ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research (ASSEHR), volume 57
1st International Conference of Mathematics and Science Education (ICMSEd 2016)

The Enhancement of Students' Critical Thinking Skills in Mathematics through The 5E Learning Cycle with Metacognitive Technique

Runisah
Department of Mathematics Education
Universitas Wiralodra
Indramayu, Indonesia
Runisah_unwir@hotmail.com

Tatang Herman
Departmen of Mathematics Education
Universitas Pendidikan Indonesia
Bandung, Indonesia
tatangherman@upi.edu

Jarnawi Afgani Dahlan
Departmen of Mathematics education
Universitas Pendidikan Indonesia
Bandung, Indonesia
jarnawi@upi.edu

***Abstract*— This study aims to describe the enhancement and achievement of students' critical thinking skills in mathematics (CTSM) as a result of 5E Learning Cycle with Metacognitive Techniques (LCM), Learning Cycle (LC) and Conventional Learning (CL) implementation is measured entirely and based on student's Mathematical Prior Ability (MPA). This research used a quasi-experimental design with pretest-posttest control group. The population of the research is Junior High School students in Indramayu City, West Java Province, Indonesia. The sample is eighth grade students from two school levels classified as high and medium levels, amounted to 173 students. Three classes were randomly selected from each school, one class received LCM, one class received LC, and the other class received CL. The instruments consisted of CTSM tests, MPA test, and observation sheet. The study revealed that in terms of overall, the enhancement and achievement of students' CTSM who received LCM is better than those who received LC and CL. Likewise the achievement of students' CTSM who received LC is better than those who received CL. The enhancement and the achievement of LCM group students' critical thinking skills is 0.62 and 27.30 while the LC group is 0.49 and 22.84, and the CL group is 0.34 and 17.80. There is an interaction effect between learning model and MPA towards enhancement of students' CTSM. However descriptively, there is no interaction effect between learning model and MPA towards achievement of students' CTSM.**

Keywords—critical thinking skills in mathematics; 5E Learning Cycle model; Metacognitive techniques

I. INTRODUCTION

Critical thinking is one of the necessary abilities to overcome various problems that arise. Critical thinking is necessary in order to have precise reason in solving the problem, which is supported by accurate evidence. The importance of critical thinking skills described by [1], she stated that the creative thinking, maintain and apply knowledge and critical thinking is essential to develop thinking skills, they are the ability to make decisions and solve the problem.

Critical thinking is a high-level thinking skills. [2] defined critical thinking as reflective and reasonable thinking that is focused on making decisions about what to believe or do. Reflective means consider or rethink everythink before taking a decision. Reasonable means all beliefs, views, or action are supported by the evidence or the right reasons. The development of critical thinking skills can be done in the process of learning, especially mathematics. As implied in KTSP curriculum or curriculum in 2013, that mathematics needs to be given to students from elementary school through high school to equip them with the ability to think logically, analytical, systematic, critical, and creative, as well as the ability to work together.

Although critical thinking skills might be essential for students, several studies indicated that the ability is still low. The results of the research included the results of Trends in International Mathematics and Science Study (TIMSS) in 2007 and 2011 that the average score of mathematics achievement is far below the average, the rank in 2011 was 38^{th} out of 42 participating countries. In TIMSS 2011, students were involved in various cognitive processes to solve problems [3]. Low ability to solve problems indicated that the critical thinking skills of students is still low. [4] in her results of research conducted on the eighth grade students in Indramayu concluded that mathematical students' critical thinking skills is still low.

The development of critical thinking skills can be done by creating a learning where students as individuals who are

active in learning and do not just accept the concept. But the reality of learning is still lacking to enable students to learn. It is based on the study included the National Research and National Education Development Department (Balitbang Depdiknas) in 2007. From the study found that starting from primary to secondary education, in general, the implementation of learning still used lecturing and question and answer methods, as well as teaching and learning activities was less in making students active in learning [5].

