

Utilization of Open-Ended Problems Model to Analyze Students'
Creative Thinking Ability on Electrochemistry Lesson

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Abstract

The objective of the present research is to study students' achievement in creative thinking ability and to determine the level of their ability in creative thinking in electrochemistry through open-ended problems model. The method used in this research is Descriptive Study. The sample of this research is 12th grade students majoring in Science of SMAN 3 South Tangerang which consist of 28 students. The sample taken are students of 12th grade majoring in science from selected classes; they have higher scores in daily test compared to 4 other classes. This was simply for convenience of studying the learning process and the implementation of open-ended model problem in this study. The data of this research was acquired from observation sheet, test and interview. In this research the achievement of student's creative thinking ability was focused on three aspects of creative thinking: fluency, flexibility and originality. The result showed that student's achievement on fluency was good, flexibility was average and originality was average. Meanwhile, the open-ended test result showed that student's achievement on fluency was good, flexibility was average and originality was also average. Level of student's ability in creative thinking was categorized as very poor, poor and average. Number of students in each category was 10 students (35.71%) in very poor category, 17 students (60.71%) in poor category, and 1 student (3.57%) in average category.

Keywords: Creative Thinking Ability, Open-Ended Problems Model, Electrochemistry

INTRODUCTION

The 2013 curriculum is a student-centered curriculum which demand an active involvement in learning process. Teachers act as facilitator or mediator as well as learning designer so as the students actively sought new discoveries (Sani, 2013). The mindset in 2013 curriculum is to generate creative Indonesian society (Yani, 2014). This is correspond to the goal of 2013 curriculum as set-forth in the Regulation of Ministry of Education and Cultural no.69/2013, i.e. preparing Indonesian so as to possess life skills as individual and citizen who is faithful, productive, creative, innovative and affective as well as capable to contribute to the society, nation, country and world civilization (Republic of Indonesia, 2013).

Ability to innovate and create are also needed in performing works in the 21st century. Within frame of competence of 21st century, it is shown that students must possess life skills and carrier, learning skills and innovating (critical and creative), ability to utilize information and communicating (Hürsen et al., 2014). In order to face challenge in the future, students must have adequate skills, among others, such as (i) basic skills comprising reading, writing, arithmetic and mathematics, speaking and listening (ii) thinking skills comprise of creative thinking, decision making, problem solving, seeing picture of idea, know how

to learn and reasoning (iii) personality comprise of aspects of responsibility, confidence, social attitude, self management and righteousness (SCANS, 1991; Aizikovitsh-Udi & Amit, 2011; Sayadian & Lashkarian, 2015).

Up to date, the student's creativity has not been appreciated in the learning process. This lack of appreciation resulted in reluctance in exploring new experiences. Creativity is not always related to ability to produce but also ability to come up with solutions without fixating to the correct answer (Hürsen et al., 2014; Chen et al., 2015). This is in accordance to Bono (2007) that the need to always provide the correct answer at school has hindered the student's ability in creative thinking. Thus, ability in creative thinking among students would not be hindered provided that the students are accustomed to provide various solutions or not fixated to one correct answer.

Poor creativity is not actually a new problem. Guilford speech during inauguration as the President of American Pshycological Association mentioned that most complaint is directed to those who graduated from university. They do well in finishing the tasks given using technique that being taught by the company, but they are not able to solve the problems with the newest ways. It indicates that lack of creativity has become urgent problem

happened in Indonesia as well as all over the world including advanced countries.

The relationship between capability of creative thinking with the approach of open-ended is being compared to the control class (Nisa & Wasis, 2013). By implementing the open-ended approach, the student is expected to be able to solve a problem by relating the known-theory, thus they may think of some alternatives for correct solution or some correct answers which can stimulate the improvement of the student's creative thinking ability (Laisema & Wannapiroon, 2014; Sekerci & Canpolat, 2014; Songkram & Puthaseranee, 2015).

The thinking ability or creative thinking ability can be measured by giving someone the task of open-ended or open task. Such tasks will expose the students to various experiences interpreting their problem and it may stimulate different ideas if it is related with the different interpretation (Silver, 1997; Piaw, 2010; Kashefi et al., 2012). Therefore, with the open-ended learning, the student has freedom to express the result of reasoning power exploration and analyze actively and creatively in solving a problem.

