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THE IMPLEMENTATION OF OPEN-INQUIRY APPROACH TO IMPROVE STUDENTS' LEARNING ACTIVITIES, RESPONSES, AND MATHEMATICAL CREATIVE THINKING SKILLS

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Abstract

This study aims to reveal the improvement of the students' learning activities, responses, and mathematical creative thinking skills (MCTS) through open-inquiry approach (OIA). Other relevant studies in mathematics learning tend to focus on guided inquiry, and especially in Indonesia, OIA is still less applied. This study is conducted at State Junior High School in Indonesia. The method used in this study is Classroom Action Research (CAR) consists of four stages: planning, acting, observing, and reflecting. Data is collected through observation, journal reviews, interview, and test. The result of the study shows that the implementation of OIA enhances the students' MCTS. It is shown by the improvement of the average of students' score from 73.05 in the first cycle to 78.95 in the second cycle. The increasing of MCTS includes some aspects: fluency, flexibility, and originality. The result also shows that in general, the students give positive response and engage well in learning activities with OIA. It can be concluded that the implementation of OIA enhances learning activities, gives positive response towards mathematics, and improves students' creative thinking skills.

Keyword: Open-Inquiry Approach, Learning Activity, Response, Creative Thinking Skill

Abstrak

Tujuan penelitian ini adalah untuk mengungkapkan peningkatan aktivitas, respon, dan kemampuan berpikir kreatif matematis siswa melalui pendekatan open-inquiry (POI). Penelitian sebelumnya dalam pembelajaran matematika, cenderung fokus kepada guide inquiry, khususnya untuk konteks Indonesia pendekatan open-inquiry, masih sedikit digunakan. Penelitian ini dilakukan di salah satu Sekolah Menengah di Indonesia. Metode yang digunakan adalah Penelitian Tindakan Kelas (PTK) berisi empat tahap, yaitu: perencanaan, pelaksanaan, observasi, dan refleksi. Data dikumpulkan melalui observasi, journals, wawancara, dan test. Hasil penelitian mengungkapkan bahwa penggunaan POI dapat meningkatkan kemampuan berpikir kreatif matematis (KBKM) siswa. Hal ini ditunjukkan oleh rata-rata peningkatan siswa dari 73,05 pada siklus pertama ke 78,89 siklus kedua. Peningkatan KBKM tersebut meliputi aspek fluency, flexibility, and originality. Selain itu, hasil penelitian juga menunjukkan bahwa pada umumnya siswa mempunyai respon positif dan aktivitas dalam kategori baik terhadap pelaksanaan POI. Kesimpulan penelitian ini adalah penggunaan POI dapat meningkatkan aktivitas belajar matematika siswa, memberi sikap positif terhadap matematika dan meningkatkan KBKM siswa.

Kata Kunci: Pendekatan Open-Inquiry, Aktivitas Belajar, Respon, Kemampuan Berpikir Kreatif

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Creative thinking is one of the fundamental capabilities which is possessed by the learners in the era of information and technology which is developing rapidly at present time. Educational institution as a conducive space to position the learners as a subject educational system to foster creative behavior, positive attitude and excellent character. Mathematics at school is a means to educate the students to become creative human. This is in accordance with the purpose of studying mathematics is to train and foster students how to think systematically, logical, creative, critic, consistent, developing a never give up attitude and confidence in problems solving.

Through the design and process of active learning mathematics with fun, doing observation, asking, reasoning can develop the knowledge and creative thinking of students.

But, the reality of students' creative thinking abilities in Indonesia is still relatively at low levels. This condition is indicated by Program for International Student Assessment (PISA) under the Organization of Economic Cooperation and Development (OECD) in 2012 reported that the mathematical skills of Indonesia learners grade VIII is ranked at 64 of 65 countries, the problem is given in PISA is divided into three domains and 6 level, where level 6 is the most complex problems. This condition is caused by the level of achievement in answering questions correctly at level 5 or level 6 is close to zero that is 0.3% and far from the average percentage of students of other countries, namely 12.6%. However, the Indonesian students reached high achievement (75.7%) in answering questions correctly at level 2 and 1 (OECD, PISA 2012). The Questions on the matter at levels 1 and 2, generally associated with interpreting the situation in a given problem, then solve procedurally using general formulas. This means, Indonesian students tend to have only lower-order thinking skills (LOT) of a procedural nature and have not been able to develop creativity and higher order thinking skills (HOT).