To develop the critical thinking skills, learning should be created to make students involved in exploration activities to find the concept or solutions from mathematical problems that are not routine. This is in line with the opinion of [6] that the conditions to think critical thinking in mathematics should contain non-routine situations. Meanwhile, [7] explained that learning provides an opportunity for students to actively think through discovery activities, problem solving and discussion are learning to develop students' critical thinking skills. According [8] the mathematical problems that involve thinking, analyzing, and synthesizing can encourage students' critical thinking skills.

In addition to develop critical thinking skills, students metacognition must be empowered. This is in line with [9] and [10] that the critical thinking skills of students in mathematics who received metacognitive approach is better than students who received conventional learning. The term of Metacognition is introduced by Flavell in 1976. Flavell in [11] stated that metacognition is a person's consciousness about the cognitive processes and independence to achieve the goal.

One of learning model that seems can be used to develop critical thinking skills is 5E Learning Cycle with Metacognitive technique. It is because various activities to develov mathematical critical thinking as stated by [6 - 8] contain in LC. Furthermore, the empowerment of students' metacognition can be done by integrating metacognitive techniques into LC.

A. *Critical Thinking in Mathematics*

Many experts defined critical thinking skills in different way. According to [12], "Critical thinking in mathematics is the ability and disposition to incorporate prior knowledge, mathematical reasoning, and cognitive strategies to generalize, prove, or evaluate unfamiliar mathematical situations in a reflective manner". [13] summarize that, the most basic concept of critical thinking is the ability of interpretation, analysis, evaluation, inference, explanation, and self regulation. More specifically, [14] linking aspect of critical thinking with mathematical content includes: concepts, generalization, algorithm and skills, and problem solving. Thus the critical thinking in mathematics can be defined as the ability to integrate prior knowledge, mathematical reasoning, and problem-solving strategies to solve mathematical problems.

Based on the description above, one of the factors that could affect the ability of critical thinking mathematically that is prior knowledge or mathematical prior ability of the students. That is because, students will have trouble when he will provide the solution of problems with reasoning or evidence that is accurate, if he does not master the knowledge or concepts in mathematics including prior knowledge.

The 5E Learning Cycle with Metacognitive Techniques

In 1980 a team of researchers Biological Science Curriculum Study (BSCS) under the leadership of Bybee develop 5E Learning Cycle model. According to [15] this model is influenced by Herbart learning psychology, thought of John Dewey and Jean Piaget.

According to [15], 5E Learning Cycle has five stages, engage, explore, explain, elaborate, and evaluate. At this stage of engage, teachers access students' prior knowledge and help them engage in new concepts that encourage their learning interest. In the stage of explore, students are involved in exploration concepts activity to generate new ideas. In the stage of explain, the students explained the conceptual understanding or process skills obtained in the previous stage. This stage also provides an opportunity for teachers to directly introduce the concept, process, or skill. In the elaborate stage, teachers broaden understanding of the concept. In evaluate stage, carried out an assessment of their understanding and ability, and provide an opportunity for teachers to evaluate student progress to achieve educational goals.

Those five stages can stimulate students' critical thinking skills, because it involves prior knowledge, non routine situation or problem, reasoning, cognitive strategies, and involved students in discussions to do exploration or find new ideas. This is in line with the opinion of [6 - 8] as already mentioned, that these activities, can develop students' critical thinking skills.

The 5E Learning Cycle model with metacognitive technique, is a learning model that integrates directly metacognitive techniques in every stage of 5E Learning Cycle model. One type of metacognitive technique is self asking. In this study the questions is made focused on three categories adopted from Beeth in [16], namely intelligibility, wide-applicability, and plausibility. In intelligibility category, the question asked is, "Is the concept I learned can be understood?" In wide-applicability category, the question asked is, "What concept that can be used to solve the problem? "or," can the concept that I learned be used to solve problems in other areas or in their daily lives? ". in plausibility category the question asked " Is the problem solving that I created believable?"

Various studies have been done on the use of 5E Learning Cycle and metacognitive empowerment. [17] concluded that critical thinking skills of students who received 5E Learning Cycle with Scientific approach is better than the expository class on derivative Function. [18] concluded that, there is no difference of critical thinking skills enhancement between students who are taught by 5E Learning Cycle and Discovery Learning model. [19], concluded that the use of 5E Learning Cycle, is more effective than conventional approaches towards critical thinking skills. [20] concluded that enhancement of students' critical thinking skills who received 5E Learning Cycle is better than students who received

conventional learning. [9 – 10] that metacognitive approach can enhance students' critical thinking skills in mathematics.

