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The Influences of Problem-Based Learning Model with Fishbone Diagram to Student's Critical Thinking Ability

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Abstract:

Problem-based learning is characterized by the existence of a real problem as the context wherein students learn critical thinking skills, problem-solving, and knowledge acquisition. The concept of critical thinking gains popularity to help students obtain the ability to conduct fact analysis, support opinion with an argument, and problem-solving. The majority of Indonesian vocational school students, however, have difficulty in developing critical thinking skills and problem-solving. This research was purportedly designed to evaluate the differences of students' critical thinking ability in response to the application of various problem-based learning model namely Fishbone diagram, problem-based learning model, and expository learning model. A quasi-experimental design was applied to assess students' critical thinking. The findings indicate that there was a significant difference in students' critical thinking ability responding to the learning models. In summary, the research proposes the problem-based learning as an alternative learning model to improve student's critical thinking ability.

Keywords: Problem-Based Learning, Fishbone Diagram, Expository Learning Model, Critical Thinking Ability

Introduction

Critical thinking ability is the ability to analyze, organize, evaluate and solve problems (Facione, 2015). Rohaeti (2010) stated that critical and creative thinking supported students' abilities on making decision, assessing and solving problems. However, the education system in Indonesia is still focused on the exam (Firdaus, Kailani, Bakar, & Bakry, 2015). The practice of teaching focuses on subject content and ignore the development of students' thinking skills (Rohaeti, 2010). Most of the teaching and learning process that takes place in school is the lecture method, which is based on memorization of facts that leads students to think less critical (Duplass & Ziedler, 2002). Thus, negligence of the importance of thinking skills in teaching and learning affects students' ability to think (Zohar & Dori, 2003). The majority of Indonesian vocational school students, however, have difficulty in developing critical thinking skills and problem-solving. This leads to students' thinking ability in Indonesia is in low level. Low ability between Indonesian students is shown by the study PISA 2015. The results of PISA 2015 survey found Indonesian students at position 63 of the 69 countries in science skills (OECD, 2016). The result of the research revealed that Indonesian students' answer weak in problem-solving involving revelations, give opinions and make reasoning. Therefore it takes a learning model that can be improve students' critical thinking ability.

Hung (2006) defined Problem-Based Learning as an instructional method aimed at preparing students for real-world settings. Problem-based learning (PBL) is a flexible instructional strategy in which students are guided to take part in the cognitive processes of advanced problem solving (Lenkauskaite & Mazeikiene, 2012). According to (Bellanca, 2009), the main purpose of PBL was to develop of critical thinking skills and problem-solving skills and at the same time develops the ability of students to actively build their own knowledge. Application of PBL model has expected students are able to think critically and have skills in solving problems. To solve a problem, one must first recognize and understand what is causing the problem. Tools that assist groups and individuals in identifying the root causes of problems are known as root cause analysis tools. Root cause analysis or Fishbone diagram is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems (Doggett, 2004).

The majority of literature recommends PBL model as the learning model are (1) PBL in teacher education (Simone, Lussier, & Hall, 2014), (2) PBL in History course (Wynn, Mosholder, & Larsen, 2014), (3) PBL in teaching program (Hou, 2014), (4) PBL in Physic learning (Prayekti, 2016), (5) PBL in medical school (Chang, 2016), and (6) PBL in computer science (Pucher & Lehner, 2011). The majority of literature recommends Fishbone as a help tool to solve the problems are (1) Fishbone strategy in teaching English (Nasir, 2014), (2) Fishbone diagram to determine the risk of an event with multiple causes, and (3) Using an Fishbone diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature (Wong, 2011). The results of the majority literatures revealed that PBL model was able to improve students' achievement while Fishbone diagram to help solving the problems. This research evaluates the differences in student's critical thinking ability between application of Problem-based learning model combined Fishbone Diagram, Problem-based learning model, and expository learning model. This paper contributes to knowledge and practice by combining Problem-Based Learning Model and Fishbone diagram in learning.

