The effect of explorative learning strategy toward enhancement of students’ conceptual understanding on geometry

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The purpose of this research are: (1) to describe of explorative learning strategy in teaching and learning on Geometry; (2) to know the effect of students’ conceptual understanding who learn under explorative learning strategy viewed from school category and prior knowledge; The quantitative method with pretest-postest control group design is used to conduct the research. The data was analysed using statistic parametric, such as T Test, Mann Whitney Test, Kruskal-Wallis, and chi square. The participant are 114 students at Islamic High School in Jakarta-Indonesia and 3 teachers. The research was concluded with that: (1) there is no difference of conceptual understanding on geometry between students who learn under explorative learning strategy and conventional learning strategy; (2) there are interaction effect from learning strategy, school category and prior knowledge toward enhancement of conceptual understanding.

Key words: Explorative learning strategy, conceptual understanding, geometry.

INTRODUCTION

Nowaday, curriculum of education is implemented to lead teaching and learning process toward enhancement of students’ competency. As we know, Principle and Standard for School Mathematics from NCTM (2000) mention five standards of process in teaching and learning mathematics: problem solving, reasoning and proof, communication, connection and representation. This principle is coincident with Indonesia curriculum of mathematics education. The teacher have to improve their pedagogical knowledge, therefore they can find, develop and use the new strategy, technique or method in teaching and learning mathematics based on situation, condition, culture, facility etc.

Geometry is one of content in mathematics. Geometry or geometrical thinking is benefit for our daily life because it can develop the power to imagine shape, to discern elements that are not shown, and apply to the material world (Goos (2007, p.200). There are some occupation or job requires geometry, e.g. conventional home builder, manufacturer, interior and exterior designer, robot designer, architect, etc (Whitely, 1999; Jones, 2000, 2001). Some example of product that use geometry are Tajmahal Building, aeroplane, technology of global positioning system (GPS) etc. A part from this benefit, geometry also can help someone in understanding of other concept, such as Algebra, Calculus, Arithmetics, etc.

In fact, some student difficulties in understanding of geometry. Particularly for Indonesia students, score for TIMMS on geonetry is lower than the international average, and score on geometry is lowest than score number, algebra and data&probability look at table 1 (Mullis, 2008, p.121). Actually, geometry is hard to understand and it cannot be understood in short time because it is consist of abstract concept which is can not visualize by the concrete object. (Bitter, 1989; Clement, 2003; Moyer, 2003; Goos 2007). The weakness of students’ understanding on geometry because some factor: low of visualization ability (Clement, 2003; Ives, 2003), cannot view and understand object (Johnston-Wilder & Mason, 2005), low and limited connection ability to construct conceptual framework on geometry (McLeay, 2006) and students cannot understand concepts, and cannot solve the problem (Basham, 2007).

Geometry is not easy to learn and also to teach, because there are five levels on geometrical thinking Van Hiele, they are: recognition, analysis, abstraction, deduction and rigor (Baynes, 1998). They are some
Table 1. Score benchmark Indonesia’s students at year 2007.

<table>
<thead>
<tr>
<th>Domain of content</th>
<th>Domain of cognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>Algebra</td>
</tr>
<tr>
<td>399</td>
<td>405</td>
</tr>
</tbody>
</table>

International Score Average = 500

Cite in: Mullis, 2008

Researcher investigate students’ geometrical thinking on visualization, because visualization is basic level in understanding geometry. McLeay (2006) improve of visualization ability by concrete object, Tartre (1990) did some exploration on visualization with three steps: understanding a problem, change 3D object become 2D, than re-arrange and interpretated on new object. While, conceptual understanding on Geometry is define as the ability to understand of basic geometry and the relationship, such that become integrated knowledge to attain of comprehensin knowledge.

As mentioned above, teaching geometry and learning geometry is not easy. It is needed a strategy or trick on teaching and learning geometry to accommodate students’ understanding. Recent, constructivism is one of trend approach in teaching and learning to enhance of students’ understanding. Learning in constructivism is define as a process that student construct their knowledge by cause a reflection abstract process, and need to train and improve continously by investigation, mathematical activity, informal and pattern experience (Confrey & Kazak, 2006). All the activity should be setting by challenge problem and build learning community therefore knowledge can build based on students skills and needs to integrated phisysical, emotional, social, language, aesthetics, and cognitive (Cunningham, 2010). Differently with Socio-cultural, teacher should involve in teaching and learning process to improve students’ understanding because they are arrange and hold the learning procedure. Ernest (1991) mentions that social constructivism as a basic on build students’ understanding because three reason, are: (a) mathematical knowledge consist of knowledge of language, rule, and structure which is builded by socio constructivism; (b) socio interpersonal process can change subjective mathematical knowledge to objective mathematical knowledge; an (c) mathematics itself use to understanding of social knowledge.