Based on the description above, the use of 5E learning Cycle with metacognitive technique can be used to develop students' critical thinking skills. However, research on the use of the 5E Learning Cycle to enhance students' critical thinking skills in mathematics, is limited. Even, research on the use of the 5E Learning Cycle with metacognitive technique to enhance students' critical thinking skills in mathematics, has not been found.

B. *Purpose and Significance of Research*

Critical thinking skills are needed by students, therefore required to develop it. For that reason, this research is expected to put more information to the literature about learning that can develop students' critical thinking skills.

The purpose of this study was to describe the enhancement and the achievement of students' critical thinking skills in mathematics who received 5E Learning Cycle with metacognitive technique, Learning Cycle, and Conventional Learning, that is measured entirely and based on student's Mathematical Prior Ability (MPA).

RESEARCH METHOD

This study used a quasi experimental method with pretest-posttest control group design.

A. *Population and Sample*

The research was conducted in academic year 2015/2016. The population of the research is Junior High School students in Indramayu City, West Java Province, Indonesia. The sample is eighth grade students from two school levels, classified as high amounting to 83 students and medium levels amounting to 90 students. In this research, one school was randomly selected from both high and medium-level school. Furthermore, three classes were randomly selected from all of the eighth grade students in high and medium level school, one class received LCM, one class received LC, and another class received CL. School level has been determined based on school accreditation score which is valid until the year 2014.

B. *Instruments*

In this study the material being taught included relations and functions, equations of straight lines, and the system of linear equations in two variables which refered to the curriculum. The instruments used were critical thinking skills in mathematics (CTSM) tests, observation sheets, and MPA tests. CTSM tests were given prior to the learning activity (pretest) and after the learning activity (posttest). MPA tests were given prior to the learning activity. CTSM test consists of 10 items with maximum ideal score of 40, MPA test consists of 22 objective test items and 2 analytical test items with a maximum ideal score of 30. Evaluation of CTSM using components, namely identification and interpretation of information, information analysis, evaluation of argument, and inference ([2] and [12 -13]). These components associated with mathematical content include concept, generalization, algorithm and skills, and problem solving according with the content of the material being taught. Meanwhile, material of MPA test was adjusted to the subject matter of Mathematics which has been studied in the previous semester of 2015/2016 which refered to the curriculum. Before used, instruments tested in limited. After being improved, instrument is tested in wide scale. Based on analysis, it is obtained that test is valid and reliable with reliability coefficient r = 0.84, for MCTS test and 0.83 for MPA test with objective form, for MPA with analytical test, r = 0.64.

The achievement of students' critical thinking skills determined based on posttest scores. Meanwhile, to calculate the magnitude of the increased, it use of the gain normalized formula developed by [21] and the gain calculation results are interpreted using the classification Gain from [22]. Futher, criteria for high level if MPA $\geq \overline{x}$ + s, medium level if $\overline{x}$ - s $\leq$ MPA $<$ $\overline{x}$ + s, and low level if MPA $<$ $\overline{x}$ - s

III. RESULTS AND DISCUSSION

A. *Description Data*

Based on analysis, the average score of MPA test is 18.94, with standard deviation is 4.18. Further, performed grouping students as follows:

High level : MPA $\geq$ 23.12,
Medium level : 14,76$\leq$ MPA $<$ 23.12 ,
Low level : MPA $<$ 14.76

The mean scores of students' critical thinking skills can be seen in Table I.

