The effect of collaborative based science learning model on enhancing students’ critical thinking skills and responsibility

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Abstract. The Collaborative Based Science Learning (CBSL) model was a learning model collaborative based science that integrates Critical Thinking Skills (CTS) and student responsibility. This study aims to analyze the effect of the CBSL model in enhancing the CTS and the responsibility of junior high school students. This study employed a quasi-experimental study with one group pre-test and post-test design. One hundred and seventy students of the eighth grade of Public Junior High School 6 Banjarmasin, Indonesia were involved and classified into five groups. The data was collected through the Critical Thinking Skills Test, a questionnaire on student responsibility, and an in-depth interview. The collected data were analyzed by using paired t-test/ Wilcoxon test and n-gain. The results of the study in group-1, group-2, group-3, group-4, and group-5 indicate that the obtained of the sig. (2-tailed) CTS of students is 0.00 (p = < 0.05), and n-gain is 0.74-0.87, showing that it is significant in high criteria. In addition, the obtained sig. (2-tailed) student responsibility is 0.00 (p = <0.05) and n-gain is 0.55-0.67; showing significant result in the criteria of moderate. It is concluded that the CBSL model is effective. This study implies that the CBSL model can be used as an alternative to maximize students’ CTS and responsibility in science learning at schools as well as equip success in students’ life and future career.

1. Introduction
In this industry era 4.0, the rapid development of science and technology demands a very fundamental change in the education system throughout the world (including in Indonesia) to put forth a generation of thinkers who is different from the past [1, 2, 3, 4]. Teachers can apply the Next Generation Science Standards (NGSS) or Framework for 21st Century Learning that has similar characteristics to the 2013 Curriculum in Indonesia [5, 6, 7, 8] so that students are able to solve various life problems that change and are increasingly complex. Students are provided with learning and innovation skills (critical thinking, creative thinking, problem-solving, collaborative, and communicative); life skills and careers
(responsible, tolerant, productive, adaptive, etc.); and skills in using media, information, and technology [9, 10] A critical thinker is not enough to only master CTS, but also must be responsible for doing the best and having concern for humanity and the surrounding environment [11].

Students’ Critical Thinking Skills (CTS) and responsibility are included in the main competencies to face the demands and challenges in the industrial era 4.0 [12, 13, 14, 15]. This has become one of the demands of the 2013 Curriculum in Indonesia to put forth quality and competitive human resources [4]. The learning process is emphasizing the development of creativity and responsibility (initiative, personality, and independence) of students in finding science [16]. Given that CTS is part of creativity, although critical and creative thinking appears to be different, both of them are seen as a single entity, inseparable, and mutually integrated [17, 18].

Achievement of KBK of Indonesian students based on the results of the TIMSS study starting in 1999, 2003, 2007, 2011 and 2015 shows that the Natural Science (IPA) scores are 435, 420, 433, 386, and 397 respectively. It indicates that Indonesian students are at the lowest or below 500 as the international standard score [19, 20]. The results of this study compare the students’ scientific knowledge, thinking, and process skills [21], where the reasoning skill as a part of the Critical Thinking Skill (CTS) is the weak point of Indonesian students. The problem of CTS in Indonesia is caused by the lack of students’ active participation in the learning process. In fact, the given lessons rarely begin with the presentation of realistic problems so that students have difficulty implementing science in life and lack training in critical thinking [22]. Besides the CTS problem, the Indonesian people are also experiencing a moral crisis (such as responsibility, honesty, cooperation, mutual respect, etc.) that are very dangerous and threatening to the younger generation [23]. The results of the preliminary study conducted by the researchers of this study at Public Junior High School 6 Banjarmasin show that 88% of students did not participate in learning; 63% of students lack respect for others; 64% of students have difficulty working together; 86% of students have difficulty in leading; and 85% of students have difficulty expressing opinions in discussions. Based on the findings above, the CTS problem and student responsibility are one of the concerns major in science learning.

Students critical thinking skills learning and responsibility in Indonesia have been using innovative learning models, including Problem Based Learning (PBL) model, inquiry model, and Process-Oriented Guided-Inquiry Learning (POGIL) [16]. This is supported by the findings of the researchers [3, 5, 6, 22, 24, 25, 26, 27] that PBL, inquiry, and POGIL models are able to increase students' critical thinking skills and responsibility in Indonesia. The results of a meta-analysis study by [28] on the results of the 2006 study in 2013 showed that PBL was effective to train the students' scientific attitudes, conditioning a learning environment that helped students understand PBL and mastered the initial concepts; but PBL has not practiced the critical thinking skills maximally. Some researchers have recommended efforts to overcome the limitations of PBL in a wider scope for instance by arranging the critical thinking skills activities in PBL more systematically [24], providing the depth of teacher instruction in improving student exploration [29] and involving the younger responsibilities in the learning process [30].

