The Effectiveness of problem-based hybrid learning model in physics teaching to enhance critical thinking of the students of SMAN

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Abstract. This research aimed at analysing the effectiveness of Problem Based-Hybrid Learning (Pro-BHL) to enhance the critical thinking skill (cts) of the students of SMA in Physics teaching. Pro-BHL model is a model of teaching which combines face – to – face PBL and online learning. Pro-BHL model is effective to enhance cts if: 1) there is a significant improvement in the students’ cts at α=5%; and 2) The minimal N-gain average falls into medium category or consistent. This study involved 86 students who spread into three groups of grade X. The design of this study was one group pre-test and post-test group design. Before the teaching using Pro-BHL model, the students in three groups were given a cts test (pre-test). And at the end of the teaching, the students were given the same test (post-test). The collected data were analyzed by Paired-Test, normalized gain (N-gain T-Test) and ANOVA. The result showed that: (1) the teaching with Pro-BHL model can enhance the students’ cts (α =5%); (2) the N-gain average for the three groups falling into high category; and (3) do not differ from one another. Thus, it this can be concluded that the Pro-BHL model is effective to enhance the students’ cts in physics teaching.

1. Introduction

One of the paradigms of the 21st century is the expectation that the students master critical thinking (cts). Cts is a paradigmatic process when a student makes a decision about what he or she believes and what he or she does [1, 2]. The indicators of cts include: to formulate a problem, to give an argument, to make a deduction, to make an induction, and to make a decision. Cts is very important to be trained since this critical thinking is carried from birth [3].

The importance of cts is in accordance with what is stipulated in curriculum 2013, which is the reference in teaching process to achieve the expected learning outcome [4]. According to Semerci [5], students with higher cts obtain higher learning achievement if they are compared to students with lower cts. Cts is the key in education to solve a problem. Most of jobs require workers with cts [6]. By examining closely how important is cts, teaching process should stress the importance of students’ cts. However, the fact shows that cts in schools in Indonesia, especially at senior high schools has not been well trained so that the cts of senior high school graduates is still relatively low [7, 8]. The low cts of the graduate of elementary schools up to university level in Indonesia is often complained [9]. One of the factors which is assumed to be the cause of the low cts of the students, among others things is the type of test item given to the students uses Bloom taxonomy at a low level, so that it does not train the...
students thinking skill [2, 10]. The quality of physics teaching as part of science education up to now is still low and experiences a decrease as seen in the results of the study done by PISA (Program for International Student Assessment), i.e., a study that focuses on reading, mathematics and science literacies, that showed that the ranking of science in Indonesia is at the 62th from 69 countries [11]. This shows that the quality of science education in Indonesia, including Bali Province tends to be low. This is supported by the result of research done by Sadia [12] in some regencies in Bali that shows that the cts of the students of senior high school students at tenth grade fall into low qualification with the mean score of 49.38 in 0-100 scale. In addition, teachers still find difficulty in teaching cts to the students and there are still a few teaching models that teach cts to the students. The result of preliminary research on cts about temperature and heat at SMAN 1 Singaraja (Bali), showed that mean score was in the range of 35.30 – 41.10; falling into insufficient category [13, 14]. Based on the exposure to problems and examples above, it is identified by preliminary research that the students’ cts is still low, the teacher knows less about how to improve the cts and we do not have adequate models of teaching to train cts. Teachers still teach the traditional teaching-learning. Traditional teaching strategies emphasize most of the materials by lecture, whereas the PBL method relies on the problem as a vehicle to guide learners to relevant content information [15, 16].

Based on the explanation above, the problem that arises is how effective is Pro-BHL teaching model to increase the cts of the students of SMAN? This problem is formulated in more detailed as follows:(1) Is there any increase in students’ cts after being given a teaching with Pro-BHL?; (2) What is the extent of the average level of the increase (average gain score) for the three groups; and (3) Is the average N-gain consistent for the three groups.