Ervynck (1991: 47) defines creativity in a framework of mathematical knowledge as an ability to solve problems or to develop thinking in structures, taking into account of the peculiar logic-deductive nature of the discipline, and of the fitness of the generated concepts to integrate into the core of what is important in mathematics. Since those definitions deal with originality and usefulness, the definition of mathematical. Compared to Ervynck (in Sumarmo, 2014: 245) is more complete explanation related to creative thinking skills, includes aspects of cognitive, affective, and metacognitive. Especially aspect of cognitive skill, covers the ability to: identify problems and opportunities, draw-up a different question, identify data which are relevant and irrelevant, to generate new ideas (fluency), the different ideas (flexibility), and the idea that new, change mindsets, and old habits, draw-up a new relationship, and renew a plan or idea (Originality). Furthermore, Silver (1997) asserts that the indicator to evaluate the creative thinking skill using The Torrance Test of Creative thinking (TTCT), contains three key components, namely fluency, flexibility, and novelty.

Regarding to the some concepts elucidated by some experts above, it can be drawn a conclusion that mathematical creative thinking skills (MCTS) is the skill to give ideas to solve a mathematical problem based on the indicators which included (1) fluency, the students' skill to create a bunch of idea in solving problem, (2) flexibility, is the skill to give a different way to solve the mathematical problem, and (3) originality, is the students' skill in self-analyzing their problem by answering through unfamiliar way. Conventional learning is still found in the subjects of mathematics, it is seen from the observation of learning activities of students in secondary schools, showed that most students simply sit passively, they are not actively involved in learning. Learning mathematics tend to be only the transfer of knowledge from teacher to student (teacher center), less students are given the opportunity to make ideas or new ideas that are different from students.

The results of preliminary observations and interviews on one of the State Junior High School in Indonesian shows that creative thinking ability of students is still relatively low, around 50% of students in the class had difficulty solving mathematical problems of non-routine. Students also have difficulty preparing their own conjecture, solving mathematical problems, generally students using exactly the same methods that have been

taught by teacher.

One of the alternative approaches to learning that can motivate and oriented to increase the ability of creative thinking is the open inquiry approach (OIA). Emphasizes on the process of searching for and finding through the process of investigation of a problem. The role of the students in this study is to seek and find their own piece of knowledge, while the teachers act as facilitators and mentors for the students to foster the appropriateness, challenging questions, and trigger student-generated investigation in learning. Open or “full” inquiry can be defined as a student-centered approach that begins with a student’s question followed by the students designing and conducting an investigation or experiment and communicating result (National Research Council, 1996; Colburn, 2000).

According to Jarret (1997: 4) there are eight stages in learning process of open or full inquiry, they are: (1) learning in a rich environment, (2) thinking of a question, and shaping it into something they can investigate, (3) hypothesizing, (4) planning an investigation, (4) collecting data, (5) analyzing that data, (6) forming a conclusion, (7) communicating their findings. Furthermore, Sani (2015), states that the stages of open inquiry learning, including: (1) formulating problem, (2) developing and formulating hypothesis, (3) designing and doing testing hypothesis, (4) drawing conclusion. The definition of learning open inquiry in this research is learning that giving freedom to students to conduct an investigation into a mathematical problem through the following steps: (1) formulate the problem, (2) formulate a hypothesis, (3) test the hypothesis, (4) draw conclusion.

Based on the mapping of the above problems, this investigation implemented open Inquiry learning approach to enhance the activity, response, and the students’ ability of mathematical creative thinking. Research questions are as follows:

1. How did the application of learning using OIA could increase the activity of mathematics learning?
2. How were the students’ response to learning using OIA?
3. How did the application of learning using OIA could improve the students’ ability of mathematical creative thinking?

The results of this research expected to give some significances not only theoretically but also practically, go to:

1. The schools, the results of the application of OIA to learning mathematics can be used as a learning model to improve the ability to think creatively both in science subjects and other relevant subjects.
2. The teachers, achievements and the profile of mathematical creative thinking obtained in this study as baseline data to develop a model of evaluation and learning to improve mathematics higher-order thinking (HOT) on various relevant materials.
3. The learners, step-by-step approach of open inquiry that has been developed in this study as a model to study mathematics independently at home to enhance the creative reasoning, and spark ideas or new ideas in mathematical problems solving.
4. The further researchers, the results of this study can be used as a source of information and theoretical and applicative reference materials for further research involving a variety of interventions to increase creative thinking abilities at any levels of education.