Electrochemistry is a lesson taught at Grade 12th which is close to daily life. Evaluating symptoms or process as occurred in exemplary electrochemistry cell (volta cell and electrolysis cell) used in daily life and analyzing factors effecting

corrosion and proposing ideas to overcome it (Republic of Indonesia, 2013). Until right now, no researchs have been found about open-ended problems in electrochemistry to determine students' creative thinking abilities. Therefore, it is necessary to do research on this matter.

Such basic competence may facilitate the student's creative thinking ability since creative thinking is the key in thinking to design, solve a problem, induce change and improvement as well as acquiring new ideas (Bono, 2007). The material taught in electrochemistry class is deemed appropriate to be utilized in analyzing student's thinking ability by open-ended problems model there by they are able to solve problems related to electrochemistry in daily life. The purpose of this study was to determine the students' creative thinking ability that could arise by giving open-ended problems to electrochemistry.

METHOD

Research method used is descriptive research. Descriptive research is a research focusing on actual problem as occurred during the research (Noor, 2011). Sample taken were the students of Grade 12th majoring in Science from selected classrooms wherein the average score of daily tests were higher than those of other 4. Such selection was to facilitate the learning process and application of open-ended problems model in this research. In

this research, sample taken by purposive sampling technique. Research instruments used were observation sheet, open-ended set of problems and interview guidance. Observation sheet used in this research serves as a mean to observe the process or the student's activity in completing the open-ended set of problems which in turn related to the aspect of creative thinking. The observation sheet were validated until they were deemed suitable to be used for data sampling process.

The objective of the test instrument is to measure the student's creative thinking ability by providing an open-ended test. Open-ended questions given to the students were set of problems with open answers. Set of problems were made to see the three aspects in student's creative thinking based on the answers given, i.e., fluency, flexibility and originality. Each aspect has their own reference in terms of assessment. Interview was conducted to acquire more in-depth information concerning the answers given in the test by the students and the student's response toward open-ended model in creative thinking ability. The interview guidance was created by researcher and consists of 8 questions.

In this research, the instrument validity uses the content of validity which leads to an instrument which has suitable content in revealing the aspects to be measured. The content validity is usually

based on the two lecturers's assessments from the Chemistry Education of Jakarta Islamic State University and a chemistry teacher from public senior high school 3 South Tangerang.

The students's answers throughout the task of open-ended were analyzed on the aspects of fluency, flexibility and originality which then interpreted into the category form in accordance to Riduwan's (Riduwan, 2010). In order to measure the student's level of creative thinking, researcher analyzed the occurrence of the three aspects of student's creative thinking in each open-ended problem set completed by the students based on their level of creative thinking ability according to Siswono's (Siswono, 2011).

From each task item given, if the student provides answer which satisfy the fluency, flexibility and originality aspects (as listed on the table above), the level of the student's creativity thinking ability is remarked as very creative. Scores from each of the problem were summed up and converted into percentage. Percentage data were interpreted into categories according to Riduwan's as previously discussed (Riduwan, 2010).

RESULTS AND DISCUSSION

Achievement in Creative Thinking Aspect

Table 1 shows the indicator of creative thinking aspects based on

Munandar. Three aspects of creative thinking are fluency, flexibility, and originality as explained in the Table 1.

Table 1. The Indicator of Creative Thinking Aspects (Munandar, 1992)

Fluency	Flexibility	Originality
The ability of students to answer with some answering and fluent in mentioning their ideas.	To think some different various ways to finish.	The student can think of the problems or somethings which have not been taught by the other people.

Table 2 contains score of creative thinking aspects. The score range is 0 to 4 of each aspects and each score has

criteria. The students's answer will be analyzed by this scoring guidelines.