Research Methods

This research used a quantitative approach with a quasi-experimental non-equivalent group design. A quasi-experimental design is one that looks a bit an experimental design but does not use a real random sample (Trochim, 2006). This research was conducted at a State Vocation Highschool. Data were collected by pretest, posttest, and questionnaire. The population of this research was all students of second-grade students in Computer and Network Engineering Study Program Study Program (TKJ). Subjects in the research were a total sampling. Class XI TKJ 3 as control class with expository learning model, class XI TKJ 2 as experiment class 1 with problem-based learning model (PBL), and class XI TKJ 1 as experiment class 2 with Problem Based Learning combined Fishbone diagram (PBL-Fishbone). The resulting sample (n = 104) consisted of 33 students in the expository learning model, 36 students in the PBL, and 35 students in the PBL-Fishbone. The subjects of this research used topic about diagnose computer network problems. Diagnosing computer network problems of the competences of expertise in computer and network engineering courses.
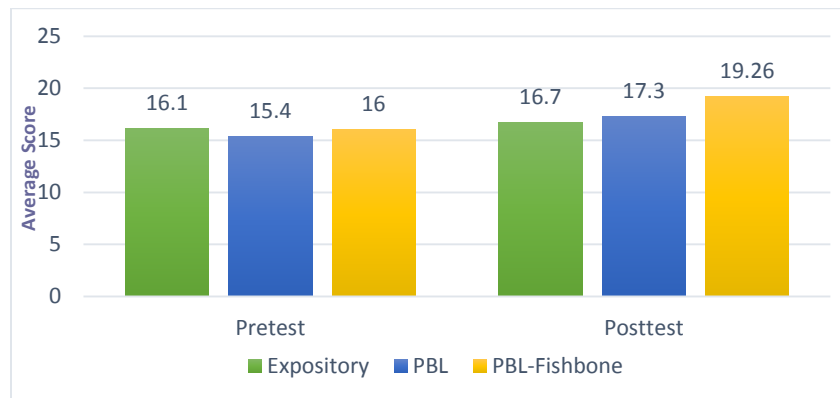
Result and Discussion

Figure 1. Bar Chart the Average Score Each Class

Based on Figure 1 the average score of each class, in control class with expository learning model obtained an average pretest of 16,1 (67,08 %) with a maximum score of 24 and the average posttest of 16,7 (69,58 %) with a maximum score 24. In the experiment class with PBL model obtained an average pretest of 15,4 (64,16 %) with a maximum score of 24 and the average posttest of 17,3 (72,08 %) with a maximum score 24. In the experiment class with treatment problem-based learning model combined fishbone diagram (PBL-Fishbone) obtained an average pretest of 16(66,6 %) with a maximum score of 24 and the average posttest of 19,26 (80,25 %) with a maximum score 24.

Hypothesis 1: The differences in student's critical thinking ability between application of problem-based learning model with Fishbone diagram, problem-based learning model, and expository learning model

The first hypothesis aimed to know the difference of students' critical thinking ability in all class of the sample. The technique used in the research is one-way ANOVA with significant level 5%. The decision of the first hypothesis testing: the hypothesis is accepted when F value > F table while the hypothesis is rejected if the F value < F table. The research questions, hypothesis, and table of the results of the first hypothesis testing are shown bellow.

Research Question 1:   Is there any difference in students' critical thinking ability between the implementation of problem-based learning model combined Fishbone diagram, problem-based learning model, and expository learning model?

Hypothesis 1: There is a difference in students' critical thinking ability between the implementation of problem-based learning model combined Fishbone diagram, problem-based learning model, and expository learning model.

Table 1. The results of the analysis of the First Hypothesis Test

F value	df1	df2	F table	Sig	Conditions
10,957	2	101	3,09	0,000	F value > F table

From the calculation of one-way ANOVA between the average posttest of expository learning class, PBL model, and PBL-Fishbone model obtained F value was 10,957. When viewed from F value and significance, the hypothesis stated that "There was a difference in student's critical thinking ability between the implementation of combined PBL and Fishbone diagram, PBL model, and expository learning model ". The result can be seen through a test decision stating that F value (10,957) > F table (3,09), from those known that the hypothesis accepted. In addition, the significant value was 0,000 < 0,05 (significant level) stated the existence of significant differences in students' critical thinking ability between the three classes of samples.Thus, the result can be stated that there were differences in students' critical thinking ability in the sample classes.