METHOD

The subjects of this study were all students of grade IX-H of State Junior High School (SMP Negeri) 1 Depok in academic year 2014/2015, and IX-H teachers as collaborator and observer. The role of researcher in this study were as perpetrator of the research while mathematics teachers as collaborators and observers where as a collaborator is working with researcher in developing the design of learning, reflecting, and determining the actions at the next cycle. As an observer is to give an assessment of the application of OIA and observing students' mathematics learning activities.

Research Design

This research applies a Classroom Action Research (CAR). This method is a process of systematic-inquiry and self-reflective which conducted by teachers to improve teaching process in the class (Basrowi & Suwandi, 2008; Mills, 2011; Altricher et al., 2005). The main purpose of the study was to improve and enhance the practice of mathematics learning. This study begins with a preliminary observation (pre-study). Based on the mapping and discovery of the problem root of pre-compiled research activities in the cycles I, covering the four stages, namely: Planning, Acting, Observing and Reflecting. In more detail of the research design is drawn in Figure 1.

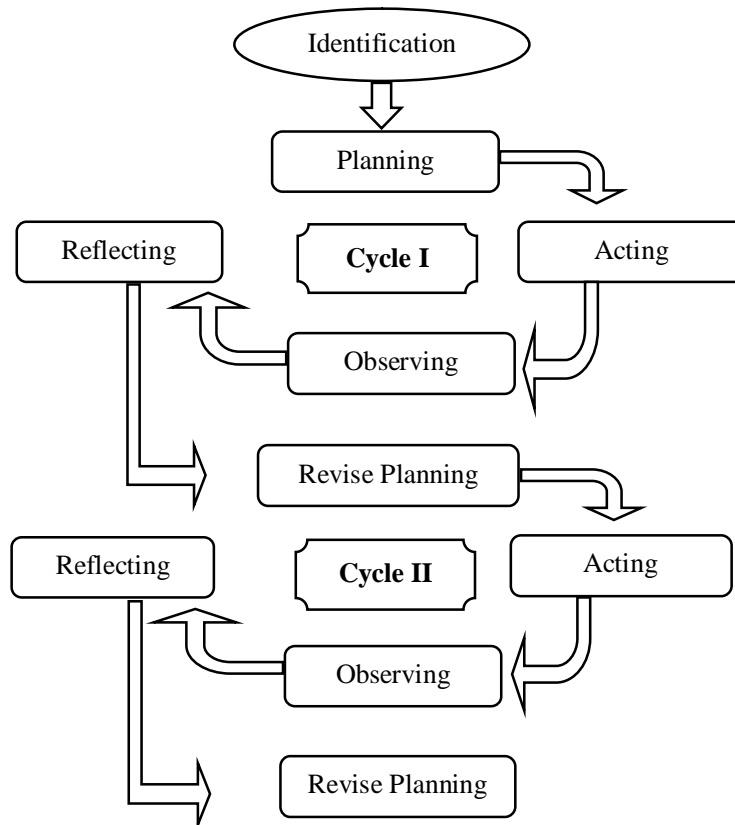


Figure 1. Classroom Action Research Design

Research Procedures

1. Planning

This stage contains the determination of the design of OIA and the types of learning activities which would be observed, developing the learning plan, set criterion, determine collaborators as

partners in the learning process in the class, and making the observation sheet, field notes, interview sheets, and test questions for the final cycle.

2. Acting

This stage is the implementation or application of the contents of the planning or draft have been made that using OIA.

3. Observing

In this stage, the researcher did observation on the OIA learning process along with collaborators (class teacher). This observation is intended to explore, and to manage all document which relevant to the indicators that occurred during the research process.

4. Reflecting

This stage is to evaluate the activity, analysis, reflection on the implementation of OIA in learning process that has been done. The results obtained from the observations which were collected and analyzed together researchers and observers, to learn whether the activities have been implemented already achieved goals (criteria) are expected or still needs improvement. This stage is implemented to improve the activities of the previous cycle, which will be applied in subsequent cycles. According to Costello (2011), that reflection is to emphasize on learning process through asking question and investigation which leads to develop students' understanding. So, reflection can change experience become a learning.