TABLE I. RECAPITULATION OF STUDENTS' CRITICAL THINKING SKILLS TEST RESULT

MPA Level	Group	Number of students	Mean		
			Pretest	*Postest*	*Gain*
High	LCM	11	11.09	36.73	0.89
	LC	11	10.82	32.64	0.75
	CL	12	10.83	26.00	0,52
Medium	LCM	33	7.33	27.64	0.63
	LC	34	6.94	22.65	0.48
	CL	37	6.51	17.00	0.31
Low	LCM	12	4.33	17.75	0.38
	LC	12	4.33	14.42	0.28
	CL	11	3,82	11.55	0,21
Total	LCM	56	7.43	27.30	0.62
	LC	57	7.14	22.84	0.49
	CL	60	6.88	17.80	0.34

From Table 1, both in terms of overall and every MPA levels it is known that the enhancement and achievement of students' critical thinking skills LCM group is greater than LC group and CL group. The enhancement of students' critical thinking skills LC group is greater than CL group.

B. *Data Analysis*

The statistical test results of critical thinking skills enhancement data of LCM, LC, and CL groups at all levels MPA have normal distribution. The statistical test results of critical thinking skills enhancement data of LCM, LC, and CL groups at high and medium level have heterogenous variance, however at low level have homogeneous variance.

Thus, the mean difference test used is One Way Anova and Kruskal Wallis. Based on analysis, it is known that the probability value (significance), both in terms of overall and every levels are smaller than the significance level $\alpha = 0.05$. Thus it is concluded that at least one of the enhancement of critical thinking skills of learning groups' data, which have an average difference. Then, further statistical tests was conducted. At low level, Scheffe test was used, Dunnett T3 test was used at high and medium level, and comparison between multiple treatments test was used in terms of overall students. Based on analysis, it can be concluded that the enhancement of critical thinking skills of LCM students is better than those of LC and CL students, and the enhancement of critical thinking skills of LC students is better than those of CL students.

Based on the test results of normality, the achievement of critical thinking skills of LCM, LC, and CL group data at the high level have normal distribution. Meanwhile, in term of overall students and at the LCM, LC, and CL group at the medium and low level, not entirely normally distributed.. Thus, the mean difference test used is One Way Anova and Kruskal Wallis. Based on analysis, it is known that the probability value, both in terms of overall and every levels are smaller than the significance level $\alpha = 0.05$. Thus it can be concluded that at least one of the achievement of critical thinking skills of learning groups data, which have an average difference.

Then, further statistical tests was conducted, In the high level using Dunnett T3 test. Base on analysis it can be concluded that achievement of critical thinking skills of LCM students is better than those of LC and CL students, and the achievement critical thinking skills of LC students better than those of CL students. At medium level, low level, and in terms of overall students, that was using Multiple Comparison between Treatments. Based on analysis, at the significance level $\alpha = 0.05$, it can be concluded that in low level, the achievement of critical thinking skills of LCM students is better than those of LC and CL students, but there is no differences in the achievement of critical thinking skills, between LC and CL students. In medium level and terms of overall students, the achievement of critical thinking skills of LCM students is better than those of LC and CL students, and the achievement of critical thinking skills of LC students is better than those of CL students.

1) Interaction between Learning Model and MPA toward Enhancement of Students' CTSM

From analysis using two-way ANOVA, it can be concluded that the learning model has a significant effect on the enhancement of students' critical thinking skills. This is indicated by the value of F = 24,97 with the probability (sig) is 0.005 that is smaller than 0.05. Thus MPA factors have a significant effect on the enhancement of students' critical thinking skills. This is indicated by the value of F = 42,94 with the probability (sig) is 0.002 that is smaller than 0.05. Meanwhile, there is interaction effect between learning model and MPA levels toward enhancement of students' critical thinking skills. This is indicated by the value of F = 3.75 with the probability (sig) is 0.006 that is smaller than 0.05.

2) Interaction between Learning Model and MPA toward Achievement of Students' Critical Thinking Skills

Based on the analysis, the achievement of students' critical thinking skills data at all levels MPA are not entirely normal distribution. Therefore, to see the effect of the interaction between learning model and MPA towards the achievement of students critical thinking skills analyzed graphically, are presented in figure 1.