Besides PBL, inquiry, and POGIL models are also applied to meet the needs and challenges faced by Indonesian students in the industrial era 4.0 [3, 27, 31, 32, 33]. Through the inquiry model, students carry out inquiry and discovery activities to design new knowledge, develop creativity and independence, analyze opinions, formulate explanations based on data or evidence and evaluate scientific explanations [3]. Inquiry learning also involves the active participation of students in seeking and finding solutions to problems through a series of critical thinking skills activities. However, the inquiry process in the laboratory is still limited to improving non-verbal communication skills and is limited to observing, drawing, and writing activities [17, 34, 35]. In addition, the POGIL model is able to improve mass solving skills, self-confidence, and student academic value [32, 33, 36]. Nevertheless, the lack of maximum collaborative activity of students in the POGIL class makes not all of the students able to work well together [37].

The aforementioned weaknesses of the PBL, inquiry, and POGIL models in training students’ critical thinking skills and responsibility need to be addressed by developing an innovative learning model called "Collaborative Based Science Learning (CBSL) Model." The CBSL model itself is an
improvement of the PBL, inquiry, and POGIL models emphasizing collaborative activities that integrate the students’ critical thinking skills and responsibility in science learning [38]. The collaborative activity emphasizes instructor authority in empowering small groups that are more open and have complex tasks, as well as connects to social constructivism views [39, 40]. Students are facilitated to become knowledge constructors and understanding collaborators [14, 41]. Learning with CBSL model begins with Phase 1: Motivation and problem orientation; teacher raises the sense of responsibility of students so that they are willing to understand the goals, processes, and assessment of CTS and responsibility, as well as collaborative problems so that they are motivated to support the success of the next learning phases. Phase 2: Collaborative-based critical thinking activities; teacher, facilitates Student Worksheet (LKS) and logistics, then guides the collaborative activities of students to maximize students’ CTS and responsibility through inquiry activities, decision making, and problem-solving. Phase 3: Communicate results; the teacher facilitates students’ responsibility in communicating the results of group work in front of the class. Phase 4: Follow-up training; students are given greater responsibility to transform knowledge and CTS through the work of the CTS. Next, phase 5: Reflection; teacher guides students to reflect right critical thinking and their responsibility [38].

In a nutshell, based on the above explanation, the focus of this study is to analyze the effect of the Collaborative Based Science Learning (CBSL) model on enhancing Critical Thinking Skills (CTS) and the responsibility of junior high school students. The research problems of this study are namely: (1) whether there is a significant (statistically) increase in CTS and student responsibility before and after the CBSL model is applied, and (2) to what extent the level of students’ CTS and responsibility improvement before and after the CBSL model is applied.

2. Method

This study was conducted at Public Junior High School 6 Banjarmasin, Kalimantan Selatan, Indonesia, from January 2018 to January 2019. The scope of the study was limited to the eighth-grade students who took science subjects in the 2018/2019 academic year. This study was emphasized on the analysis of the CBSL model by analyzing the increase of the students’ CTS and responsibility before and after following the process of science teaching and learning with the CBSL model. The effect of the CBSL model was determined based on a statistically significant increase is in the pre-test and post-test of students’ CTS and responsibility, as well as the mean n-gain determined by the criteria of the low, moderate, or high.

The population of this study was 295 students of the eighth grade of Public Junior High School 6 Banjarmasin, South Kalimantan, Indonesia. The research sample was taken based on Slovin’s formula, i.e. sample = [population/(1+e2 x population)] with an error tolerance e = 5% [42]; so that the research sample obtained was 170 students divided into 5 groups, namely group -1, group -2, group -3, group -4, and group -5. Each group consists of 34 students representing different classes, namely classes VIII-A, VIII-B, VIII-C, VIII-D, and VIII-E. Each group has the same initial ability, namely mastery of CTS, and its responsibility is still low.