The differences were known from the posttest given to each class in this research. Each model of learning had different steps. The expository learning model emphasizes the role of the teacher in delivering the

verbal learning material (Sanjaya, 2009). Problem-based learning model (PBL) presents real problems to be solved by the students through their knowledge and critical thinking ability (Duch, 2001). The PBL-Fishbone presented real and direct students solving the problems helped by fishbone diagram. Fishbone diagrams helped students understanding the problems and provide guidance for linking the causal factors (Anthony et al., 2004). Through the different steps in learning implementing expository learning model, PBL, and PBL combined Fishbone diagram then there was a difference posttest results after learning.

Rath et al.(2004) stated that one of the factors that can influence the development of critical thinking ability is the interaction between teachers and students. Students need an academic atmosphere giving freedom and a sense of security to express their opinions and decisions during their participation in learning activities. Through the combined PBL learning model and fishbone diagrams, students were more interact with teachers during learning process. Those results were different from the expository learning model made students less actively during learning process. The results of this research were similar to the research of Saputri in 2005 which stated that there was a difference of critical thinking ability between implementation expository learning model, PBL, and PBL model combined Fishbone diagram.

Hypothesis 2: the comparison effectiveness between problem-based learning model and expository learning model to student's critical thinking ability

The second hypothesis aimed to know the difference of students' critical thinking ability between PBL class and the expository class. The technique used in the research is Scheffe with significant level 5%. The decision of the second hypothesis testing: the hypothesis is accepted when F value > F table while the hypothesis is rejected if the F value < F table. The research questions, hypothesis, and table of the results of the second hypothesis testing are shown bellow.

Research Question 2: Is there any difference in student's critical thinking ability between the implementation of problem-based learning model and expository learning model?

Hypothesis 2: There is a difference in student's critical thinking ability between the implementation of problem-based learning model, and expository learning model.

Table 2. The result of the analysis of the Second Hypothesis Test

F value	df1	df2	F table	Scheffe Sig	Conditions
1,242	1	67	3,98	0,543	F value < F table

From the calculation of Scheffe test can be obtained significant was 0,543. When viewed from F value and significance, the hypothesis which stated that "There was no significant effectiveness difference between problem-based learning model and expository learning Model to student's critical thinking ability". The result can be seen through a test decision stating that F value (1,242) < F table (3,98), from those known that the hypothesis was rejected. In addition, the significant value was 0,543 > 0,05 (significant level) stated there were not significant differences in students' critical thinking ability between the two classes of samples.Thus, ithe result can be stated that there was not difference in students' critical thinking ability in the PBL and expository class.

Based on the analysis had been done to the research data, found a positive difference but not significant between implementation of PBL model and expository learning model to student's critical thinking ability. Prayekti (2016) stated that there was a positive and significant difference. This also showed the PBL model was more effective than expository learning model. However, should be noted that the population, variables, and subjects used in this research was different with the samples used by previous researchers. In addition, there was a difference in the practice of teachers had done the learning steps and the factors of teacher delivering the course were also different for each teacher. Teacher competence was required in order to deliver course (Mulyasa, 2014). Implementation of learning model in this research was monitored by observation sheet. The PBL and expository learning steps were observed in the observation sheet had shown the step work properly. However, students were also an important element to achieve a successful learning. Students with PBL learning model had not been able to solve the problem through their thinking ability and knowledge optimally. Therefore a more active role of student was needed in order to improve their critical thinking ability in problems solving.

Hypothesis 3: the comparison effectiveness between the combining problem-based learning model and fishbone diagram and expository learning model to student's critical thinking ability

The third hypothesis aimed to know the difference of students' critical thinking ability between PBL-Fishbone class and the expository class. The technique used is Scheffe with significant level 5%. The decision of the third hypothesis test: The hypothesis is accepted when F value > F table while the hypothesis is rejected if the F value < F table. The research questions, hypothesis, and table of the results of the third hypothesis test are shown bellow.