Tabel 2. Scoring of Creative Thinking Aspects

Creative Thinking Aspects		
Fluency	Flexibility	Originality
Score 4: if the student was able to give more than one complete and accurate answers (the correct answer may be the point of flexibility and originality)	Score 4 : if the student was able to answer completely and accurately	Score 4 : asserting rare idea which was conveyed by the most students, but it is still in the task context
Score 3 : if the student was able to give more than one answers, but one of the answers is not correct.	Score 3 : if the student was able to answer accurately but not complete	Score 3 : asserting rare idea which was conveyed by the most students, but it is uncompleted
Score 2 : if the student was able to give more than one answer, but there is no correct answer or the student gave one correct answer	Score 2 : to give the answer which is not in the point of flexibility but it is in the point of fluency or originality	Score 2 : providing answer which is related to the task context which refer to text books
Score 1 : if the student was able to give one answer but it was not correct	Score 1 : incorrect answers	Score 1 : incorrect anwer
Score 0 : if the student did not give any answers at all	Score 0 : no answers at all	Score 0 : not providing any idea at all

Table 3 shows the result of good score, while flexibility and scoring of the student's answer from originality is average in score. Open-Ended test. Fluency aspects has

Table 3. The Achievement of Creative Thinking Aspect Based on Open-Ended Test

Creative Thinking Aspect	Number of Tasks	Number of Students	The maximum score of each Task	The number of gotten score	The average of score = $\frac{\text{The number of gotten score}}{\text{maximum score}}$	The achievement of creative thinking aspect	Desc.
Fluency				1066	$\frac{1066}{1680} = 0.6345$	63.45	Good
Flexibility	15	28	4	907	$\frac{907}{1680} = 0.5398$	54.98	Average
Originality				807	$\frac{807}{1680} = 0.4803$	48.03	Average

A. Fluency Aspect

Fluency in problem solving refers to variation of correct answers given by the students. The varied answers were not necessarily different. Some answers were deemed as vary but not different if the answers were not the same as one another but the answers appeared to be based on particular pattern or sequences. Based on the Table 3, percentage of achievement in

fluency aspect in open-ended test was scored the highest and categorized as good by 63.45%. This result shown that the students have good capability in providing various solutions from given open-ended problems. The fluency aspect is the lowest aspect in creative thinking compare to flexibility and originality (Siswono, 2011). Therefore, student's achievement in this aspect placed in the highest position.

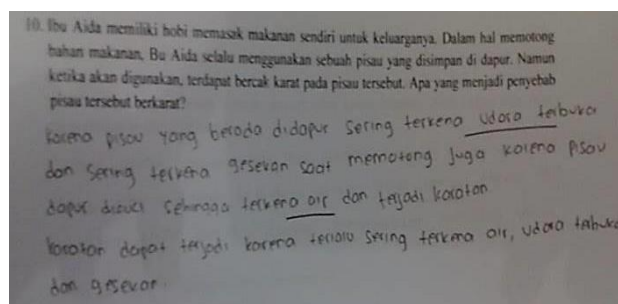


Figure 1. Achievement of Fluency Aspect

From the Figure 1, the fluency aspect on the student's answer which is seen from various ideas related to the

cause of corrosive. Students have the tendency to be fluent. This have been proven by the student's response in

interview and given questions concerning new experience found during open-ended problems learning. The following is the respondent response: "Now I know that battery is not only one type and that there are many types of battery such as primary and secondary" (Students from Group 1). From the questions given, the student opined that variation in battery such as primary and secondary batteries was something new for the student. This proved that the students have dominant fluency aspect since various kind of batteries was not considered as something new for the students in their current level of knowledge.

B. Flexibility Aspect

Flexibility in problem solving refers to student's ability in solving a problem with various different ways. Based on the Table 3, achievement in flexibility aspect based on open-ended test came in second position with percentage at 54.98% and categorized as average as well. Flexibility aspect is the second most important aspect after originality since this aspect shows idea productivity used in solving a problem (Siswono, 2011). In Flexibility aspect, students were urged to provide various solutions.