Learning process can not separately from students’ motivation, students won’t learning or knowing something without teacher motivation. So teaching and learning process on constructivism need teacher motivation because knowledge is not come from students construction only but also pushing or engagement from the teacher. It is an accordance with Sweller (Kirschner, 2006) showed that exploration practice (a discovery technique) caused a much larger cognitive load and led to poorer learning than worked-example practice. The more knowledgeable learners did not experience a negative effect and benefited equally from both types of treatment, guided instruction not only produced more immediate recall of facts than unguided approaches, but also longer term transfer and problem-solving skills.

Related to exploration activity, McLead (2010) said that scaffolding technique on theory of Vygotsky is an effective way to support students need on improving their knowledge, because scaffolding technique can put the students on right position to get their successfullly. Other researcher develope learning strategy based on constructivism approach (Gravenmeijer, 1994; Moley, 2003; Johnson, 2006), they showed that exploration activity is one of important step on teaching and learning mathematics, beacause it can push on students to doing math (Confrey & Kazak, 2006), mathematical knowledge need doing math activity to construct new knowledge, receive some information, and to know what we need to build understanding with object in mathematics.

Explorative and investigation have similarity with investigation. As Greenes (Diezmann, 2001:2) mention that “Investigations present curiosity provoking situations, problems, and questions that are intriguing and captivate students’ interest and attention. At the outset, students are unable to solve the problem because they are complex, often necessitating the design of a plan or approach, and frequently require the completion of several tasks. Most investigations are interdiscilinary, requiring students to apply concepts from the various areas of mathematics, and, for some problems, from other disciplines as well .....Generally, there is more than one way to approach or solve each problem. Identifying different solution paths and evaluating them is often part of the solution process. Because of multiple tasks, investigations are often designed to be tackled by students working in pairs or teams and for long periods of time”.

Explorative and investigation have similarity when students try to find the solve, pattern, and connection among concept in mathematics. While the differences are exploration is an activities trial and error to finds the answer and investigation is an activity to look for data for something which has been known. Yeo (2006, p.4) said they true mathematical investigations are different from explorations of mathematical concepts in that the former has no specific goals. In exploring mathematical concepts, students are guided to discover a particular concept. But in true mathematical investigations, there is plenty of scope for students to discover many new things.
that even the teacher may not have anticipated. We will illustrate this with the following example. To engage the students in their minds, it may be more effective to let the students try the worksheet themselves so that they can discover the concept for themselves.

Yeo (2009, p.3) said that investigation is just a vehicle for other learning might be seen as learning to be mathematical. Mathematical investigation can help students develop mathematical thinking processes which are useful in unfamiliar situations. The idea of investigation is fundamental both to the study of mathematics itself and also to an understanding of the ways in which mathematics can be used to extend knowledge and to solve problems in very many fields. Others subscribe to the view that mathematics classrooms should reflect the practices of mathematicians who not only solve problems but pose problems to solve, formulate and test conjectures, construct arguments and generalise. The distinguishing characteristics of a classroom environment in which students do mathematics as mathematicians: (a) collaboration in small groups on challenging mathematical tasks; (b) the students are encouraged to develop and share their strategies, and to be persistent in the mathematical tasks; (c) mathematical discussions and communication among the students and with the teacher; and (d) the students are responsible for decisions concerning validity and justification.

Further, Mancosu (2005, p.75) mention that mathematical activity in order to highlight some relatively neglected philosophical aspects of mathematics. There are four step on mathematical activity, as *discovery*: means that students should investigate some other data to build and enrichment of knowledge, *explanation*: means that students understanding what they have got from the discovery activity, *justification*: this activity related to mathematical proof based on theorem, or sudent get a hypothesis or conjecture, *Application*: mean that apply practical benefits on the daily life, other discipline or in mathematics it self.

