Inquiry-based learning and problem-based learning: which one has better effect on students critical thinking skills profile of thermochemistry?

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Abstract. This study aims to know the comparison of students' critical thinking skills profiles in classes that apply the inquiry-based learning model and students in classes that apply a problem-based learning model. The profile of the critical thinking skills was analyzed with the descriptive quantitative method. This research was conducted at SMA Negeri 1 Tempilang, West Bangka Regency, Bangka Belitung Islands Province. Sampling was done by random technique. The total sample used was 50 students divided into two research classes. Class XI MIPA 1 applies the inquiry-based learning model while Class XI MIPA 2 implements a problem-based learning model. The results of the analysis showed that class XI MIPA 1 had a better critical thinking skill profile compared to class XI MIPA 2 on all critical thinking skills indicators. Therefore, it can be concluded that the inquiry-based learning model has a better effect on the profile of students' critical thinking skills on thermochemistry material than the problem-based learning model.

1. Introduction

Critical thinking skills are one of the most important student learning outcomes. According to Ennis, critical thinking is reasonable and reflective thinking that focuses on deciding something that must be believed or done [1]. Educational researchers throughout the world have long paid attention to the importance of critical thinking skills, both in the academic world and in the world of work [2]. In Indonesia, attention to the importance of critical thinking skills was only widely socialized after the government adopted the 2013 curriculum. After the implementation of the 2013 curriculum, learning was directed to develop the 4 skills needed in the 21st century consisting of critical thinking, creative, communicative, and collaborative. However, until now students' critical thinking skills in Indonesia are still relatively low.

The portrait of critical thinking skills in Indonesia, especially at the senior high school level is still low. This is indicated by the low national exam results, especially questions categorized by HOTS. To work on HOTS questions, students need adequate critical thinking skills. Analysis of HOTS category questions on the national chemistry subjects 2018/2019 academic year shows that the success rate of
students in answering HOTS questions is less than 55% [3]. It means the majority of students fail to work on HOTS questions on chemistry exams.

Another circumstance that shows low critical thinking skills is the results of observations and interviews conducted by researchers at several high schools in West Bangka Regency, Bangka Belitung. The speech of some chemistry teachers stated that most students were not able to work on HOTS questions that required critical thinking skills. Furthermore, the teachers also stated that so far, the students lacked training in developing critical thinking skills.

One reason student lack training in developing critical thinking skills is that the model used by teachers in learning tends to be teacher-centered. Critical thinking skills must be trained by providing a stimulus that requires a person to think critically. One method for developing critical thinking skills is through education through a series of learning activities that can stimulate and stimulate students to develop critical thinking skills. Several learning models can be used to improve students' critical thinking skills, including inquiry-based learning models and problem-based learning models. In the 2013 curriculum, both of these learning models are recommended to be applied by teachers [4].

Inquiry-based learning (IBL) can be defined as learning that makes students active in the classroom, improves scientific processes, and enhances critical thinking skills through discussion and various activities [5]. With these activities, students will practice in developing their critical thinking skills towards a material. IBL can be divided into 3 levels namely structured inquiry, guided inquiry, and open inquiry [6]. In this study, the guided inquiry learning model is used, where the teacher still guides the form of questions and guidance to students to learn the material.

Problem-based learning (PBL) is a student-centered learning model, in which students are given a problem and then students are asked to define, analyze and find solutions to existing problems [7]. In the PBL model, the problems presented in learning are everyday problems that are relevant and relate to the learning material being discussed. This problem stimulus will provide opportunities for students to practice developing critical thinking skills.

There have been several studies that prove that both IBL and PBL models affect students' critical thinking skills. The IBL model has a positive effect on students' critical thinking skills [5], [8], [9]. Meanwhile, PBL models also have a positive effect on students' critical thinking skills [10]–[13]. This study aims to compare the two learning models namely IBL and PBL toward student critical thinking skills profile on thermochemistry material.