Flexibility aspect is the second most important aspect after the originality aspect because the flexibility aspect shows the productivity of idea which is used to solve a problem (Siswono, 2011). On the

flexibility aspect the student was asked to be able to give various solutions. The creativity shown can be classified into two types, one of them is "everyday", in this case the creativity becomes one of normal thinking which is implemented on each situation. It is occurred without co incidental effort, it means that the creative thinking has been usual to be implemented in daily life (Bono, 2007). There is also a special creativity, in this case there is an intentional effort by using systematic technique from the ability of the creative thinking to produce the newest ideas (Awang & Ramly, 2008). The lack of habitual creative thinking in the daily life becomes one of the reasons of poor flexibility in solving the problem. The problem of learning model implementation in the class with poor level of creativity to promote the capability in student's creative thinking was the flexibility aspect fell in average category.

C. Originality Aspect

Originality in problem solving refers to student's ability in answering problem set with various correct answers or one answer that is unusual for a student in their level of development or level of knowledge. Based on Table 3, achievement percentage in this aspect is categorized as average with percentage of 48,03%.

Originality aspect is placed at the highest position among two other aspects

of creative thinking as originality is the major feature in assessing product of creative thinking which must be different than the previous one (Siswono, 2011). Therefore, originality aspect is deemed important in determining the student's creative thinking ability. Unfortunately, this aspect in creative thinking was at the lowest position when compared to other aspects of creative thinking such as flexibility and fluency. Since this originality aspect is placed at the highest position, students found it difficult to achieve this aspect (Ersoy & Başer, 2014; Piaw, 2014).

Higher achievement in creative thinking aspects in observation result was resulted from provision of learning sources such as book and internet during the learning activities. While during tests, learning sources were prohibited. Potential development of the learning participant which is related to creativity development may be executed through learning by using learning sources. Through such learning process, learning participant became curious in everything (Wardani, 2013).

In the open-ended tests, students worked on the problems set without aid from learning sources and only relied on their knowledge or connecting their own experiences to the problem set. Decreased in achievement of creative thinking aspect occurred as the effect of learning sources.

By accessing the learning sources, students were able to explore knowledge as well as facilitating the student in fulfilling their curiosity thus they can generate many solutions for the problems given. Achievement in creative thinking would thus be improved when the learning sources were given (Surif et al., 2014)

Based on description for the three aspects of creative thinking, one can conclude that achievement in the student's creative thinking with the highest percentage and categorize as "good" from observation result and open-ended test is the fluency aspect. While the lowest achievement in creative thinking aspect is the flexibility aspect, as shown in observation sheet, and in originality aspect as seen from the result of open-ended test.

The order of achievement creative thinking aspects based on the open-ended test results are as follows: aspects of fluency in the first place, followed by the aspect of flexibility and finally, aspect of originality. The order of these three aspects of the same achievement as the result of the second test on the open-ended test to measure the ability to think creatively (Nahadi et al., 2015). According to Nahadi, achievement in creative thinking aspect was still lacking. The lack of ability in creative thinking among students could not be separated from learning process taking places in the formal education.

D. Level of Creative Thinking Among Students

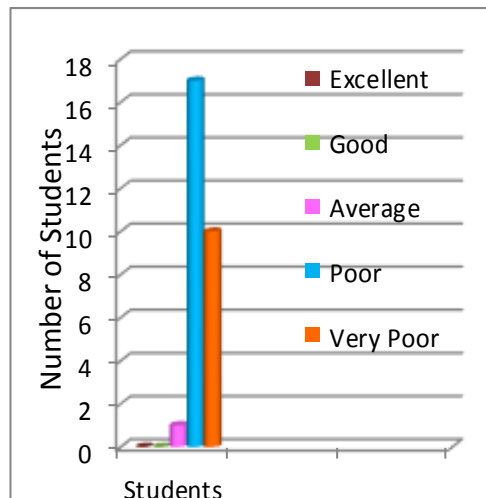


Figure 2. Level of Creative Thinking Among Students

Based on Figure 2, none of the students able to reach good and excellent level in creative thinking ability. In other words, the students could not solve the problem given by fulfilling the three aspect of creative thinking in order to reach level of excellence. Further, the students could not meet the aspect of fluency and originality in solving the whole problem set given and reach good score. Based on students grouping (high, medium and low), the level of the student's ability in creative thinking is shown by Figure 3.

