Cognitive conflict strategy to the improvement of students'lateral mathematical thinking ability

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Cognitive conflict strategy to the improvement of students'lateral mathematical thinking ability

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Abstract. Challenges of lateral thinking in basic geometrical concepts need to provide adequate opportunities for students to make observations, exploration, investigation, and experiment to see and suspect the existence of a truth and then test it before completing a geometry problem. The research aims to analyze: the improvement of mathematical lateral thinking ability between students who are exposed to cognitive conflict strategy and those taught by expository as seen from overall students as sample, prior mathematical knowledge of students. The interaction between learning types and categories of prior mathematical knowledge, and the difficulties encountered by students in completing lateral thinking questions. This study used a mixed-method of experimental pre and posttest control group design that involved 73 student teachers education at university in Bandung Indonesia as samples.The findings show that: The overall and prior mathematical knowledge of students' average value of experimental group which belongs to high category, higher than of control group which belongs to medium category. Conclutions: The mathematical lateral thinking ability of students who are exposed to cognitive conflict strategy has higher improvement level than students who are exposed to expository teaching based on overall students as sample and prior knowledge mathematics of students. There is an interaction between learning types and prior mathematical knowledge of students, thus students' difficulties in completing the lateral thinking questions can be minimized.

1. The first section in your paper

High level of reasoning determines the role of lateral thinking in mathematics within intellectual thinking framework, and greatly influences the individual's success in tackling real-world problems. It is not taboo to use lateral thinking in constructing a mathematical truth. Although the mathematical truth must be derived from proof that was built through logical-deductive reasoning based on an axiomatic system, but often a truth is obtained through lateral thinking; thus, the truth can be accepted. In mathematics, the deductive reasoning and creative, intuitive, and lateral thinking should mutually synergize. The habit of thinking critically, creatively, intuitively and laterally must be constantly embedded so that it could be reflected in the way of thinking. This could finally trigger the development of high-level thinking ability. This process in turn will constantly grow confidence and persistence of students in learning mathematics.

Lateral thinking is the process of solving problems by using the power of imagination focusing on various demands with uncommon and new ideas [1] argued lateral thinking ability will sharpen creativity of a person to cope with anything at hand, as lateral thinking is closely associated with creativity. Creativity is the description of the outcome, therefore then the lateral thinking provides

description of the process. Mathematicians and researchers in mathematics education, as well as psychologists have researched mathematical creativity in different scientific viewpoints [2], [3] also associated creativity with an attitude of openness, curiosity, imagination and courage to take risks. Moreover, [4] revealed that the creative environment should include open and non-routine activities that give learners the freedom to implement imaginative ideas and find new methods or solutions from various perspectives.

In this research, lateral thinking ability is assessed from the ability to manipulate geometry as a manifestation of the spatial intelligence. Through manipulation of geometry, we can develop how to obtain mathematical truths. Since life is surrounded and shaped of structures (space and surface), learning geometry needs to be based on and directed to understand the structures in the vicinity. This is in line with [5] that the purpose of studying geometry is to make students understand the concepts, properties, and procedures of geometry as well as able to complete various related tasks. Students' perceptions about such discipline can grow because the tasks they have to finis, [6]. Students will not get a deep understanding through repetition, but learning actively by linking several things, giving meaning to it, and developing past experience through group work. Consequently, efforts made to improve the teaching and learning process are always interesting to study.

Cognitive conflict strategy is a learning method which is interactive, inspiring, fun, and challenging. It motivates students to actively participate in thinking process and leaves enough room for the development of their initiative, creativity and independence relevant to their talent, interest, psychological and cognitive development. This fact also indicates that learning is inseparable from thinking process which requires problem solution. A study by [7] and [8] show that a learning process is considered meaningful when it can stimulate students' motivation and enthusiasm to come up with a new product or project such as a documentary video which can be used to make a cognitive conflict, a resolution leading to further understanding of a concept, and a multimedia-based learning to uncover new ideas which can decrease cognitive conflict. Another study by [9] states that one way to reduce misconception is by directly experiencing the problem so that it can cause accommodation disequilibrium as suggested by Piaget's cognitive conflict. An interaction between cognition and environment used to stimulate conflict is also stated, which is the conflict between initial or entry concept and new materials to learn. In addition, also argues that the conflict between new learning material and environment can be explained by initial or entry concept. Meanwhile, Piaget believes that such this conflict can be explained by the concept to be learned.