Regarding the still low cts of the students of senior high schools in Bali, an alternative solution needs to be found to train the cts of the students in accordance with curriculum 2013 [4]. One of the alternative models which assumed to be able to train the cts with Problem-Based Hybrid Learning model (Pro-BHL). Based on hybrid learning, learning is basically a social process which will be compromised if all the modules that take place in the virtual world are far from human interaction [17, 18]. Driscoll [19] shows that blended/hybrid learning can mean differently for different people. Pro-BHL model is teaching model which combines face to face Problem Based Learning (PBL) in the classroom and online learning. In the Pro-BHL model, the students are faced with the problem of ill-structure, then the students work in groups to formulate the problem. The teacher facilitates the students in learning, organizes the learning tasks, mediates problem formulation, and formulates hypotheses. Students in groups to solve problems that have been formulated earlier. Traditional teaching strategies emphasize the broad coverage of content areas through lecture, giving the example problems, and practice questions [20]. Students conduct investigations, collect data, analyze inductively and deductively, and make conclusions, to seek information through printed books available on the internet, have a discussion, are engaged in question and answer activities and present their work through a series of activities on the model Pro-BHL done carefully so it could be expected to train CTS.

Pro-BHL model in Senior high school Physics teaching contains ill-structured problems, physical phenomena, strategic and essential concept, contextual concept, animation/simulation, video, examples and contextual exercises; while learning tools such as lesson plans, worksheets, and teaching materials for Pro-BHL model can be accessed online with address http://Probhl.com. Pro-BHL model in Physics teaching refers to Blended Problem-Based Learning model (BPBL) [18, 21] and Problem Based Blended Learning model (PPBL) Wannapiroon [22]. Donnelly [16] combines face to face PBL teaching in the classroom with e-learning which is known as blended PBL (BPBL). Wannapiroon [22] combines blended/hybrid learning model and PBL which is known as PBBL.
2. Method

2.1. Research Design
This study emphasized the analysis of the effect of Pro-BHL model in Physics teaching on students’ cts, therefore in this study used pre-experimental with pre-test and post-test design as follows: O1 X O2 [23, 24]. Before teaching by using Pro-BHL model, the three groups where given pre-test (O1), and after teaching ws done by using Pro-BHL model (X), the three groups were given the same test again(post-test) (O2).

This research was done with three groups (A, B, and C) of the students of tenth grade in the academic year 2015-2016 at SMA Negeri 1 Singaraja with the total of 86 students, each group consisting of 29, 29, and 28 students respectively.

2.2. Method data collecting and Analysis of data
This research use test method for collecting the data. The test was used to know the improvement in cts of the students before and after the implementation of Pro-BHL model. The test consisted of pre-test and post-test according to cts indicators. The cts test instrument was in the form of essay test, consisting of the following indicators: (1) formulating problems, (2) giving arguments, (3) making and deduction, (4) making induction, and (5) making decision.

The data from the result of the cts test collected were analyzed by using paired t-test or non parametric analysis of Wilcoxon test. Paired t-test was done if the criteria of population data had normal distribution [23, 25, 26, 27]. If the data did not meet the criteria of normal distribution, then Wilcoxon test was used. While, the computation of N-gain value was done to analyze the level of the students cts which was caused by Pro-BHL model implementation in Physics teaching. The mean of the cts improvement was determined by the value of the normalization of gain (N-gain). The category of N-gain according to Hake [28] are: (1) teaching with “high improvement average”, if \( N\text{-gain} \geq 0.7 \); (2) teaching with “medium improvement average”, if \( 0.7 > N\text{-gain} \geq 0.3 \); and (3) teaching with “low improvement average”, if \( N\text{-gain} < 0.3 \). Statistical analysis was done using IBM SPSS Statistics 20 software [27]. After that, analysis of variance (ANOVA) was done to analyze consistence (no difference) in the average of cts improvement using Pro-BHL model among classes A, B, and C. ANOVA was done when the requirement of N-gain average for the three groups, each coming from population with a normal distribution and the three groups were homogeneous was met.

3. Result and Discussion

3.1. Result
The description of data of every group: A, B, and C is shown in diagram consisting of: mean score for pre-test, mean score for post-test, and N-gain average for cts. The description is shown in Figures 1 and 2.

