CONTRIBUTION OF DISCOVERY LEARNING AND PEER TEACHING ON STUDENT'S MATHEMATICAL CRITICAL THINKING AND SELF CONFIDENT

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Abstract

The purpose of this experiment was to analyze contribution of discovery learning and peer teaching (DL-PT) on student's mathematical critical thinking (MCT) and self confident (MSC). The experimental took pretest-postest control group design and involved 72 eleventh grade students, a MCT test, a MSC scale, and perception on DL-PT and on DL scales . The study found that on MCT and its N Gain, students getting treatment with DL-PT attained better grade than students taught by DL alone; even if both student's grades were at medium level, and students realized difficulties on examining the truth of enumeration process and on proving problem. On MSC, there was no different student's grades between students taught by DL-PT.By DL alone and those grades were at medium level. In addition, there was no association between MCT and SCM, students learned actively during DL-PT and DL and students performed positive opinion on DL-PT and on DL

Keyword: mathematical critical thinking, mathematical self concept, discovery learning, peer teaching

Abstrak

Penelitian ini adalah suatu eksperimen berdisain pre test-postes dan kelompok kontrol bertujuan menganalisis peranan pembelajaran diskoveri dan tutor sebaya (PD-TS) terhadap berpikir kritis (BKM) dan kepercayaan diri matematik (KDM) siswa. Penelitian melibatkan 72 siswa kelas-11, satu tes uraian BKM, satu skala KDM, dan satu skala persepsi terhadap DTS. Penelitian menemukan dalam BKM dan peningkatannya, siswa yang memperoleh PD-TS mencapai mutu yang lebih baik daripada mutu siswa yang mendapat PD saja. Mutu BKM siswa tergolong pada level medium. Selain itu siswa mengalami masih kesulitan dalam memeriksa kebenaran proses perhitngan dan membuktikan berkenaan dengan turunan fungsi. Temuan lainnya adalah tidak ada perbedaan mutu KDM siswa pada kedua kelas pembelajaran, dan mutu KDM siswa tergolong cukup baik. Temuan lainnya lagi, terdapat asosiasi sedang antara BKM dan KDM, siswa lebih aktif belajar selama PD-TS dan PD serta siswa menunjukkan persepsi yang baik terhadap PD-TS dan terhadap PD

Kata kunci: berpikir kritis matematik, kepercayaan diri, pembelajaran penemuan, pembelajaran tutor sebaya

INTRODUCTION

Based on limited researchers' observation during some mathematics lessons in 2018, researchers obtained interesting impressions. There were many students failed to examine the truth of solution process, and they were unable to identify rules used in each step of a

solution process. Likewise, students avoided to complete problems voluntary but they prefered to wait teacher's help. Beside that, students were affraid to explain their work in front of the class and they seemed having no power doing mathematics task as good as other students. Those conditons ilustrate that students still realized difficulty on solving problem critically and they performed low self confidence. The low student's ability in mathematical critical thinking (MCT) from that observation were smiliar to findings of some recent studies such as(Kurniati, Kusumah, Y.S, Sabandar, Y. Herman, 2015; Palinussa, 2013; Widyaningtias, R., Kusumah, Y.S., Sumarmo, U. Sabandar, 2017) that students getting treatment with various innovative teaching obtained better grade on MCT than students taught by conventional eaching. However, those grades were still at low-medium level, and many students realize difficulties in solving MCT tasks. Even if, Murni, S. dan Sugandi (2018) by using Realistics Mathematics Education (RME) and Sunaryo (2013) which implementing problem based learning reported that sudents attained fairly good grade on MCT.

Basically, MCT and MSC are essential mathematics learning outcomes should be enchanced on high school student. There are some reasons support that statement, among other are: a. MCT and MSC are attached in The Goal of Mathematics Teaching (Indonesia Mathematics Curriculum, 2013,(NCTM, 2000); b. Student which having MCT habit will able to solve problem effectively (Peter, 1985); b) When student thinks critically, he will not accept information without checking its source, and he will pose his opinion together with rational reasoning.