As suggested by [10], at high level, equilibrium happens due to intervention or scaffolding deliberately provided by peers or teachers to help support the thinking process so that the assimilation and accommodation can take place properly. It can, therefore, be concluded that cognitive conflict disequilibrium needs to be conditioned to achieve equilibrium higher than the previous one. In the context of cognitive conflict strategy, mathematical knowledge tends to be accepted by individuals through challenging tasks which cause conflict.[11], [6] argues that learning which is based on social construction can create and develop knowledge through tasks or assignments, not merely from teacher's instruction. Let alone in this information era where teacher is not the only source of information. Individual knowledge is heavily reliant on social construction from peers and teachers who help reconstruct new learning concept to overcome conflict. Therefore, sustained completion of exercises or tasks is required to meet the challenges resulted from problem. Cognitive conflict provides challenges thus exerting good influence for students in solving problems [12]. Technically, prior mathematical knowledge is purposed of observing the similarity between experiment group and control group and each sample has considerably same degree. Furthermore, the categorization of prior mathematical knowledge is done to study the different treatments towards students in each category during learning.

2. Method

This research used Quasi-Experiment Non-equivalent Pretest-Posttest Control Group Design on two homogenous groups. Randomly chosen, samples were 73 student teachers of medium qualification at a local public religion-based higher education in Bandung, Indonesia. They were categorized into two

groups; 35 students of class B consists of 25 women and 10 men as control group who received individual expository (conventional) and 38 students of class C consists of 30 women and 8 men as experiment group who were exposed to cognitive conflict strategy cooperatively in group. As for the instrument, consists of 6 essay question each with 2 low, 2 middle, and 2 high opened ended question. An initial test was administered to identify students' prior mathematical knowledge followed by a pretest and posttest on mathematical lateral thinking ability. Before the instruments were employed, they were validated by five experts in mathematics education through content and face validity. The instruments were then revised and tested to analyze the validity, reliability, significance, and level of difficulties. Validation of the content was carried out by considering conformity between the questions and criteria of prior mathematical knowledge aspects, learning materials, and level of difficulties of students. Most importantly, it was validated using lateral thinking ability indicators of students. Data analysis was done through significance test of t-test for normally distributed data (Gaussian), and the Mann-Withney U for test if the data was not Gaussian. Meanwhile, to see the interaction between dependent variables, F test was employed if normality was met; if not, then Adjusted Rank Transform was used.

3. Result and Discussion

The development of learning material in this research is based on a preliminary study on learning problems experienced by students as learners and lecturers as instructors. This study found that the problem faced by students is epistemologically related to their knowledge and concept about geometry, construction and logic. With reference to observation characteristics, it is believed that most students cannot remember in detail the three dimensional geometry formula. Although students are asked to come up with their life experienced problems, the learned concept will not stay long in their long-term memory.

This experimental study started with a test on prior mathematical knowledge administered to two groups of students to identify and distribute students to high, medium, and low levels. Prior mathematical knowledge of students in the experimental and control groups have the greatest frequency at average levels with total 48 people of 73 students. The average early mathematical ability of students is 65.7 at sufficient category. This distribution indicates that the average prior mathematical knowledge belongs to sufficient or enough. The statistical result of pretest shows that the overall lateral thinking ability of students in both control and experiment groups is relatively similar. The mean of pretest score of experimental group is 14.21 and that of the control group is 12.14. This mean of pretest score indicates that students' prior mathematical knowledge of lateral thinking ability is still very low.

Having introduced cognitive conflict strategy to experimental group, it is identified that the mean of their mathematical lateral thinking ability increases significantly. In general, this difference is evidenced from the obtained posttest result. Overall, the mean of posttest result of experimental group is 73.68 whereas that of the control group is 63.88. Findings also suggest that the improvement of lateral thinking ability of experimental group is also identified from both overall and prior mathematical knowledge categories (high, medium, and low). The experimental group has also obtained more variety of results than the control one. These findings indicate that cognitive conflict strategy has good impact against lateral thinking ability. Cognitive conflict provides challenges thus exerting good influence for students in solving problems (Masalimova & Sabirova, 2014).

In addition to the results of the posttest, the differences in lateral thinking ability are also apparent from the increased ability of students in both groups based on the normalized data gain. Descriptively, the normalized data gain on lateral thinking ability can be explained in Figure 1.