This study employed a quasi-experimental study with one group pre-test post-test design, i.e., O1 X O2 [43]. The learning began with giving a pre-test (O1). Each student was asked to work on a Critical Thinking Skills (CTS) pre-test and then fill out the questionnaire of student responsibility. The CTS test instrument consists of 16 items referring to the CTS indicator adapted from [44], including the skill of interpreting, analyzing, evaluating, and influencing. Each CTS indicator was measured using four items of tests on the material of the human motion system for the eighth grade of junior high school. The responsibility questionnaire consists of 20 statements referring to responsibility indicators adapted from [45, 46], including participating, respecting others, working together, leading, and expressing opinions. Each indicator of responsibility is represented by four positive or negative statements. After the pre-test, the teacher applied the CBSL model and supporting devices for four meetings in each group (X). The teacher started the lesson by presenting motivation and problem orientation, guiding collaborative thinking activities based on collaboration, communicating results, advanced training, and ended with reflection. The learning process was ended with a post-test (O2). Each student was asked to
do the post-test of CTS. Then, they were asked to answer the questionnaire of student responsibility. In addition, an in-depth interview was conducted for several students to clarify the problems found during the science learning.

Data from the pre-test and post-test results for each CTS indicator are then calculated using the assessment rubric in Table 1.

| Table 1. The critical thinking skills scoring rubric |
|----------------------------------------------------|
| **Indicator** | **Assessment Aspect** |
| Interpretation | Explain from the situation/event that matches the answer key |
| | Make interpretations according to the answer key |
| | Make interpretations using scientific and logical language |
| Analysis | Identify the relationships of several statements (e.g., questions, concepts, descriptions, and various models) according to the answer key |
| | reflect thoughts/views.beliefs/decisions/reasons/information and opinions according to the answer key |
| | create an analysis using scientific and logical language |
| Evaluation | make decisions based on the relationships from several statements (e.g., questions, concepts, descriptions, and various models) according to the answer key |
| | test the truth of the statement used to convey thoughts/views.decisions, reasons/opinions according to the answer key |
| | make evaluations using scientific and logical language |
| Inference | make conclusions based on the facts that are based on data/information/statements/events/principles/opinions/concepts according to the answer key |
| | identify and select the elements needed to draw conclusions that have reasons/to guess and enforce diagnosis/to consider the information in accordance with the answer key |
| | make inference using scientific and logical language |

Based on Table 1, the CTS indicator scores are given based on the suitability of the students' pre-test and post-test results with the assessment aspects specified. If three aspects of the assessment are met, students are given a score of 4; if two aspects of the assessment are fulfilled, a score of 3 is given; if one aspect of the assessment is fulfilled, students are given a score of 2; and when all aspects of the assessment are not met, they are given a score of 1. In addition, to calculate the students' core responsibility, the number of scores obtained is divided by the maximum score multiplied by 100. The choice of testing method depends on fulfilling the normality assumption for CTS pre-test and post-test scores and student responsibility. It is then statistically tested with paired t-test (parametric) or Wilcoxon test (non-parametric). This test was carried out with the help of IBM SPSS 16.0 software.

3. Result and Discussion
The learning outcomes of all groups relating to students' critical thinking skills and responsibilities are presented in Figure 1. The black bars represent the mean score of the pre-test, and the grey bars represent the average post-test score.
Figure 1. Students’ critical thinking skills and responsibility pre-test and post-test scores for all groups.

Based on Figure 1, before the CBSL model was applied, the average Critical Thinking Skills (CTS) score of the students under standardized score (minimum score of 60 in the score 0-100), namely the average score of CTS for group-1, group-2, group-3, group-4, and group-5 each is 33.50; 32.76; 32.03; 32.40; and 33.18. Students so far are less skilled in interpreting, analyzing, evaluating, and influencing problems to get a logical solution. From the interview with several students, some information was obtained. They reported that their knowledge about the CTS is still limited. The students also find it difficult to associate the material with the other materials, and they are less skilled in constructing explanations based on the analysis of the evidence and arguments critically. The causes of CTS problems are in line with the findings of [22, 47]; namely the lack of students' initial understanding of CTS, learning does not involve students' active participation, difficulties in applying science in real life, lack of training in CTS in problem-solving, and students' social and personal ambitions. Conversely, after the CBSL model was applied, the mastery of students’ CTS became better, namely the average score of CTS for group-1, group-2, group-3, group up-4, and group-5 respectively are 82.49; 84.05; 85.98; 88.60; and 91.04 (far exceeding the minimum score of 60.00 in the score range 0-100). This indicates that there is an impact of applying the CBSL model to the increase in students’ CTS.