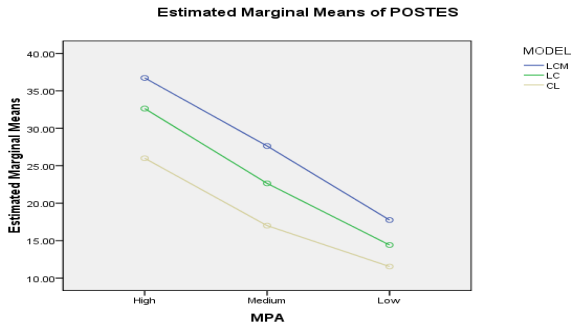

Fig. 1. Interaction between Learning Model and MPA toward Achievement of Students' critical thinking skills

In Figure 1, it can be seen that the achievement mean of LCM students' critical thinking skills sequence from largest to smallest are high-level students, medium level students, and low-level students. The same sequence occurs in the achievement mean of CL and LC students' critical thinking skills. Figure 3 also shows that the lines almost parallel. These conditions indicates that there is no interaction between learning model and MPA levels toward achievement of students' critical thinking skills

C. *Discussion*

In terms of overall students, the enhancement of critical thinking skills students who received LCM is 0.62, the students who received LC is 0.49, while the students who received CL is 0.34. According to Hake, the enhancement has a medium level.Then, the statistical test results confirms that the enhancement of critical thinking skills students who received LCM is better than students who received LC and CL, the enhancement of critical thinking skills students who received LC is better than students who received CL.

The enhancement of students' critical thinking skills is supported by its achievement. In terms of overall students, the statistical test results concluded that the achievement of students' critical thinking skills who received LCM is better than students who received LC and CL. The achievement of students' critical thinking skills who received LC is better than students who received CL. This shows that learning model (LCM) has a significant effect on students' enhancement and achievement critical thinking skills

Research shows that MPA has a significant effect toward achievement and enhancement students' critical thinking skills. This finding can be seen at every level. At high level, enhancement and achievement of students' critical thinking skills who received LCM is greater than students who received LCM at the medium level. At medium level, enhancement and achievement of students' critical thinking skills who received

LCM is greater than students who received LCM at the low level. The same conditions occurred in LC and CL. At high level, enhancement and achievement of students' critical thinking skills who received LC end CL is greater than students who received LC and CL at medium level. At medium level, enhancement and the achievement of students' critical thinking skills who received LC and CL are greater than students who received LC at the low level

Another findings, there is interaction effect between learning model and MPA towards enhancement of students' critical thinking skills. Thus, MPA factors require close attention, because enhancement of students' critical thinking skills, in addition affected by learning model also depends on MPA. In other words simultaneously MPA and learning model influence on enhancement of critical thinking skills.

The presence of interactions effect, can be seen for students at low level, the use of LCM and LC did not leave a large effect on the enhancement of student critical thinking skills.The enhancement of students' critical thinking skills who received LCM is 0.38, students who received LC is 0.28. The magnitude of enhancement is slightly less with enhancement critical thinking skills of students who received CL, amounting to 0.21. This is possible because, on LC and LCM, it requires the ability to explore, elaborate, explain, and empower their metacognition in learning activities. These activities are more easily to carry out by students at high level. While the students at low level, generally still difficult to explore, elaborate, explain, and empower their metacognition. This is reflected in the learning activities that take place.

In high level, students have better ability to perform a variety of learning activities in LCM to spur increased students' critical thinking skills mathematically. It can be seen, in enhancement of LCM group students' critical thinking skills is 0.89, while LC group is 0.75, and CL group is 0.52. In medium level, the enhancement of LCM group students' critical thinking skills is 0.63 while the LC group is 0.48, and the CL group is 0.31. Thus the use of LCM and LC will be more successful when applied to students at high and medium level to enhance critical thinking skills. This is in accordance with the opinion of [23] that the lower level schools have a tendency of student learning outcomes that are less good.

Generally, this study shows that LCM is better in facilitating students to develop critical thinking skills than LC and CL. LC is better in facilitating students to develop critical thinking skills than LC. This is possible because in LC students are involved in discussion to analysis, evaluate, solve the problem and found new idea. These activities, can develop ability to think critically as revealed by [6 - 8]. Meanwhile in LCM, students' metacognition is more empowered than students who received LC and CL. According to [24], students who use well their metacognition will be a critical thinker, problem solver, as well as good decision makers. Otherwise, in the conventional learning teacher gives the concept or the material directly through lectures, then teachers provide practice questions to the student. Thus the conventional learning less spur students to develop critical thinking skills through activities that took place on LC.