![Figure 1](image1.png)  
**Figure 1.** Mean scores for cts pre-test, post-test

![Figure 2](image2.png)  
**Figure 2.** Mean scores improvement <g> cts
Figure 1 shows improvement in cts in three groups: A, B, and C. Improvement in cts of the three groups were categorized into high category shown by N-gain value as in Figure 2. The result of paired t-test between pre-test and post-test of cts for the three groups had met the criteria of normality and homogeneity as shown in Table 1. While, the ANOVA result about the improvement of cts of student for the three groups had met the criteria of normality and homogeneity as shown in Table 2.

Table 1. Result of Paired T-Test between The Scores for Pre-Test and Post-Test

| No | Data       | Average Test (t) | Df | p (2-tailed) | Remark      |
|----|------------|-----------------|----|--------------|-------------|
| 1  | Group A   | -32,339         | 28.00 | < 0.0001 | Ho is rejected |
| 2  | Group B   | -49,938         | 28.00 | < 0.0001 | Ho is rejected |
| 3  | Group C   | -35,788         | 27.00 | < 0.0001 | Ho is rejected |

*p < 0.05 (2-tailed)

Table 2 shows that the value of p for the result paired t-test of the scores of pre-test and post-test in cts in the three group is < 0.05 and on the whole have negative values. This means that there is a significant difference (statistically) in the cts of the students between before and after the implementation of Pro-BHL model in teaching. The cts of the students after the implementation of Pro-BHL model was higher then before the implementation of Pro-BHL model.

Table 2. Results of ANOVA of the Improvement of the Students’ cts

| No | Data                                | F      | Df | P    | Remark        |
|----|-------------------------------------|--------|----|------|---------------|
| 1  | Average N-gain of the cts of Groups A, and C | 0.496  | 83 | 0.611 | Ho is accepted |

*p < 0.05

Table 2 shows that the value of p in the result of ANOVA for groups A, B , and C is 0.611. Since the value of p > 0.05, then statistically, there is no difference in the average of improvement in the students’ cts (consistent), significant at α = 5% for the three groups A, B, and C.

3.2. Discussion

Pro-BHL model can be implemented in Physics teaching. This model requires the identification of unstructured problems, formulating problems, collecting information from the internet to solve the problems, processing information, presenting the result of problems solving, doing a discussion, asking and answering questions, so that the students are able to master cts.

The achievement of cts by the students is shown in Figure 1. The mean scores in cts for the pre-test in the three groups (A, B, and C) before Pro-BHL model was implemented were low, i.e., 30.3; 29.9; and 30.1 from 0 – 100 scale. After Pro-BHL model was implemented, the means score in cts of the students in the three groups were higher, i.e., 81.8; 81.0; and 79.9. The low score and cts of the students in the condition before Pro-BHL model was implemented was probably cause by the students who had not been cts after Pro-BHL model was implemented, their scores were higher. They improvement of the mean score in cts of the students is shown in Table 1, statistically significant α = 5%. In Table 2 it is shown that the average N-gain for every groups: A, B, and C, all have high categories according to Hake’s criteria [28] that is 0.7.

In Table 2 it is shown the improvement of cts of the students, N-gains in the three groups: A, B, and C which are not different one and another or consistent. This shows that the implementation of Pro-BHL model could consistently improve the students cts. This is in line with the schema theory that state when individual reconstructs information, he or she adaptated which the knowledge that he or she had in mind [29]. Pro-BHL model is a model for integrating ICT in education which can give opportunity for the achievement higher level of cts. The effect of Pro-BHL model only improvement of cts is supported by the finding Wannapiroon [20] who state that higher level cts was achieve after
teaching by using PBL model. Similarly this is also supported by the result of the research done by [30,31] who state that the students cts improve in Physics through the implementation PBL online; Elnethra and Sulaiman [30, 31] who conclude that PBL online can improve cts; and [32] who shows that PBL significantly improve the students competence in planning and organizing teaching. The ability Pro-BHL model that provide hyperlinks familiarize the students to see the flexibility of the teaching material.

4. Conclusion
Based on the discussion of the result of the research it can be concluded that Physics teaching with Pro-BHL teaching model can effectively improve the cts of the students of SMA N 1 Singaraja, as shown by: (1) the improvement of the students cts significantly at $\alpha = 5\%$, (2) the average of cts gain (N-gain average) for the three groups = 0.7 categorize into high category, and (3) the N-gain averages are not different for the three groups of research or consistence.

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