Figure 1 also illustrates the students’ responsibility. Before the CBSL model was applied, the mastery of students’ responsibility was still low, namely the average score of responsibility for group-1, group-2, group-3, group-4, and group-5 is 54.15; 54.08; 54.96; 55.55; and 55.58. The students understand the definition and role of their responsibility in learning, but they lack the self-awareness to try to be responsible for the quality of their learning processes and outcomes. Based on the results of the interviews of the researchers with several teachers of Public Junior High School 6 Banjarmasin, the obtained information was there is a misconception of the teachers regarding the learning responsibility at school. Teachers thought that spiritual and social attitude competencies (such as responsibility) are the responsibility of religion and civics teachers; so that the science learning process merely emphasizes knowledge and skills competencies. This is in accordance with the findings of [48, 49]; when responsibility is less integrated into the learning process, students understand responsibility solely to the extent of knowledge or possess less awareness to succeed in learning. On the contrary, once the CBSL model was implemented, the responsibility role of the students increased, that is, the average responsibility score for group-1, group-2, group-3, group-4, and group-5, each at 79.41; 81.39; 84.63; 85.00; and 85.18. This indicates that there is an impact of applying the CBSL model to enhancing the students’ responsibility in science learning.

The level of increase in students’ CTS and responsibility before and after the CBSL model is calculated through n-gain. The mean SCT n-gain values and responsibilities for the five groups are presented in Figure 2.
Figure 2. The CTS and responsibility n-gain mean on all groups

Figure 2 shows that the n-gain mean value of CTS for group-1, group-2, group-3, group-4, and group-5 are 0.74; 0.76; 0.79; 0.83; and 0.87. It means an increase in CTS of students is in high criteria. On the other hand, the n-gain mean value for each group is 0.55; 0.60; 0.66; 0.66; and 0.67. It indicates that an increase in students’ responsibility in the moderate criterion. Furthermore, to determine the significance of the impact of CBSL model, it can be seen from the results of the inferential statistical test that begins with the normality test score of pre-test and post-test to the whole group. The normality test results with one-sample Kolmogorov-Smirnov Z test are presented in Table 2.

Table 2. The normality test result of the pre-test and post-test of CTS and responsibility of all groups

| Group | Test   | N  | Critical Thinking Skills | Responsibility |
|-------|--------|----|--------------------------|-----------------|
|       |        |    | Mean | Std | Error | Mean | Std | Sig. | Mean | Std | Error | Sig. |
| 1     | Pre-test | 34 | 33.50 | 0.54 | 0.037 | 54.15 | 0.36 | 0.003 |
|       | Post-test | 34 | 82.49 | 0.68 | 0.100 | 79.41 | 0.49 | 0.001 |
| 2     | Pre-test | 34 | 32.76 | 0.58 | 0.200 | 54.08 | 0.34 | 0.020 |
|       | Post-test | 34 | 84.05 | 0.77 | 0.024 | 81.39 | 0.58 | 0.022 |
| 3     | Pre-test | 34 | 32.03 | 0.46 | 0.147 | 54.96 | 0.37 | 0.007 |
|       | Post-test | 34 | 85.98 | 0.65 | 0.014 | 84.63 | 0.42 | 0.000 |
| 4     | Pre-test | 34 | 32.40 | 0.52 | 0.200 | 55.55 | 0.40 | 0.062 |
|       | Post-test | 34 | 88.60 | 0.68 | 0.200 | 85.00 | 0.45 | 0.200 |
| 5     | Pre-test | 34 | 33.18 | 0.53 | 0.020 | 55.58 | 0.53 | 0.000 |
|       | Post-test | 34 | 91.04 | 0.58 | 0.138 | 85.18 | 0.49 | 0.000 |

Table 2 shows that the CTS and responsibility pre-test and post-test scores are normally distributed in group-4 only. In the other four groups, both scores (pre-test and post-test) or one of the scores were not normally distributed. Therefore, the impact of implementing the CBSL model on enhancing students’ CTS and responsibility for group 4 was analyzed through paired t-test, while the other four groups were analyzed through the Wilcoxon test. The results of the paired t-test and Wilcoxon test are presented in Table 3.

Table 3. Results of the paired t-test/ Wilcoxon test for CTS and responsibility in all groups