Some writers define term of critical thinking (CT) differently, but those definition include similar meaning and complete each other, such as follow: a) CT is ability to explain individual's thinking (Fisher, 2009); b) CT is reasonable reflective thinking and focussed on trusted activities (Glazer, 2004); c) CT is process of thinking in deriving reasonable conclusion (Fisher, 2009); d) CT is process deriving a conclussion about what should be trusted and be done.

Further, as a guide for compiling instrument to assess student's MCT, writers summarize some experts' ideas on indicators of CT as follow: a) MCT includes five main activities such as: to give simple explanation, to build basic skill, to conclude, to clarify in depth and to manage strategy; b) MCT involves activities: to prove, to generalize, to solve problem (Glazer, 2004); c) MCT contains activities: to determine credibility of resources, to differenciate relevant and unrelevant data, to identify and to evaluate unwritten asumption, happened bias, viewpoint, to evaluate proof for supporting confession (Bayer, (Hassoubah, I, 2007)). Those indicators of MCT ilustrate that MCT is a kind of high order thinking in mathematics and it implies for executing MCT task student should have strong disposition and interest in mathematics, and believe to be able to solve difficult problem. That strong mathematical disposition among other is mathematical self confidence in (MSC). Some experts define self confidence in various expressions, even if they involve similar notion such as believe on own capability and they complete each other.

Mathematics Curriculum 2013, proposes that mathematical hard-skill such as MCT and mathematical soft-skill as MSC should be developed simoultaneously. Moreover, Polya (1973), states that teacher's role not only to extend mathematics content but the most esential things are: to act as students, to appreciate student's thinking, to help students to think and to construct new knowledge. That argument suggests researchers should select a kind of teaching approach that able to comply suggestion of Mathematics Curriculum 2013 and

Polya's opinion for improving student's MCT and MSC. After analyzing the traits and steps of some teaching approaches, reseachers estimate discovery learning (DL) will be suitable approach for our goals.

(Kurniasih, I. dan Sani, 2014) and (Suryosubroto., 2015)clarify that DL is learning approach which promoting student active learning, process orienting, self directed learning, self invented and reflevtive thinking through observing and concluding presented information during learning activities. Friedler, Nachmias, and Linn (as cited in(Rohaeti, E.E., Hendriana, H., Sumarmo, 2017) propose some steps in DL namely: a. To define a scientific problem; b. To compile hypothesis; c. To observe, to collect, to analyze, and to interpret data; d. To desgin an experiment; e. To implement the results; and To compose prediction based on the results. Those activities during the steps of DL allow student opportunity to practice to examine relevant and unrelevant data, to conclude, to evaluate proof and other activities that describing mathematical critical activities. Our prediction on DL for enchancing student's MCT and MSC is great increasingly when DL is accompanied with peer teaching (PT) strategy. It is caused of during PT strategy, student either as a leader or as a member of a team will more active learning to explain to other member, to share ideas, to work and to conclude together, and to appreciate each other so that DL-PT will improve student's MCT and MSC better.

Recently, there are limited studies analyze student' MCT and or MSC by using DL-PT accordingly. However, there are some studies examine those variables separately. For examples, beside afformentioned studies have been reported, other studies namely (Kaniawaty, 2016) and (Sriwayuni, 2017)respectively reported advantages of DL and advantages of PT than conventional teaching on improving student's MCT, but those students' grades were still at medium level. Some other studies (Fitriani, 2013; Hendriana, H., Rahmat, U.S., Sumarmo, 2014; Saputri, n.d.; Sumarmo, U., Hidayat, W., Zulkarnaen, R., Hamidah, Sariningsih, n.d.) by using various innovative teaching approaches found that students obtained MSC at fairly good grade level. Based on those findings, seemingly MCT tasks is more difficult than performing MSC behaviour for high school students.

The afforementioned arguments and findings, motivate researchers to carry out a study for improving students' MCT and MSC by using DL-PT and formulate research questions as follow.
1. Are MCT grade and its normalized gain, and MSC grade of students getting treatment with DL-PT better than the grades of student taught by DL alone?
2. What are student's difficulties on solving MCT tasks?
3. Is there any association between MCT and MSC?
4. What are student's believe on DL-PT?Ini adalah contoh paper yang akan dikirim ke IOP.