Research Instruments

The instruments used to collect data in this study consisted of two types of test instruments and non-test instruments. Test was one of the instruments used as the formative test that conducted at the end of each cycle. This test aims to analyze or to know to what extend the students' MCTS on of all materials that has been given as the implications of the action. Observation of individual activity sheet was used to determine students' mathematics learning activities. Observation sheet is also used to analyze and reflect on each cycle to improve learning in the next cycle. Furthermore, the group activities were observed through checklist observation sheet, it used to determine the development of group activities of each group was studying mathematics. Interview sheet used to interview the teachers and students in gaining information directly related to conduct instruction and any problems were found in the classroom. Students' daily journal made to obtain the response from students in learning process through OIA in each session.

Data Analysis Technique

Data analysis technique applied in analyzing the data of this investigation was descriptive analysis. To ensure the data were valid, data were cross-checked by using triangulation technique. The triangulation types used in this study, covers triangulation of sources and techniques. Before performing data analysis, researchers re-examine the completeness of data from various sources. Data analysis was commenced by presenting the overall data were obtained from various sources, perusing

the data, then recapitulation the data, and compared to the criteria of success on intervention.

RESULTS AND DISCUSSION

Learning Activities

The students' activity in learning process used OIA is presented in comparison of the percentage of students in learning activities by using OIA, in Figure 2.

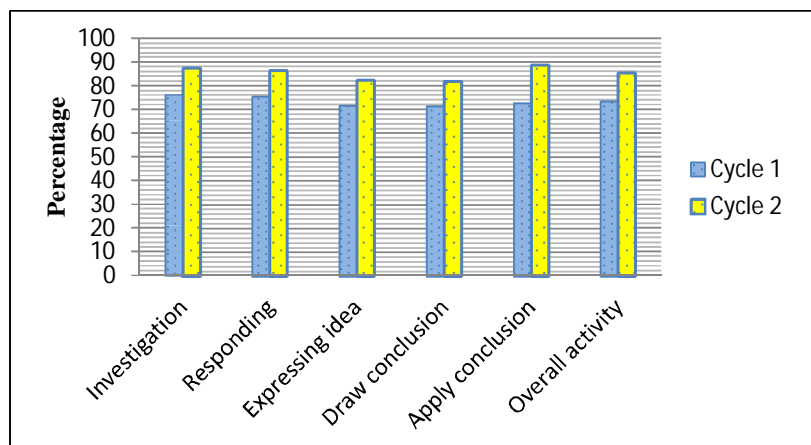


Figure 2. Learning Activities by Using OIA

Based on the analysis in the table and the Figure 2 above, it indicates that the overall activity of students' mathematics learning cycle 1 and cycle 2 with OIA increased from 73.51% in cycle 1 to be 85.34% in cycle 2. Increased activity include: do investigations, responding to, expressing opinion, drawing conclusion, and apply the conclusions on exercises. The following are some examples of intervention result in OIA:

1. Formulate a hypothesis (Figure 3)

A bag manufacturer plans to make hand bag with tubular type with a radius of 7 cm pedestal and height of 30 cm. What is the area of fabric required to produce one dozen?

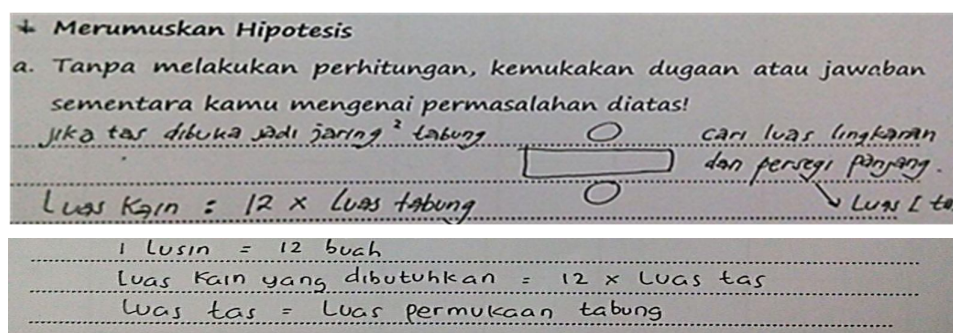


Figure 3. Formulate a hypothesis

2. Hypothesis Testing (Figure 4)

In doing hypothesis testing, teacher gives replica cone with different measurement. The example of hypothesis testing is presented in Figure 4.

b. Untuk menguji dugaan sementara kamu, lengkapi tabel dibawah ini!