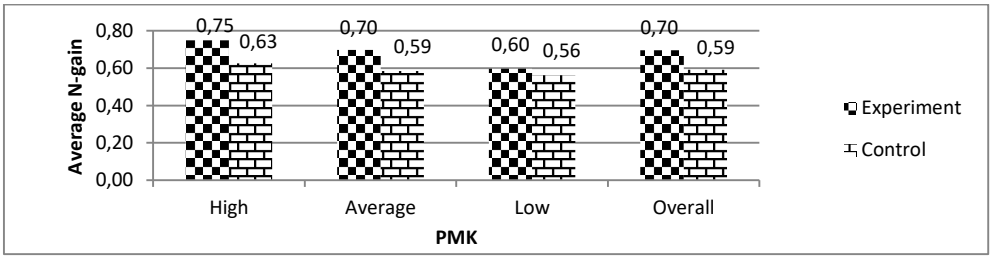

Figure 1. Average value of lateral thinking between experiment and control groups

As the diagram above shows, the overall average value of experimental group is 0.70 which belongs to strong category, higher than that of the overall average value of control group of 0.59 which belongs to average category. Based on prior mathematical knowledge, it is identified that the experimental group has the following prior mathematical knowledge categories respectively (high, medium, and low) of (0.75, 0.70, and 0.60). Based on this, high and medium prior mathematical knowledge levels belong to high whereas low prior mathematical knowledge is included in medium, which is higher than the averages of control group (0.63, 0.59, 0.56) which belong to average category. This difference of improvement indicates that the use of cognitive conflict strategy gives a better contribution to the improvement of students' mathematical lateral thinking ability than the expository learning.

Test of the variance of lateral thinking pretest of both experimental and control groups has the following criteria. H_0 is accepted if the value sig (*1-tailed*) 0.179 > α equals 0.05. This means that there is no variation in the pretest of lateral thinking ability between experimental and control groups. The test result also indicates that statistically prior to treatment, both experimental and control groups do not have significant difference. The difference of ability improvement of both groups in variance test of lateral thinking has the value of Sig (*1-tailed*) equals 0.000 and is smaller than 0.05. So that H_0 is rejected. This means that students in the experimental group who received cognitive conflict strategy have higher improvement of lateral thinking ability than those in the control group who were exposed to expository learning.

Variance test of mathematical lateral thinking ability based on prior mathematical knowledge of high, medium, and low levels respectively have the values of Sig (0.001, 0.000, and 0.032) smaller than 0.05 so that H_0 is rejected. This means that students in experimental group have higher improvement of mathematical lateral thinking ability than those in control group. This difference of improvement also indicates that cognitive conflict strategy has better contribution in improving students' lateral thinking ability than the expository learning based on prior mathematical knowledge levels (high, medium, and low). The finding suggests the similarity among all categories of prior mathematical knowledge of cognitive conflict group; the students managed to gain benefit from the emergence of conflicts in enhancing their competence.

Interaction test of prior mathematical knowledge gives a significant influence on lateral thinking ability of value Sig (0.000) which is smaller than 0.05. For this interaction test, based on prior mathematical knowledge levels and lateral thinking ability learning, it is identified that value sig. (0.000) is smaller than 0.05 so that H_0 is rejected. This shows that there is an effect of relationship interaction between learning and prior mathematical knowledge (high achieving, medium and low) which influence students' mathematical lateral thinking ability. It shows that the implementation of the cognitive conflict strategy needs to pay attention to the students' prior mathematical knowledge (high, medium, and low).

The high prior mathematical knowledge of students has mean of 79.17, medium with mean of 73.80, and low level with mean of 70.00, while a control group of expository learning has a lower mean; high prior mathematical knowledge has mean of 68.75, medium level by 63.69, and low level by 60.00. The difference in such improvement indicates that descriptively cognitive conflict strategy contributes to better improvement of spatial visualization skill on all levels of prior mathematical knowledge, high, medium or low than that of expository learning.