Research Question 3: Is there any difference in student's critical thinking ability between the implementation of problem-based learning model combine fishbone diagram and expository learning model?

Hypothesis 3: There is a difference in student's critical thinking ability between the implementation of problem-based learning model combine fishbone diagram and expository learning model.

Table 3. The result of the analysis of the Third Hypothesis Test

F value	df1	df2	F table	Scheffe Sig	Conditions
20,441	1	66	3,98	0,000	F value > F table

From the calculation of Scheffe test can be obtained significant was 0,000. When viewed from F value and significance, the hypothesis which stated that "There was significant effectiveness difference between problem-based learning model combined fishbone diagram and expository learning model to student's critical thinking ability. The result can be seen through a test decision stating that F value (20,441) > F table (3,98), from those known that the hypothesis was accepted. In addition, the significant value was 0,000 < 0,05 (significant level) stated the existence of significant differences in students' critical thinking skills between the two classes of samples.Thus, the result can be stated that there was difference students' critical thinking ability between implemented of the problem-based learning model combined fishbone diagram and expository learning.

Based on Figure 1 the average score in control class implemented expository learning model obtained an average posttest was 16,7 and in the experiment class implemented PBL-Fishbone obtained an average posttest was 19,26. This results known that the average score of PBL-Fishbone class was higher than the class implemented expository learning model. Thus stated that the implementation of PBL model combined Fishbone diagram was more effective than expository learning model to student's critical thinking ability.

Based on the analysis that had been done to the research data, found a positive and significant difference between PBL-Fishbone model and expository learning model to student's critical thinking ability.The students implemented PBL-Fishbone learning model was more active than students implemented expository learning model. They were very interest to create a fishbone diagram with their group. Fishbone diagram patterns improve students' enthusiasm to discover the various causes of WAN network damage problems. The Fishbone diagram made student to understanding the problems of WAN network damage problem easily. According to (Anthony et al., 2004) stated, Fishbone diagram can be used to solve problems. This statement was relevant to the result of this research utilize fishbone diagram to help students solving the problems. Etiubon & Ugwu (2016) stated that the effects of PBL on academic achievement, show results that were consistent with this research.

Hypothesis 4: the comparison effectiveness between problem-based learning model combined fishbone diagram and problem-based learning model to student's critical thinking ability

The fourth hypothesis aimed to know the difference of students' critical thinking ability between PBL-Fishbone class and the PBL class. The technique used is Scheffe with significant level 5%. The decision of the fourth hypothesis test: The hypothesis is accepted when F value > F table while the hypothesis is rejected if the F value < F table. The research questions, hypothesis, and table of the results of the fourth hypothesis test are shown bellow.

Research Question 4: Is there any difference in students' critical thinking ability between the implementation of problem-based learning model combine fishbone diagram and expository learning model?

Hypothesis 4: There is a difference in student's critical thinking ability between the implementation of problem-based learning model combine fishbone diagram and problem-based learning model.

Table 4. The result of the analysis of the Fourth Hypothesis Test

F value	df1	df2	F table	Scheffe Sig	Conditions
11,442	1	69	3,98	0,004	F value > F table

From the calculation of Scheffe test can be obtained significant was 0,004. When viewed from F value and significance, the hypothesis which stated that "There was significant effectiveness difference between problem-based learning model combined fishbone diagram and expository learning model to student's critical thinking ability. The result can be seen through a test decision stating that F value (11,442) > F table (3,98), from those known that the hypothesis was accepted. In addition, the significant value was 0,004 < 0,05 (significant level) stated the existence of significant differences in students' critical thinking skills between the three classes of samples.Thus, the result can be stated that there was difference in students' critical thinking ability between implemented of the problem-based learning model combined fishbone diagram and PBL model.

Based on Figure 1 the average score of class implemented PBL model obtained an average posttest was 17,3 and in the experiment class implemented PBL-Fishbone obtained an average posttest was 19,26. The results known that the average score of the implemented PBL-Fishbone higher than the class implemented expository learning model. The combining PBL and Fishbone diagram was more effective than PBL model to student's critical thinking ability.