2. Method
The design of this study uses a quantitative descriptive approach. There are 2 experimental classes used, the first-class applies the inquiry-based learning model and the second class applies the problem-based learning model. The research sample came from two science classes in West Bangka Regency, which were determined by a random sampling technique. The total sample that participated in this study amounted to 50 students.

The instrument used to retrieve the main data of this study was a 25 questions thermochemistry critical thinking skills test. The questions are developed based on indicators of critical thinking skills adopted from Facione [14] and Ennis [1] which consist of basic clarification, interpretation, inferences, analyze, and evaluation. Before being used, the question of critical thinking skills has validated both contents and empirically. Content validation was carried out by 2 experts in the field of learning and thermochemistry material. Empirical validation was done by testing the questions of critical thinking skills to 63 students who have received thermochemistry material. Next, the empirical validation data were analyzed using the Rasch model. The analysis showed that the reliability of the instrument items about critical thinking skills was 0.73 with good criteria and was appropriate to be used.

Critical thinking skills data in the form of scores then analyzed descriptively. Data are grouped into ideal rating categories. Data categorization is based on Azwar [15] as shown in Table 1 below:
Table 1. Ideal Rating Category

| Score Range | Category  |
|-------------|-----------|
| X > 75      | Very High |
| 75 ≥ X > 58.3| High      |
| 58.3 ≥ X > 41.7 | Medium  |
| 41.7 ≥ X > 25  | Low       |
| X ≤ 25      | Very Low  |

3. Result and Discussion

3.1. Result

The profile of critical thinking skills of students was analyzed based on 3 things: the average score of second class thinking skills, the percentage of critical thinking skills categories of both classes, and the percentage of categories of critical thinking skills on each aspect of critical thinking skills. Table 2 below is a statistical description of the scores of critical thinking skills of the two classes:

Table 2. The Descriptive Statistic of Students Critical Thinking Skills

| Class                                | N | Mean   | Standard Deviation |
|--------------------------------------|---|--------|--------------------|
| XI MIPA 1 (Using IBL Model)          | 26| 53.30  | 13.44              |
| XI MIPA 2 (Using PBL Model)          | 24| 42.75  | 14.10              |

Based on Table 2, it can be seen that Class XI MIPA 1 that applies inquiry-based learning models has an average score of critical thinking skills higher than Class XI MIPA 2 which applies problem-based learning models. Both classes have the same critical thinking category, which is the medium category.

The profile of critical thinking skills then analyzed based on the percentage of students' critical thinking skills categories in each class. Profiles based on the percentage of categories are calculated based on the number of students who have very high, high, medium, low, and very low critical thinking categories for each class. A comparison of critical thinking skills profiles based on the percentage of categories can be seen in Figure 1.

Figure 1. Critical Thinking Skills Profile Based on Percentage of Student Critical Thinking Skills Criteria in Each Class

Based on Figure 1, the profile of critical thinking skills of students is divided into very high, high, medium, and low categories while the profile of critical thinking skills of students in PBL classes is
divided into high, medium, low, and very low categories. In short, the critical thinking skills profile of the IBL class is better than the PBL class.

The profile of critical thinking skills then analyzed based on indicators of critical thinking skills. Indicators of critical thinking skills used are basic clarification, interpretation, inference, analysis, and evaluation. Figure 2 below shows the profile of critical thinking skills of both classes based on indicators of critical thinking skills:

![Figure 2. Critical Thinking Skills Profile Based on Each Indicator](image)

Based on Figure 2, it appears that the class applying the IBL model is superior in all indicators of critical thinking skills compared to the class applying the PBL model.

3.2. Discussion

Based on the average score of critical thinking skills of the two classes, class XI MIPA 1 has a higher score compared to class XI MIPA 2. The same results are also shown when the critical thinking skills profile is analyzed based on the percentage of critical thinking skills categories. Class XI MIPA 1 has critical thinking skills that are more dominant in the medium and high categories while Class XI MIPA 2 has critical thinking skills that are more dominant in the low and medium categories. In short, the profile of critical thinking skills in the IBL class was better in terms of scores and categories of critical thinking skills in thermochemistry material than in the PBL class.

