | Average Score | N |
|---|---|---|---|---|
| Pretest | 15.00 | 55.00 | 34.84 | 31 |
| Posttest | 35.00 | 90.00 | 68.87 | 31 |

The increase in the average score, as well as the minimum and maximum scores, proves that the applied learning method successfully helped improve the understanding of students across all academic ability levels in the class.

Prior to testing the hypothesis, a Normality Test was performed employing the Shapiro-Wilk method. A normality test was conducted as a prerequisite for the statistical analysis to assess whether the data followed a normal distribution. The results are presented in Table 3.

Table 3. Normality Test Results

| Treatment | Shapiro-Wilk Statistic | df | Sig. | Information |
|---|---|---|---|---|
| Pretest | 0.934 | 31 | 0.057 | Normal |
| Posttest | 0.939 | 31 | 0.076 | Normal |

The findings from table 4 indicated a significance value (Sig.) of 0.057 for the pretest and 0.076 for the posttest. Since both values exceed 0.05, it can be inferred that the research data follow a normal distribution.

Once the data was confirmed to be normally distributed, the Paired-Samples T-Test was performed to determine the significance of the difference. The results of the paired samples t-test are presented in

Table 4. Paired Sample T-Test Results

| Treatment | Sig. (2-tailed) | Remark |
|---|---|---|
| Pretest & Posttest | $p < 0.001$ | there is significant difference |

Since the *P* value is much smaller than 0.05, the null hypothesis ($H_0$) is rejected, and the alternative hypothesis ($H_a$) is accepted. Statistically, the students' posttest scores proved to be significantly higher than their pretest scores. This confirms that the improvement in student learning outcomes was genuinely caused by the application of the integrated RQA and PBL learning methods, not by chance.

Although the t-test proved the existence of a significant difference, it did not indicate the magnitude of the applied learning's effectiveness. Therefore, the Normalized Gain (N-Gain) value was calculated based on the average pretest score (34.84) and the posttest score (68.87). The calculation results showed an N-Gain value of 0.52 (or 52.2%) it means include in moderate category.

Next, to view the detailed improvement in student understanding, the data was analyzed based on the three cognitive levels of HOTS : Analyzing (C4), Evaluating (C5), and Creating (C6). The distribution of HOTS aspects is presented in Table 5.

Table 5. Distribution of HOTS Aspect

| HOTS Aspect | Item Number | Pretest Average (%) | Posttest Average (%) | N-Gain Score | Category |
|---|---|---|---|---|---|
| Analyzing (C4) | 1, 6, 10, 11, 13, 14, 18, 19 | 29.03 | 58.47 | 0.415 | Moderate |
| Evaluating (C5) | 2, 4, 7, 8, 12, 15, 17, 20 | 23.79 | 71.77 | 0.630 | Moderate |
| Creating (C6) | 3, 5, 9, 16 | 68.55 | 83.87 | 0.487 | Moderate |

During the pretest, students' average abilities in Analyzing (C4) and Evaluating (C5) were still very low (29.03% and 23.79%, respectively). Students found it challenging to recognize types of chemical reactions and evaluate the legitimacy of a theory. Notably, in the Creating (C6) category, the starting percentage was already relatively high at 68.55%. Nevertheless, this elevated initial score is probably due to students simply guessing the answers without thorough analytical thought.

Following the introduction of RQA-PBL, the Analyzing (C4) skill increased to 58.47% with an N-Gain of 0.415. The most significant

Enhancement was noted in the Evaluating (C5) skill, rising from 23.79% to 71.77% with an N-Gain of 0.630 (nearly reaching the High category). This demonstrates that the group discussion activities within the PBL framework effectively prepared students to evaluate one another's ideas and substantiate empirical data using robust scientific reasoning.

Along with HOTS, advancements were also evaluated across nine indicators of science literacy. The specific enhancements for each metric are displayed in the Table 6.