Kerucut	Jari-jari alas	Luas alas kerucut	Garis Pelukis	Tinggi Kerucut	Luas selimut	Luas (alas+sel)
1	7	$L = \pi \times 7 \times 7$ $= \frac{22}{7} \times 7 \times 7$ $= 154 \text{ cm}^2$	$s = \sqrt{24^2 + 7^2}$ $= \sqrt{576 + 49}$ $= 25 \text{ cm}$	24	$L = \pi r s$ $= \frac{22}{7} \cdot 7 \cdot 25$ $= 550 \text{ cm}^2$	$L = 154 + 550$ $= 704 \text{ cm}^2$
2	$r = \sqrt{s^2 - t^2}$ $= \sqrt{5^2 - 3^2}$ $= \sqrt{16} = 4 \text{ cm}$	$L = 3,14 \times r^2$ $= 3,14 \times 4^2$ $= 50,24 \text{ cm}^2$	5	3	$L = \pi r s$ $= 3,14 \cdot 4 \cdot 5$ $= 62,8 \text{ cm}^2$	$L = 50,24 + 62,8$ $= 113,04 \text{ cm}^2$
3	5	$L = 3,14 \times 5^2$ $= 78,5 \text{ cm}^2$	$s = \frac{L}{\pi \cdot r}$ $= \frac{204,12}{3,14 \cdot 5}$ $= 13 \text{ cm}$	$t = \sqrt{s^2 - r^2}$ $= \sqrt{13^2 - 5^2}$ $= \sqrt{169 - 25}$ $= \sqrt{144}$ $= 12 \text{ cm}$	204,12	$L = 78,5 + 204,12$ $= 282,62 \text{ cm}^2$

Figure 4. Hypothesis Testing

3. Draw conclusions

Please observe some times and you have to pour cone or ball contains butter in order to fill the tube until it is full. If you have done experiment, try to draw conclusion about cone volume and ball volume. The conclusion of the formula about the two volumes above are described in Picture 5.

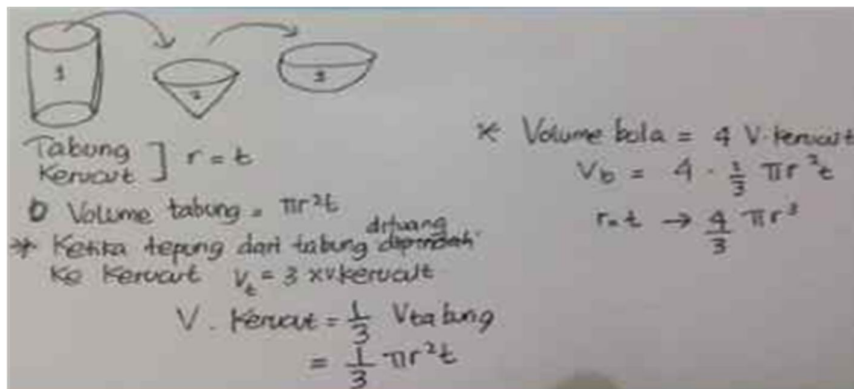


Figure 5. Draw conclusions

Students' Response

The percentage of positive responses, neutral, and negative students to open-inquiry based learning approach open daily journal in cycle 1 and cycle 2 can be seen in Figure 6.