Explorative learning strategy is arranged based on three of theory, Van Hiele theory about level of teaching and learning geometry, Piaget theory about intellectual cognitive development and Viaget theory about scaffolding. According to the theory Van Hiele (Clement, 2003, p. 154), model of teaching in geometry through five phases in moving students to understanding of geometry. In phase 1, information, the teacher places ideas at students' disposal. In phase 2, guided orientation, the teacher engage students actively in exploring object. In phase 3, explicitation, teacher guides students to become explicitly aware of their geometric conceptualization. In phase 4, free orientation, students solve problems whose solutions require synthesizing and using those concept and relations. In phase 5, integration, teacher encourage students to reflect on and consolidate their geometric knowledge, with an increased emphasis on the use of mathematical structures as a framework for consolidation, and eventually place these consolidated ideas in structural organization of formal mathematics.

While Piaget (McLeod, 2009) mention three of intellectual cognitive development namely assimilation, accommodation and equilibration. Assimilation means the process that students understand a new object or situation by their own knowledge to grasp a schema, when the schema or knowledge has been build, students are confronted to new situations than accommodation will occur if the students' schema or knowledge is not work to process or to understand a new problems, and last is equilibrum. Equilibrum means a process or situation where students confront to emergency situation occurs, causing frustration, and the students try to restore balance by mastering new knowledge. To accomodate these process, intellectual cognitive development theory recommended discovery learning as one of teaching and learning approach.

Combine of theory Van Hiele, Piaget, and Vigotsky are bring out the theory of explorative learning strategy. The relationship of all and explorative learning strategy is represented in Figure 1:

Based on the Figure 1 explorative learning strategy undertaken in this study includes five stages of teaching and learning:

1. Explorative problem, mean that students provide explorative problem or open problem which is that should be finished by. The problem should be new issue or new problem that can stimulate of students’ curiosity therefore students can apply their own knowledge to solve the problem,
2. Individual exploration: after student get some problem they should do exploration by them selves to fine some information due to problems. The exploration are required to recall the materials related to the concepts of geometry and students can use the knowledge of the old (old cognitive structures) to help solve new problems through internet or book.
3. Presentation, this stage some students are asked to present what they have done or what the results when they do individual exploration, then the other students and teachers provide feedback, suggestions and improvements to the presentation. So at this stage will be encourage students to achieve better result and finding.
4. Group exploration, means that further exploration is done at groups. It assumed that individual exploration is not give maximum results or finding, therefore students further do exploration group to deep into the problem, sharing with other students.
5. Discussions, means that implementation of geometry concept to solve geometry problem. Discussion here is different with discussion in general, some students finish a geometrical problem by individual than discuss with other students and teacher.
Based on the explanation above, the problem in this study is: Can explorative learning strategy enhance of students conceptual understanding viewed from school category and prior knowledge aspect?

**Purpose of the study**

The purpose of this study is to assess the enhancement of students’ conceptual understanding on Geometry which is explorative learning strategy was used in the teaching and learning process. The specific objectives were:

1. To describe the quality of teaching and learning geometry by explorative learning strategy toward enhancement of students’ conceptual understanding.
2. To know the different students’ conceptual understanding at experiment class and control class.
3. To assess comprehensively interaction effect of learning strategy, school category and prior knowledge toward enhancement of students’ conceptual understanding.

**RESEARCH METHODOLOGY**

The method is used on this research is quantitativemethod withpretest-posttest control group design. Quantitative method is used to compare students’ conceptual understanding between experiment class (by using explorative learning strategy) and control class (by using conventional learning strategy).

Participants in this study consist of 114 students at Islamic Senior High School in Jakarta-Indonesia with category A and B. category A means that school has high level, and category B means that school has middle level.

The implementation research for each class is 8 times, and the time is along with teaching and learning process that is included in the school’s curriculum.

Data collection using two instrument: “Prior Knowledge Test” and “Conceptual Understanding Test”. Prior knowledge test is used to know how deep students’ understanding on geometry this is given to students before the treatment and conceptual understanding test is given after the treatment.

After data has been collected, than that data was analyzed by statistic parametric using t-test, Mann-Whitney test, Kruskal-Wallis test, and Chi Square Test. There are two hypothesis is used to analisyse:

**Hypothesis 1**

H₀: there is no different students conceptual understanding on geometry between who learn under explorative learning stage and conventional learning strategy.

H₁: students conceptual understanding on geometry who learn under explorative learning strategy is higher than conventional learning strategy.

**Hypothesis 2**

H₀: there is no interaction effect from learning strategy, school category and prior knowledge to students conceptual understanding on geometry.

H₁: there is interaction effect from learning strategy, school category and prior knowledge to students conceptual understanding on geometry.