Cognitive conflict learning strategies are an interesting multidisciplinary study, beginning with the giving of assignment based on content standards, allowing the students to work collaboratively in a peer

group, and thus become capable of developing the knowledge in completing tasks, identifying and solving the challenges, making differences in their community, and sharing the best deals by enhancing the use of sustainable resources and technology they use in everyday life to solve complex yet contextual misunderstanding. Furthermore,[13] revealed that misunderstanding occurs when students acknowledge a gap between new knowledge and the previous one, which should be upgraded through a conceptual change based on cognitive perspective, so that new logical ideas arise. The implementation of cognitive conflicts strategy in the learning still left some obstacles and difficulties were found among student when doing mathematical tasks using lateral thinking: some students were still confused and not familiar to do assignments demanding diverse points of view and new ideas. They still considered that space is flat; hence, the lines intersect while actually they are crossing. They have just learnt the type of tests which promote lateral thinking, that they knew a little or even had never been seen before. It needs to train their lateral thinking ability especially about geometry reasoning.

4. Results

Based on the data analysis and interpretation, learning strategies of cognitive conflicts can provide a new learning atmosphere for students, give effect to their lateral thinking ability in mathematics. This is in contrast to expository learning which make the students less active during the study. From the results of the analysis, some conclusions can be drawn up as follows: First:The overall improvement of mathematical lateral thinking ability between students of high category who received cognitive conflict strategy treatment is higher than those of average category who were given expository learning. Second: Based on all three prior mathematical knowledge levels; high, medium, and low, students who received cognitive conflict strategy treatment have higher improvement of mathematical lateral thinking ability than those who were given expository learning. Third: There is an influence of interaction between learning types (cognitive conflict and expository) and prior mathematical knowledge levels (high, medium, and low) on students' mathematical lateral thinking ability. Fourth: Students' difficulties encountered in solving lateral thinking questions can be reduced or minimized.

References

[1] A. Arsisari, "Penerapan pendekatan problem centered leraning untuk meningkatkan kemampuan berpikir lateral dan persistence (kegigihan) matematis siswa di SMP," Universitas Pendidikan Indonesia, 2014.

[2] A. Ayele, M, "Mathematics teachers' perceptions on enhancing students' creativity in mathematics," *(IEJME -International Electron. J. Math. Educ.*, vol. 11, no. 10, pp. 3521–3536, 2016.

[3] W. Y. Hwang, N. S. Chen, J. J. Dung, and Y. L. Yang, "Multiple representation skills and creativity effect on mathematical problem solving using a multimedia whiteboard system," *Educ. Technol. Soc. J.*, vol. 10, no. 2, pp. 191–212, 2007.

[4] A. Shriki, "Towards promoting creativity in mathematics of pre-service teachers: The case of creating a definition," in *Proceedings of the 5th International Conference on Creativity in Mathematics and the Education of Gifted Students*, 2008, p. 201–210.

[5] & P. Lappan, Fey, Fitsgerald, Friel, *Getting to know connected mathematics. An implementation guide*. New Jersey: Prentice Hall, 2002.

[6] A. I. Maron, "Priorities of teaching mathematics in universities," *IEJME-International Electron. J. Math. Educ.*, vol. 11, no. 9, p. 3339–3350., 2016.

[7] R. Baddock, M., & Bucat, "Effectiveness of a Classroom Chemistry Demonstration using the Cognitive.," *Int. Educ. Stud.*, vol. 30, no. 8, pp. 1115–1128, 2015.

[8] W. K. Lam, S., Cheng, R., & Ma, "Teacher and student intrinsic motivation inproject-based learning," *Int. J. Learn. Sci.*, vol. 37, no. 6, pp. 565–578, 2009.

[9] K. Dahlan, J. A., Rohayati, A., "Implementasi pembelajaran konflik kognitif dalam upaya meningkatkan high order mathematical thinking siswa," *urnal Pendidik.*, vol. 13, no. 2, pp. 65–76, 2012.

[10] D. Suryadi, *Membangun budaya baru dalam berpikir matematika.* Bandung: Rizqi Press, 2012.
[11] S. R. Filonovich, "Life-long learning: consequences for higher education," *Educ. issues*, vol. 4, no. 1, p. 55–67., 2009.
[12] & S. L. L. Masalimova, A. R., "Multi-dimensional classification of types and forms of corporate education," *Am. J. Appl. Sci.*, vol. 11, p. 1054–1058., 2014.
[13] M. Kabaca, T., Karadag, Z., & Aktumen, "Misconception, cognitive conflict and conceptual changes in geometry: A case study with pre-service teachers," *nternational J. Educ.*, vol. 1, no. 2, pp. 44–55, 2011.