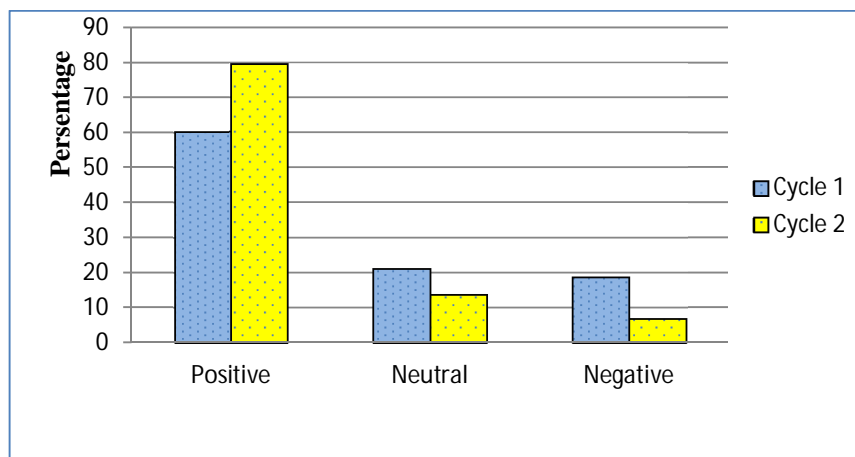


Figure 6. Comparison of Students' Response between Cycle 1 and Cycle 2

Based on the analysis of students' daily journal, it appears that the positive response of students from cycle 1 to cycle 2 undergone increasing by 19.32%, and a neutral response, and in particular the negative response of students from cycle 1 to cycle 2 decreased by 11.93% . It shows that most of the students liked the OIA. The response is positive, neutral and negative recorded in the daily journal linked by easy or hard materials studied every meeting with an OIA. Generally, if the material in the learning process easily perceived and understood then it will be a positive response, and vice-versa.

Mathematical Creative Thinking Skills (MCTS)

The data description of MTCS is presented completely in the Table 1 below.

Table 1. MCTS in Cycle 1 and Cycle 2

Statistic	Cycle 1	Cycle 2
Total	44	44
Mean	73,05	78,95
Median	73,00	80,00
Std. Deviation	12,26	12,65
Minimum	40	47
Maximum	93	100

The results of descriptive analysis as presented in Table 1 above, shows that the average score of students' ability in mathematical creative thinking, especially in cycle 1 is at 73.05 increased to 78.95 in cycle 2, where the average cycle has exceeded two successfulness indicator is 75. Furthermore, creative thinking abilities of students according to performance indicators mathematical fluency, flexibility, and provide answers to the unusual or originality in cycle 1 and 2 are presented in Figure 7.

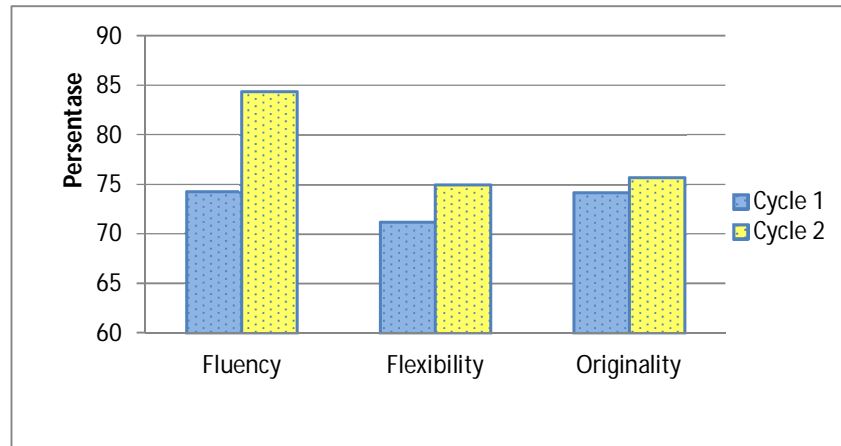


Figure 7. Percentage of the Students Ability of MTCS of Cycle 1 and Cycle 2

Based on the chart, figure 4, students' MCTS increased from cycle 1 to cycle 2. These results happened on all indicators of creative thinking. This shows that the OIA intervention in cycle 2 has reached pre-determined success criteria, namely 75.

Based on the result analysis from the observation of students' learning activity, observation of students' response, and post-action in cycle 1 shows that the activity of students' learning mathematics have not reached the indicator. This respect is marked by the activity in stages of OIA learning has not maximal yet. Students still have difficulty in developing hypothesis and drawing conclusion. The activity of question of responding is at low level. The result of observation on students' response is more neutral and negative. The score of students' MTCS mostly has not reached the successfulness criteria which made by the researcher was 75. The students' score is still at low category.

In the cycle 2 was done some improvements in doing the stages of OIA and student work sheet (LKS) would be interested in both language aspect, performance, and learning atmosphere which are more fun, so that the passive students feel motivated in posing question or idea, answering, responding, and describing related to instructional materials.

The finding of the recent research reveals that students' activity in learning mathematics with OIA undergone the development from the first to the second cycle. The increasing of the activity which covers: doing investigation, responding, expressing idea, drawing conclusion, and applying the conclusion in solving problem. The students' process of learning mathematics with OIA runs well, through improving based on the result of the first cycle, so that, the students more motivated in following the next cycle (cycle 2). In the first cycle, there are still many students who have not got used to learning with using OIA, this condition is signed by some students who unwilling to work-out the exercises in the Task. Next, researcher gave some counseling to the students about the finding and building self-knowledge through OIA Task, so, in the second cycle, the students are more enthusiasm more active to get involved in learning activity. This finding is like what Sadeh and Zion (2012) reports that learning using open inquiry gives the opportunity to the students to be involved in

investigating a problem compared to guide inquiry learning strategy.