**FINDINGS AND RESULTS**

Explorative learning strategy, based on Van Hiele
teaching geometry consisting of five levels are: information or inquiry, guided orientation, explicitation, free orientation and integration. This strategy offers new situation in learning process, and students have experience in mathematical activities.

The enhancement students’ conceptual understanding who learned mathematics under explorative learning strategy or conventional learning strategy is not differently significant (see table 2). It is because, due to some factor, such as: differences of prior knowledge, limited time to do exploration, limited observation on integration, and there are some intervention from outside environment therefore exploration activities did not do perfectly for some students.

Data analysis for students’ conceptual understanding is reviewed from learning strategy shows that sig. (0.111) > α, therefore H₀ is accepted, the conclusion is students’ conceptual understanding who learn under explorative learning strategy is not different than that students who learn under conventional learning strategy. Otherwise for students’ conceptual understanding is reviewed from school category that sig. (0.005) < α, therefore H₀ is rejected, the conclusion is students’ conceptual understanding who learn at school category A is higher than that students who learn at school category B. (see Tabel 2).

Reviewed from prior knowledge, shows that sig. (0.0745) > α, therefore H₀ is accepted. The conclusion is students’ conceptual understanding who have prior knowledge high, middle and low is not differently significant (see table 3).

Based on theory, explorative learning strategy can enhance of student ability on mathematics, but the result of investigation shows that there are not significantly different of students’ conceptual understanding on geometry who learn under explorative learning strategy and conventional learning strategy.

Last analysis for quantitative method is interaction effect of learning strategy, school category and prior knowledge toward enhancement of students’ conceptual understanding on geometry. Based on result, shows that there is interaction effect together from learning strategy and school category toward enhancement of students’ conceptual understanding, there is interaction effect together from school category and prior knowledge toward enhancement of students’ conceptual understanding, and there is interaction effect together from learning strategy, school category and prior knowledge toward enhancement of students’ conceptual understanding (see Table 4).

**DISCUSSION**

Based on data analysis, we conclude that students conceptual understanding on geometry for students who learn under explorative learning strategy is not different significantly with students who learn under conventional learning strategy. It is because some reasons, are:

1. students have been forgot with lessons before which is taught when they study at junior school;
2. the prior knowledge of students are various, therefore students feel difficult to understand of problem when they do explorative activities, so that intervention of teacher happen in the process of teaching and learning. Cite from Kirschener (2006:84): “Even for students with considerable prior knowledge, strong guidance while learning is most often found to be equally effective as unguided approaches. Not only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge”.
3. Explorative activities need a lot of students’ understanding, but students have different in prior knowledge, cite in Sweller showed “that exploration practice (a discovery technique) caused a much larger cognitive load and led to poorer learning than worked-example practice” (Kirschener, 2006:80).

And for interaction effect of learning strategy, school category and prior knowledge, there is interaction effect from learning strategy, school category and prior knowledge toward enhancement of students’ conceptual understanding on geometry. But there is no interaction effect from learning strategy and prior knowledge toward enhancement of students’ conceptual understanding. Means that students’ prior knowledge is not a measure for success in learning. The successfully of students to understand of concept influenced selection of teaching and learning strategies by the teacher and the work hard of students. Students who have good in prior knowledge is not guaranet will succeed if he/she does not strive to be better, whereas students with lower in prior knowledge will succeed if he/she shows good effort in understanding of mathematical concepts.

Explorative learning strategy define as a learning strategy that is done by students to find and to construct knowledge by inquiry process, and investigate of problem, while the teacher’s job are give a task or a problem. There are five stage on explorative learning strategy: problem explorative, individual exploration, presentation, group exploration and discussion.

Problem explorative use activities worksheet. There are six worksheets used in this study, the problem on each worksheet shows students’ conflict cognitive, mean that students have disequilibrium between new information and their own knowledge, therefore students try to find the answer or the solution.