IBL and PBL models are learning models that have been widely used to improve critical thinking skills. Duran and Dokme [5] research report the results that inquiry-based learning has a significant effect on critical thinking skills. Likewise, research conducted by Maryam et al [9] states that inquiry-based learning models have an effect on improving students’ critical thinking skills. On the other hand, PBL models are also proven as learning that can be used to improve students’ critical thinking skills [10]. This results are similar to those of Maulidiya et al [12] who also reported that the PBL model can improve critical thinking skills.

The superiority of the IBL model over the PBL model toward the profile of critical thinking skills on thermochemistry material is inseparable from several influencing factors. The first factor is the students’ habits before the research is carried out. Students in the two research classes have never gotten a student-centre learning model like IBL and PBL. The IBL model is superior in this regard because the IBL (guided inquiry level) model provides more assistance to students than the PBL model. This greatly affects the mental condition of students who have never studied independently. The second factor is the ability of the prerequisites in the PBL model. PBL models require students to have skills in scientific literacy to deepen the exploration of a problem, work in groups, and knowledge of other variables to
solving problems [16]. This becomes an obstacle when learning takes place with the PBL model, there are still many students who have not been skilled, especially in literacy, so that it impacts on students' success in developing critical thinking skills. On the other hand, the IBL (guided inquiry) model does not require prerequisites like the PBL model.

Meanwhile, the critical thinking skills profile analyzed based on indicators of critical thinking skills shows that class XI MIPA 1 is superior to all indicators of critical thinking skills compared to class XI MIPA. In the evaluation indicators, the IBL class got an average score of 49.6 (medium category) and the PBL class got an average score of 45.3 (medium category). Thus, the IBL model has a better influence on critical thinking skills on evaluation indicators. This is consistent with the research of Masitoh et al [17] which states that the application of the IBL model has succeeded in increasing students' evaluation abilities.

In the analysis indicator, the average score of critical thinking skills in the IBL class is 50.5 (medium category) and the PBL class is 29.9 (low category). The IBL class is superior to the analysis indicators because it has the ability to make hypotheses from the problems raised by the teacher, while in the class with a problem-based learning model there are no stages in determining hypotheses that require analysis skills so these skills are less developed. These results are in accordance with the research of Masitoh et al [17] who reported that the application of the IBL model could increase the percentage of critical thinking in the analysis indicators by 53.13%.

In the inference indicator, the average score of critical thinking skills in the IBL class is 40.8 (low category) and the PBL class is 39.4 (low category). The inference is the ability to identify and choose the elements needed to make reasonable conclusions [14]. With an average result that is still low, it means that both the learning model, both the IBL model and the PBL model, have not had a significant effect on improving students' inference abilities. This can occur because of the low literacy ability found in both classes. Based on the observations of the teacher and also the observer, students have not been able to independently identify the problems that occur during thermochemistry learning.

On the indicator of interpretation and basic clarification, the average score of critical thinking skills in IBL classes was 81.1 (very high category) and 67.3 (high category) while PBL classes were 60.4 (high category) and 59.4 (high category). Interpretation is the ability to understand and explain and give meaning to the data or information received. The learning syntax of IBL and PBL models that are more student-centered provides more opportunities for students to develop interpretation skills on the material so that in this indicator the scores obtained are very high. Basic clarification indicator also have high scores. The high category of this indicator is because it is supported by the syntax of learning both models of guided inquiry learning and problem based learning models. The stages of problem presentation in both models encourage students to practice expressing their opinions and provide simple explanations. These results are also consistent with the research of Nurmayani et al [18] which states that the guided inquiry model is effective in increasing basic clarification skills or providing simple explanations.

4. Conclusion

Overall, class XI MIPA 1 which applies inquiry-based learning has a better profile of critical thinking skills than class XI MIPA 2 which implements problem-based learning models both in terms of the average score of critical thinking skills, percentage of critical thinking skills categories, and of in terms of indicators of critical thinking. Thus, it can be concluded that the inquiry-based learning model has a better effect on the profile of students' critical thinking skills on thermochemistry material than the problem-based learning model.

5. References
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