Table 6. Indicators of HOTS Science Literacy

| Science Literacy Indicator | Item Number | Pretest (%) | Posttest (%) | N-Gain | Category |
|---|---|---|---|---|---|
| Identifying information and data | 6, 9 | 45.16 | 77.42 | 0.588 | Moderate |
| Utilizing information and data | 14, 19 | 30.65 | 56.45 | 0.372 | Moderate |
| Generating explanatory models | 5, 8, 16 | 48.39 | 82.80 | 0.667 | Moderate |
| Distinguishing scientifically investigable questions | 2 | 0.00 | 70.97 | 0.710 | High |
| Formulating hypotheses | 3 | 77.42 | 87.10 | 0.429 | Moderate |
| Making predictions | 13 | 38.71 | 90.32 | 0.842 | High |
| Analyzing data | 1, 10, 11, 18 | 28.23 | 47.58 | 0.270 | Low |
| Interpreting data | 12, 20 | 32.26 | 79.03 | 0.690 | Moderate |
| Drawing conclusions/presenting results | 4, 7, 15, 17 | 26.61 | 66.13 | 0.538 | Moderate |

The highest improvement is seen in Indicator differentiating questions that can be investigated scientifically. In the pretest, the percentage recorded was 0.00%, indicating that no student was able to distinguish between testable scientific questions and regular ones. After the learning process, this percentage soared to 70.97% (N-Gain 0.710 / High). By creating independent questions during the RQA phase and conducting group investigations in the PBL phase, students effectively learned how a variable is scientifically assessed and altered. Additionally, concerning Indicator Making predictions, students saw a significant rise to 90.32%, indicating their growing proficiency in analyzing trends in experimental data.

The indicator (data interpretation) also rose quickly to 79.03%. This suggests that students started to get used to interpreting visual diagrams once deemed difficult, like Hess's Law graphs or potential energy curves. Likewise, for Indicator (Generating explanatory models), students saw a significant rise to 82.80%. They ceased to just memorize definitions and instead could integrate facts into a cohesive scientific explanation.

Although students experienced enhancements in nearly every area of conceptual understanding, Indicator (Analyzing data) continued to be a lacking aspect. This metric showed the least growth, rising from 28.23% to 47.58%, with an N-Gain of just 0.270 (Low category).

The enhancement of this learning outcome depends significantly on the mutual support provided by the two methods (RQA and PBL). When the PBL model is implemented alone, students frequently experience stress initially because they encounter intricate problems without adequate conceptual understanding. This may indeed reduce students' enthusiasm for learning.

This is where the importance of the RQA strategy becomes vital. The processes of reading, summarizing, and questioning done prior to class require students to engage in independent study. When learners generate questions for themselves from the textbook, they intentionally engage their metacognitive skills.

Therefore, when they come to class and the teacher initiates the PBL model with real-world case problems, the students already possess the vocabulary and basic concepts of thermochemistry in their heads. The RQA activities cut down the time needed for explaining basic materials, allowing students in the class to immediately discuss and practice analyzing at a higher level. Through the combination of these two methods, a previously passive class transforms into an active (student-centered) environment, which indirectly helps equip students to improve their science literacy.

## CONCLUSION

Based on the data analysis and hypothesis testing in this study, it can be concluded that students' initial abilities regarding HOTS and science literacy in thermochemistry are still classified as very low. This is evidenced by the average pretest score of only 34.84, where the majority of students were unable to distinguish types of scientific questions (0%) or interpret graphs. This fact proves that conventional, teacher-centered learning methods are insufficient to equip students with the analytical skills needed in the 21st century.

After the integration of the Reading, Questioning, and Answering (RQA) method with Problem-Based Learning (PBL) was implemented, there was a statistically significant improvement ($P<0.001$) in students' abilities. The application of this learning resulted in an increased class average score of 68.87 on the posttest, with an N-Gain index of 0.52, which falls into the moderate category. This learning model successfully stimulated students at the Evaluating (C5) cognitive level and was highly effective in training students to read prediction trends and formulate hypotheses from real-world problems. The independent study tasks during the RQA stage proved effective in preparing students' theoretical background before engaging in problem-solving discussions during the PBL stage.

Nevertheless, this research also identified constraints with materials involving quantitative calculations and numerical analysis, as the N-Gain for the data analysis indicator remained in the low category (0.270). This suggests that in addition to theoretical support, students still need additional practice with algebraic computations. In general, the application of this integrated RQA and PBL approach is strongly advised for teachers as a powerful means to change students' learning behaviors to be more critical, self-sufficient, and engaged in scientific activities.

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