Furthermore, the research finding expresses that the students' positive response on learning with OIA undergone increasing from the first to the second cycle. On the contrary, neutral response and negative on OIA undergone decreasing from the first to the second cycle. This finding shows that the students found of and support learning process uses OIA, because in this instruction, the students guided to think and express the mathematical ideas through the problems which are presented in the students activity sheet (Task) with using their own experience and knowledge have had before. This finding similar to Zion and Mendelovici (2012) that the effectiveness of open inquiry learning in developing cognitive and procedural skills for inquiry and autonomous learning, as well as more positive attitudes towards science and science learning. This finding also similar to Gulo (2008), stated that inquiry not only developing intellectual competence but also all potency, included emotional development and inquiry skill is a process which started by formulating the problem, formulating hypothesis, collecting data, analyzing data, and drawing conclusion.

The research finding reveals, in general, the MCTS undergone development from the first to the second cycle. The MCTS increasing mentioned above focuses on some indicators, they are fluency, flexibility, and originality. Referring to these condition, it can be drawn that the increasing of MCTS on indicator of 'fluency' is supported by data description which is not so difficult or complicated, such as the students were described with the appropriate elements which meet the size of volume geometry. The students have expressed their idea in solving the problems, as shown by the students' answers which more than expected by questions posed.

The MCTS competence on indicator 'flexibility' seen from the number of students which could answer the question differently, even though, some of the students' answers have not completed with the appropriate concepts. Furthermore, the better result which is seen by the indicator 'originality' in the first cycle are more students answered formally and used a certain formula. Meanwhile, in the second cycle, the students could answer the tests with unfamiliar ways. Next, the students also could answer with various way and unique and accompanied by solution process systematically, and mostly the students are more scrutiny in answering the tests while paying attention to the incorrect answers in the previous cycle (first cycle).

The finding above, reveals that OIA shows that students' motivation for autonomous learning, finding and developing their own knowledge. The process of acquiring knowledge for the students were conducted not only through the materials which given by the teacher but also the students were given an autonomy on their own creation, and logical thinking through the space or opportunity to find novel ideas in learning mathematics. These findings in line to Zion and Mendelovici (2012) that critical and logical thinking play an important role in an inquiry process. On the lower levels of inquiry, logical thinking focus on the linear and logical transition between the inquiry question, hypotheses, the inquiry plan and conclusions. On higher levels of inquiry, logical thinking which connects between the inquiries questions comprising a certain inquiry project, in matching the inquiry

questions with the inquiry plan, and throughout the entire process of setting up an experiment system.

The results of this investigation are in line with the findings which reported by Nishitani (2011), their findings reported that open inquiry learning approach is more effective than that shown in conventional learning process. This is also in line with what has been found by Fatah, et al. (2016) that learning through open-ended approach can better increase the students' mathematical creative thinking ability despite the different school category. Furthermore, viewed from the school category, the self-esteem of students at high and middle school categories who learn through open-ended approaches better than that of those who learn conventionally.

CONCLUSION

Based on the finding and discussion, it can be drawn conclusion that: Students' activity in learning mathematics with OIA undergone a good development from the first to the second cycle. The increasing of activities meant are doing investigation, answering, responding, expressing ideas, and drawing conclusion based on the solution obtained from problem solving. The positive response to the learning mathematics using OIA is at good categorized and over the success indicator which has been designated before. The students like, fun, and directly involved in learning mathematics using OIA.

The ability of MCTS through learning mathematics using OIA has reached a good categorized/level and undergone a significantly increase from the first to the second cycle. The obtaining of MCTS competence is in the last period of the second cycle also has fulfilled the successfulness criteria which have been made in the previous action. The increasing of the competence of MCTS, covers fluency, flexibility, and originality. Finding which is related to the indicator 'fluency', students have could give more creative answer from which they were expected by the tests. Meanwhile, regarding to the indicator 'flexibility', the students have could give various answer types. Next, in the last indicator, the students have not only could give various answer types but also unique one.

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