METHOD

This study is a pre test-post test experimental control group design which having a goal to analyze the role of DL-PT on students' MCT and MSC. The study involved 72 eleventh grade students, an essay MCT test, a MSC scale, and a perception on DL-PT scale. The MCT test consists of 5 items, and by using as a guide it is obtained charactristic of MCT test as follow: reliability test is 0.73; item validity are $0.59 \leq IV \leq 0.75$; discriminat power are $0.33 \leq DP \leq 0.58$, and difficulty index are $0.32 \leq DI \leq 0.48$. In the following, we attach sample items of MCT test, sample items of MSC scale, and some items of perception on DL-PT.

1. *Sample item of mathematical critical thinking test*
   (To examine sufficiency of element for completing maximum problem)
   Hendra has a sheet of paper where its width is ¾ times its length. Hendra cut each edge of the paper and he make an opened box. Sum of surface area of the box is 108 cm^2.
   a. Examine sufficiency of information for determining the maximum of volume of the box.
   b. Compile mathematical model of the problem and then solve it.
   (To give reason toward computation of derivative problem)
   Given equation function $F(x) = (p + 1)x^3 – 3qx^2 + 9x$ and F" (x) can be divided by (x-1) without rest. Show and explain that the curve of y = F(x) has no local extreme when $−3 < q < 0$

2. *Sample item of Mathematical Self Confidence Scale*
   Note: QO: qiuet often   QS: qiuet seldom
          O: often   S: seldom

Table 1. Sample item of Mathematical Self Confidence Scale

	Statement	QO	O	S	QS
1.	Believe able to solve difficult extreme problem without teacher's help.				
2.	Hesitating able to draw graph of a function of three degree as well as my friend's work				
3.	Having self-reliant to side with certain opinion when pose two against point of view about solution of extreme of a function				
4.	Be confused to decide a choice between two different ways of implementing derivative of function				
5.	Feel learning spirit still intense even if failed to examine the truth of statement about tangent line on a function.				
6.	Hopeless when be unsuccessful to complete an extreme problem by using rule of derivative.				

RESULTS AND DISCUSSION

Description of MCT, MSC, and perception toward DL-PT and toward DL of studentsin both classessare attached in Table 2.

Table 2. Description of Mathematical Critical Thinking Ability, Mathematical Self Concept, Perception toward DL-PT, and Perception toward DL od Students

Variables	Stat	Discovery Learning-Peer Teaching (DL-PT)				Discovery Learning (DL)			
		Pre-Test	Post-Test	N Gain	n	Pre-Test	Post-Test	N Gain	n
MCTA	$\overline{X}$	12,50	31,75	.51	36	13,415	30,833	.47	36
	%	26,6	67,55			28,54	65,6		
	SD	26,6	67,55	.53		4,277	6,078	.19	
MSC	$\overline{X}$	-	83,17	-	36	-	77,31	-	36
	%		69,31				64,43		
	SD		10,36				7,24		

Note:
MCT: mathematical critical thinking   Ideal Score: 47
MSC: mathematical self concept   Ideal Score: 120

From Table 1, in pre-test it found that there is no difference of student's MCT in both teaching approaches, and the grades were at very low level. Nevertheles, after learning process, on MCT and its gain (N-$\langle$G$\rangle$), students taught by DL-PT   attained better grades but it was at medium grade level. Those findings were similar to the previous studies that on MCT students taught by various innovative teaching approahes obtained better grades than students taught by conventional teaching, but almost the students' MCT grades were still at low-medium level. Even if, finding of this study on MCT was different with finding of(Fisher, 2009) who found student's grade on MCT was at fairly good level.

Seemingly students realized difficulties in solving mathematical MCT tasks. Those students' difficulties on solving MCT tasks, were attached in Table 3. Students taught by DL-PT attained medium score only on item 3 (68% out of ideal score), but in others items students attained low grades on mathematical critical thinking ability. Nevertheles, students taught by conventional still had difficulties on all items of mathematical critical thinking ability. Seemingly, mathematical critical thinking ability problems were difficult mathematical processess for high school students.