This research results in line with the results of research conducted by [17 – 20], they concluded that enhancement of students' critical thinking in mathematics who received 5E Learning Cycle is better than student who received conventional learning. Another line of study carried out by [9-10] that the metacognitive approach, influence in improving students' critical thinking skills in mathematics.

IV. CONCLUSION

In terms of overall students, the enhancement and achievement of students critical thinking skills who received LCM is better than students who received LC and CL. Likewise the achievement of students' critical thinking skills who received LC is better than students who received CL. At all levels, the enhancement of students' critical thinking skills who received LCM is better than students who received LC and CL. Likewise, the enhancement of students' critical thinking skills who received LC is better than students who received CL. At the high and medium level, the achievement of students' critical thinking skills who received LCM is better than students who received LC and CL. The Achievement of students' critical thinking skills who received LC is better than students who received CL. At the low level, the achievement of students' critical thinking skills who received LCM is better than students who received LC and CL, but there are no differences in achievement of critical thinking skills between students who received LC and students who received CL.

There is interaction effect between learning model and MPA towards enhancement of students' critical thinking skills. However descriptively, there is no interaction effect between learning model and MPA towards achievement of students' critical thinking skills.

LCM can be used to enhance critical thinking skills in all MPA level because in any level, students who received LCM have better in enhancement and achievement of critical thinking skills than students who received LC and CL. To use LCM, teachers need to prepare worksheets used in exploration or investigation. The Worksheets are made should provide a situation or a mathematical problem so it encourage students to think and play an active role in the learning process. Therefore the students' thinking skills become one consideration in determining the situation or problem mathematically created. Besides that, the discussion goes well, the group should be heterogeneous

Based on these results, in terms of overall enhancement and the achievement of critical thinking skills students who received LCM are in the medium level, thus the enhancement and achievement of critical thinking skills did not obtain the maximum results. Therefore, further research is needed to assess the cause.

Acknowledgment

Thanks to the Ministry of Research Technology and Higher Education Republic of Indonesia, which has funded this research.

References

[1] Z.I. Hassoubah, Developing creative & critical thinking skills. Bandung: Nuansa, 2004

[2] R.H. Ennis, Critical thinking. United States of America: Prentice-Hall, Inc, 1996.

[3] I.V.S. Mullis, O. Martin, Michael, P. Foy, & A. Arora, "TIMSS 2011 international result in Mathematics", TIMSS &PIRLS international study center lynch school of ed. Boston college, Cheotnut Hill, MA USA and IEA Amsterdam. Retrieved from http://timssandpirs.bc.edu/timss2011/downloads/T11_IR_Mathematics_ Fullbook.pdf, 2012.

[4] Runisah, "A Study on critical thinking skills in mathematics on eight grade students. Proceeding international seminar on Mathematics, Science, and Computer Science Education", UPI Faculty of Mathematics and Science Education. (pp 5-10). Bandung, 2015.

[5] Departemen Pendidikan Nasional, "Kajian kebijakan kurikulum mata pelajaran Matematika". Jakarta: Badan Penelitian dan Pengembangan Pusat Kurikulum Depdiknas, 2007.

[6] E. Glazer, "Technology enhanced learning environments that are conductive to critical thinking in Mathematics: Implication for research about critical thinking on the world wide web", Retrieved from http://www.http://lonstar.texas.net/ ~mseifert / crit2.html, 2004.

[7] J. Beaumont. "A sequence of critical thinking tasks", TESOL Journal, 2010, 4th ed, vol 1, pp. 427-448.

[8] E.U.,Aizikovitsh, & D. Cheng.. "Developing critical thinking skills from dispositions to abilities: Mathematics education from early childhood to high school", Creative Education, 2015, Vol. 6, pp. 455-462.