| Learning Outcome | Group | Mean | Std Error Mean | t     | df  | Sig. (2-tailed) | Z   | Sig. (2-tailed) |
|------------------|-------|------|----------------|-------|-----|-----------------|-----|----------------|
| SCT              | 1     | 0.74 | 0.55           |       |     |                 | 0.00|                 |
|                  | 2     | 0.76 | 0.60           |       |     |                 | 0.00|                 |
|                  | 3     | 0.79 | 0.66           |       |     |                 | 0.00|                 |
|                  | 4     | 0.83 | 0.66           |       |     |                 | 0.00|                 |
|                  | 5     | 0.87 | 0.67           |       |     |                 | 0.00|                 |
| Responsibility   | 1     | -0.590 | 1.764 | -17.358 | 67 | .000 | -7.173 | .000 |
|                  | 2     |       |                |       |     |                 | 0.00|                 |
|                  | 3     |       |                |       |     |                 | 0.00|                 |
|                  | 4     | -0.687 | 3.399 | -38.970 | 67 | .000 | -7.173 | .000 |
|                  | 5     |       |                |       |     |                 | 0.00|                 |
Table 3 shows that the CTS mean score for group-4 is -0.590, and the degree of freedom (df) = 67, the t score gives the value $t = -17.358$ for group-4. The score is significant because $p < 0.05$. Likewise, in group-1, group-2, group-3, and group-5, the $Z$ values are -7.174; -7.172; -7.174; and -7.173 respectively with a significance level of $p < 0.05$, which is significant. On the other hand, the average score of the responsibility for group-4 is -0.687 and df = 67, the t score gives the value $t = -38.970$. The score is significant because $p < 0.05$. Meanwhile, the $Z$ scores of group-1, group-2, group-3, and group-5 are -7.175; -7.174; -7.180; and -7.175 with a significance level of $p < 0.05$; this is also significant.

Figure 2 and Table 3 show the impact of the CBSL model on enhancing students’ CTS is significant in high criteria. The success of the CBSL model is because the CTS is a major concern in every phase of the model. It starts from the motivation and problem orientation (phase 1), the activity of critical thinking based collaboration (phase 2), and communicating the result (phase 3), CTS tasks (phase 4), and reflection (phase 5). This is in accordance with the social constructivism theory by Vygotsky [50] covering social learning theory (students learn through interaction with adults and older peers who are more capable); Zone of Proximal Development (students learn concepts best when they are within their closest development zone); and scaffolding theory (students are given complex, difficult, and realistic tasks, and then given adequate assistance to accomplish their task). Critical thinking skills facilitate students in solving an issue, applying the concepts of science, freedom of thought, being responsible for taking a decision, interpreting the problem, and being responsible for success in learning [45, 51].

The application of the CBSL model also has a significant impact on increasing students’ responsibility in the moderate criteria. This is according to the English & Kitsantas recommendation (2013); the CBSL model as PBL improvement involves the role of student responsibility to support the success of learning activities in each phase of the model. The CTS can help the teacher to generate self-awareness (a sense of responsibility) of students to understand the goals, processes, and assessments of critical thinking and responsibility and to understand collaborative problems well (phase 1); enhance the responsibility through active collaboration-based critical thinking (phase 2), communicate the results (phase 3); and establish students’ responsibility by facilitating the task of establishing the CTS (phase 4); finally, reflect on the role of responsibility during learning (phase 5). This result is in accordance with the theory of self-regulated learning, the ability to control all aspects of one's learning, from advance planning to evaluate afterward performance. Students who are responsible will try to show the best behavior in participating, respecting others, working together, leading, and expressing opinions during the learning [45, 49].

Based on the findings above, it can be synthesized that the effect of the CBSL model on enhancing the CTS and responsibility of junior high school students is caused by (1) the existence of collaborative problems, which are presented in the form of open questions that inspire them to engage in activities in later phases; (2) critical responsibility, each individual is responsible for improving the quality of their own critical thinking and using it for the common good; (3) collaborative critical thinking activities, students integrate CTS and responsibilities in scientific inquiry, problem-solving and decision making; (4) CTS tasks, students are given the responsibility to transform their knowledge and CTS to solve real-life problems; and (5) reflection, students, assess the quality of CTS and their responsibilities while learning along with their solutions. This is in line with [52] that CTS is best understood as the ability of thinkers to be responsible for criteria and standards that are good at assessing their thinking and using it to improve the quality of their thinking. Therefore, the integration of CTS and responsibilities in the CBSL model is able to inspire students to do their best, never give up when facing difficult CTS tasks, think about the quality of thinking, and have concern for humanity and the surrounding environment [45, 46, 53]. Hence, in line with [11, 54, 55] the application of CBSL not only equips students with CTS, but they are also given the responsibility to be prepared to become critical and independent thinkers in order to strive to succeed during future student learning and career.
4. Conclusion
The implementation CBSL model is effective in enhancing the CTS and responsibility of junior high students in learning science since the findings show that there are significant improvements of the students’ CTS in the high category and students’ responsibility in the moderate category for all five groups. This effectiveness is due to collaborative problems, critical responsibility, collaborative critical thinking activities, CTS tasks, and reflection as a characteristic of the CBSL model. However, collaborative activity as a characteristic of the model has not been an instructional goal in this study and the responsibility is only trained in the learning process so that the increase is still in the criteria of being. Further research is needed to examine the impact of the CBSL model on increasing or enhancing students’ collaborative activity and how to involve students' critical responsibility before, during, and after the learning process.

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