Based on the analysis that had been done to the research data, found a positive and significant difference between PBL-Fishbone model and PBL model to student's critical thinking ability. Through the implementation of fishbone diagrams, students was more active and easy to find the causes of the problem. According to (Anthony et al., 2004) stated the fishbone diagram can increase creativity and understanding of the problem. The students implemented PBL-Fishbone learning model were more interested in learning and understanding the problems presented easily. The results of this research was relevant to the research of Nasir (2014) which stated that Fishbone diagram can be applied to learning English, show results that was indicate a positive response to the use of fishbone diagrams on students' achievement.

Hypothesis 5: the comparison effectiveness between problem-based learning model combined fishbone diagram and expository learning model to students' critical thinking ability

The fifth hypothesis aimed to determine the most effective learning model between the implementation of problem-based learning model combined fishbone diagram, problem-based learning model and expository learning model to of students' critical thinking skills. The technique used Gain Scores analysis from (Hake, 1999). The decision of the fifth hypothesis test: The hypothesis is accepted when *n-gain* PBL-Fishbone higher than PBL and expository. The research questions, hypothesis, and table of the results of the fifth hypothesis test are shown bellow.

Research Question 5: Which is the most effective learning model between the implementation of problem-based learning model combined fishbone diagram, problem-based learning model and expository learning model to students' critical thinking ability?

Hypothesis 5: The combining of PBL and Fishbone diagram is the most effective learning model than PBL learning model and expository to students' critical thinking ability.

Table 5. The result of the analysis of the Fifth Hypothesis Test

Class	*n*-Gain
PBL-Fishbone	0,418
PBL	0,390
Expository	0,154

From the calculation can be obtained n-gain class implemented expository learning model was 0,154, n-gain class implemented PBL was 0,390, and n-gain class implemented PBL combined Fishbone diagram was 0,418. The value n-gain of class implemented PBL-Fishbone learning model was highest than PBL and expository class. When viewed from n-gain, the hypothesis stated that "The use of PBL-Fishbone learning model was more effective than PBL learning model and expository to students' critical thinking ability. The result was seen through improving students' critical thinking ability through pretest-posttest results was shown on Figure 1. The class was implemented the combining of PBL model and Fishbone diagram had the highest n-gain value.

Based on the analysis that had been done to the research data, found that PBL-Fishbone was the most effective learning model than PBL model and expository learning model to student's critical thinking ability. The students implemented PBL-Fishbone learning model was more excited and easier to understand the problems presented, from those students can solving the problems with their group. According to (Ilie & Ciocoiu, 2010) stated in their research entitled "Application of Fishbone Diagram to Determine The Risk Of An Event With Multiple Causes", generating a positive response that fishbone diagram can be used in various cases including in this research that was diagnose WAN network problems. According to (Anthony et al., 2004) stated that the fishbone diagram can be used as an alternative to solve problems including in solving the problems in the matter of diagnosing network problems. Suciati (2015) stated the relevant results with this research that the fishbone diagram was effective against to improve students' achievement. Thus, the result of this hypothesis was indicate PBL-Fishbone can be used as an alternative learning model to improve students' critical thinking ability than PBL and expository learning model.

Conclusions

The findings of the research indicate that the PBL learning model combined with Fishbone diagram is an effective method to be utilized. It was demonstrated that the PBL learning model trained students to solve real problems, while the Fishbone diagram was applicable to be an assistance tool to solve problems faced by students. The application of problem-solving method was significantly contributive to students' critical thinking skills. While critical thinking skill was considered substantial for students both in their social and school life, it is advisable that critical thinking skill is embedded into teaching and learning. Students devised with the critical thinking skill during learning activities would likely survive their daily hardships. This research argues for the combination of Fishbone diagram as the alternative model in the improvement of students' critical thinking skill. The implication of this research was Fishbone diagram can be combined with technology to attract students' anthusiasm. Fishbone diagram can be developed by learning media software and diagram media sofware such as Adobe Flash, Lectora, Edraw Mind Map, and Yed Graph Editor. Besides, the teachers need to improve knowledge at learning technology to implementation the combining Fishbone diagram and learning media software for learning process.

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