[9] N.M. Achdisty, "Meningkatkan kemampuan pemecahan masalah dan berpikir kritis matematis siswa melalui pendekatan metacognitive instruction. unpublished Thesis, UPI, Bandung, 2012.

[10] B. Anggoro, Y.S. Kusumah, Darhim & J.A. Dahlan. "Enhancing students' critical thinking ability in Mathematics by through IMPROVE method", Mathematical Theory and Modeling, 2014, 5th, Vol. 4, pp. 68 – 77.

[11] L.T. Lioe, H.K. Fai, J.G., Hedberg, "Students'metacognitive problem solving strategies in solving open-ended problems in pairs", Retrieved from http://conference.nie.edu.sg/paper/new converted/aboo 287.pdf., 2006.

[12] E. Glazer, "Using web sources to promote critical thinking in high school Mathematics". Retrieved from http://math.unipa.it/~grim/AGlazer79-84.PDF, 2001.

[13] I. Firdaus, B.B. Kailani, Nor, & Bakry, "Developing critical thinking skills of students in mathematics learning", Journal of Education and Learning, 2015, 3rd ed, Vol.9, pp. 226-236.

[14] H. Innabi,. Aspects of Critical Thinking in Classroom Instruction of Secondary School Mathematics Teachers in Jordan. Proceedings of the International Conference. P. 124-129. Retrieved from http://www.unipa.it/grim/21_project/21_brno03_Innabi.pdf, 2003.

[15] R.W., Bybee, at al, "The BSCS 5E instructional model: Origins and effectiveness and applications executive summary", Retrieved from http://bscs.org/sites/default/files/_legacy/BSCS_5E_Instructional_Model -Executive_Summary_0.pdf , 2006.

[16] S. Mittlefehldt & T. Grotzer, "Using metacognition to facilitate the transfer of causal models in learning density and pressure", Presented at the National Association of Research in Science Teaching (NARST) Conference Philadelphia. Retrieved from ftp://202.83.110.129/Volume_1/from%202TB/FAC%20FOUND%20STUDIES/FYLHR9~3/Subject%20Components/Grey%20matters/R54ZK1~G/Project%20Zero/www.pz.harvard.edu/Research/UCPpapers/P2NARST03.pdf., 2003.

[17] Sofuroh, Masrukan & Kartono. "Model Learning Cycle 5E dengan pendekatan scientific untuk meningkatkan disposisi matematis dan berpikir kritis", Unnes Journal of Mathematics Education Research, 2014, 2nd ed, Vol.3, pp. 91-97.

[18] G. Kadarisma, "Meningkatkan kemampuan berpikir kritis dan logis matematis serta kemandirian belajar siswa SMP melalui Learning Cycle 5E dan Discovery Learning", unpublished Thesis, UPI, Bandung, 2015.

[19] B.P. Erlian, " Pegaruh penggunaan model daur belajar (Learning Cycle) terhadap kemampuan berpikir kritis dan sikap siswa kelas XI MA Muallimat NW Pancor pada mata pelajaran Matematika." Jurnal Educatio, 2009, 2nd ed, Vol.4, pp. 73-83.

[20] N. Fatimah, "Penerapan model Learning Cycle 5E dalam mata pelajaran Matematika untuk meningkatkan kemampuan berpikir kritis siswa SMA". Retrieved from http://repository.upi.edu/, 2012

[21] D.E. Meltzer, "The relationship between mathematics preparation and conceptual learning gains in physics: a posible "hidden variable" in diagnostic pretest scores," American Journal of Physics, 2002, 12th ed, Vol. 70, pp. 1259-1268.

[22] .R.R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses", Journal of American Association of Physics Teachers, 1998, 1st ed, Vol.66, pp. 64 -74.

[23] Darhim, "Pengaruh pembelajaran Matematika Kontekstual terhadap hasil belajar dan sikap siswa SD kelas awal dalam Matematika", unpublished doctoral dissertation, UPI, Bandung, 2004.

[24] T. Laurens, "Pengembangan metakognisi dalam pembelajaran Matematika" Retrieved from http://p4mriunpat.wordpress.com/2011/11/14/metakognisi-dalam-pembelajaran-Matematika/, 2011