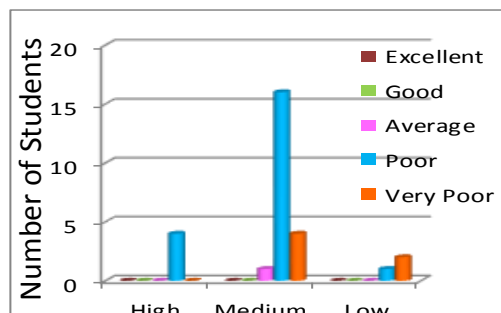


Figure 3. Level of Student's Creative Thinking Ability Based on Group

In Figure 3, average result was achieved only by 1 student in the Medium group and failed to be achieved by students in the High group. Creativity or ability in creative thinking could not be forced upon students, instead creativity must be nurtured. Habituation or cultivation in creative thinking could be applied as an effort to develop thinking ability and the student's ability in problem solving (Kuspriyanto & Siagian, 2013).

Solving problems using the open-ended model is a new learning method and relatively unknown by the students. Therefore, this learning model could not be used for students to develop their creative thinking ability. This is shown by Figure 2 which demonstrated the level of creative thinking ability with the largest number of students in Poor category of 17 students. The lack of ability in creative thinking among students is deemed as the result of lack of habituation in using the open-ended problems model in learning process. This was reinforced by response of one of the student during interview as follow:

“Does open-ended learning motivate you to be more creative? What is your reason?”(Researcher)

“Yes it does, because this method is new for me. The reason is we were grouped thus we could discussed opinions from each of group member and the best

opinion would be presented” (Student of High group 2)

From the above interview, the student conveyed that the open-ended learning was novel and newly experienced. Therefore, the students have not yet accustomed themselves to this learning model. Students have also found trouble in applying open-ended problems model which resulted in low score in their creative thinking level. Such difficulty was identified from some respondents as follows:

“Did you find any troubles during this study?”

“We did not know the whole thing. So, yes, there were some troubles” (Student of Average group 1).

“The trouble was we must do a little searching, concerning the material” (Student of Low group 1).

This is in accordance to a research conducted by Setiawan & Harta (2014) which resulted in student’s negativity toward open-ended learning since they were not accustomed and found troubles frequently. Based on observation, even during initiation, some students became flustered when they were given problem-set in the form of open-ended thereby they did not feel confident in working on the given problem set.

Based on the 15 open-ended problems given, some students were able to achieve a very creative level in certain

problems. In this very creative level, the students were able to achieve the three aspects of creative thinking, i.e., fluency, flexibility, originality in answering the given problems. Problem no.3 concerning how to make a gold ring looks anew, was answered very creatively by 1 student and problem no.9 concerning the cause of difference between gold metal and iron metal was answered very creatively by 1 student. The open-ended test is capable in measuring creative thinking ability among student, however, the level of creative thinking was low in this research because the students were not familiar with this model.

Open-ended test were able to measure aspects of creative thinking and the level of creative thinking of students, but the low level of students' creative thinking skills as shown in this study was caused by the unfamiliarity of the open-ended problems model for students. So students are advisably to be given open-ended questions frequently, especially in the application of the 2013 curriculum. Open-ended questions are a form of questions that present a problem that has a variety of solutions /methods of settlement that can be related to students' creative thinking abilities. Because creative thinking is the ability to find a new relationship, see various subjects from one new perspective, and find new

combinations of two or more existing concepts (Nahadi *et al.*, 2015).

CONCLUSION

Based on the research findings and discussion on creative thinking ability among the grade 12th students in electrochemistry in learning through open-ended problems model, it is concluded that based on open-ended test results, fluency is achieved under Good category, flexibility is achieved under Average category and originality is achieved under Average category.

Overall level of creative thinking among 28 students is achieved by 1 student under Average category, 17 students under Poor category, and 10 students under Very Poor category. If the result is converted into percentage, Average achievement is 3.57%, Poor achievement is 60.71% and Very Poor achievement is 35.71%. Creative thinking ability aspect that can be achieved by the students by highest percentage is fluency.

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