Individual explorative is the next level, after students understand to the problem that they do the activity by the worksheets, and students try to collaborate old knowledge with new knowledge, while teacher help some
Table 2. Mean rank enhancement of students’ conceptual understanding viewed from learning strategy and school category.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Group</th>
<th>N</th>
<th>Mean rank</th>
<th>Sum of rank</th>
<th>Levene’s Test F</th>
<th>Sig.</th>
<th>T-test t</th>
<th>df</th>
<th>Sig. (1-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.745</td>
<td>.055</td>
<td>-1.229</td>
<td>112</td>
<td>.111</td>
</tr>
<tr>
<td>School Category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.023</td>
<td>.879</td>
<td>2.519</td>
<td>112</td>
<td>.005</td>
</tr>
</tbody>
</table>

Table 3. Mean rank enhancement of students’ conceptual understanding viewed from prior knowledge.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Group</th>
<th>N</th>
<th>Mean rank</th>
<th>Sum of rank</th>
<th>χ²</th>
<th>Sig. (1 tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Knowledge</td>
<td>High</td>
<td>13</td>
<td>65.96</td>
<td>857.96</td>
<td>3.813</td>
<td>.0745</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>76</td>
<td>59.59</td>
<td>4528.84</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>25</td>
<td>46.74</td>
<td>1168.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Interaction effect of Learning Strategy, School Category and Prior Knowledge toward enhancement of students’ Conceptual Understanding.

<table>
<thead>
<tr>
<th>Source</th>
<th>Conceptual Understanding</th>
<th>Type III</th>
<th>Wald Chi-Square</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(Intercept)</td>
<td></td>
<td>(Intercept)</td>
<td>162.824</td>
<td>1</td>
<td>.000</td>
</tr>
<tr>
<td>LS * SC</td>
<td></td>
<td>LS * SC</td>
<td>10.036</td>
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<td>.002</td>
</tr>
<tr>
<td>LS * PK</td>
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<td>LS * PK</td>
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<td>.208</td>
</tr>
<tr>
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<td></td>
<td>SC * PK</td>
<td>7.585</td>
<td>2</td>
<td>.023</td>
</tr>
<tr>
<td>LS * SC * PK</td>
<td></td>
<td>LS * SC * PK</td>
<td>6.627</td>
<td>2</td>
<td>.036</td>
</tr>
</tbody>
</table>

Figure 2. Discussion on explorative problem.

Figure 3. Activity on exploration.
students who feel difficult to find the answer. Beside that, teacher give some explanation to misconception on students opinion. Presentation mean that explanation of concept in clearly such that the other students can understand and they dont have misunderstanding on concept. Teacher take over the activity by ask all students to look at to him/her. Teacher ask some students to explained result of discussion other listen and give opinion.

Group exploration is done by free activity. There are two kind of activity, students make a 3D object and than students observe the element of 3D, example: dot, line (perpendicular or parallel), angle. These activity help students to understand about visualization of 3D object, further students can understand about distance among dot, line and plane. In other hand, group exploration can grow students persistence, students can solve the problem with different way or creative.

Discussion is last level on explorative learning staretgy. In this level, students integrate of they understanding to solve the problem especially on geometry. Integrated knowledge is done by individual. They can discussion with other students. Further, here some of example for students answer on the question.

**Question 1:** *In the prism ABC.DEF has triangle with same side 6 cm and the high of prism is 15 cm. If point O at line AD such that AD: AO = 5:1, and point P in the midlle of line EF. How long the distance of point O to point P? Explain your answer!*

**Figure 4** shows different representation of problem. (For the question 1 there are 3 type of answer from the students:

1. students can draw prism with different visualisation. such the triangle as a based of prism, and some other the rectangle as a based of prism and they can solve the problem.
2. students can answer the question without visualization of prism
3. students did not understand the problem, they can not draw the prism so they could not answer correctly.

**Question 2:** *Block ABCD.EFGH, length of AB, BC and CG are 12 cm, 6 cm and 18 cm. P at the line EF such that EP:PF = 1:3, and line QR on plane DCGH such that PB//QR, and point Q in the midlle line GH, how long the distance between line PB and line QR? Explain your answer!*

**Figure 5** shows that representation students based on the problem. Most of students can draw the block ABCD.EFGH but most of students difficult to visualize point P, Q and R. Therefore most of students cannot solve question 2.

**Conclusion**

Based on the above analysis the conclusion have been
drawn: the first, students’ conceptual understanding who learn under explorative learning strategy is not different with conventional learning strategy. Although experiment class is given by explorative problem, in reality most of students ask the teacher about the problem, while in the control group, students is given problem by teacher tought ask question.

So the distinction of teaching and learning process in experimen class and control class is the way to raise the problem, so it is cause no different students’ conceptual understanding who learn under explorative learning strategy is not different with conventional learning strategy. And the second, there are interaction effect of learning strategy, school category and priorknowledge toward enhancement of students’conceptual understanding.

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