Table 3. Mean Score of Each Item of Mathematical Critical Thinking (MCT) of Students in The Both Teaching Approach

Teaching approach	Desc. Stat.	No.1	No 2.	No.3	No.4	No.5
	Ideal score	8	8	10	6	15
DL-PT	$\overline{X}$	6,20	5,86	6,46	4,66	8,77
	% of ideal score	77,5	73,21	64,57	77,62	58,48
DL	$\overline{X}$	6,47	5,61	6,92	3,50	8,33
	% of ideal score	80,9	70,14	69,17	58,33	55,56

But there was no difference grades of MSC in both teaching approaches, and those grades were at medium-fairly good level. The testing hypothesis of those data were attached in Table 3. These findings were similar to findings of previous studies that found student's MSC are at fairly good grade level.

Table 4. Testing Hypothesis of Mean Difference of Mathematical Critical Thinking Ability, And Mathematical Self concept on Both Teaching Approaches

Variables	Teaching Approach	$\overline{x}$	SD	n	Sig (2-tailed).	Sig (1-tailed).	Interpretation
MCT	DL-PT	31.69	7.03	36	.156	.078	No difference of MCT_{DL-PT} and MCT_{DL}
	DL	29.36	6.77	36			
N-Gain MCT	DL-PT	0,51	0,21	36	.389	.195	No difference of N-Gain MCT_{DL-PT} and N-Gain MCT_{DL}
	DL	0,47	0,19	36			
MSC	DL-PT	83,17	10,361	36	.07	.035	$MSC_{DL-PT} > MSC_{DL}$
	DL	77,31	7,238	36			

Note: Mathematical Critical Thinking Ability   Ideal score : 47
      Mathematical Self concept   Ideal score MSC :120

Further analysis, was concerning association between MCT and MSC. That association was analyzed by using contigency table such as in Table 3 and by using χ^2 testing The analysis obtained value $\chi^2 = 4.467^a$ and sig.(2 tailed-.220 > .005). This was meant that there was no association between MCTA and MSC.

Table 5. Contigency Table of MCT and MSC in DL-PT

MSC / MCT	High	Medium	Low	Total
High	2	4	1	7
Medium	1	16	3	20
Low	1	8	0	9
Total	4	28	4	36

Table 6. Test of Pearson-Chi Square and Contigency Coefficient between Mathematical Critical Thinking and Mathematical Self Concept

Pearson-Chi Square (χ^2)	Df	Contigency Cofficient (C)	Sig.(2-tailed)
4.467^a	4	.346	.346

Further, based on Table 4 and Table 5 there was no   association between MCT and MSC (sig (2- tailed: .346>.05). This findings was similar to other previous studies Hendriana, & Sumarmo, (2016); Widyaningtias, Kusumah, Sumarmo, & Sabandar (2017) that there were no association between MCT with various affective mathematics learning outcomes. but, those findings was different with some other studies Kaniawaty (2016) that there were association between MCT with mathematical self confidence (MSCd). Those findings indicated that there were incosistent findings on the existence of association between MCT and various affective mathematics learning outcomes.

Figure 1. Student's activity when accept

Figure 2. Student's activity when doing excercises

Besides that, this study found that students performed more active learning in all four phases of discovery learning and peer teaching than in discovery learning such as in the following figures (Figure 1, Figure 2).

CONCLUSION

Based on findings and discussion, the study derived conclusion as follow: The discovery learning and peer teaching (DL-PT) took better role than discovery learning (DL) on improving students' MCT and its gain, but not on students' MSC. However the students' MCT grades were still at low-medium level and on MSC students' grades were at mediu-fairly good level. Beside that, students on both teaching approaches realized few difficulties in solving MCT tasks. The other conclusion were that, students peformed more active learning in all four phases of DL-PT than in DL alone and there was no association between MCT and MSC.

SUGGESTION

Based on the conclusion and discussion the study proposed some suggestion as follow: The students' grade on mathematical critical thinking ability in both class were at low level. Mathematical critical thinking was classified as high order thinking (HOT) in mathematics. For obtaining HOT ability such as mathematical critical thinking abilty, firstly students should master prerequisite of mathematical process and content of mathematical critical thinking ability. So, before teacher were going to explain a new mathematics topic or content or to conduct study on mathematical HOT ability, it was suggested to examine students' abilities of its prerequisite firstly. Besides that, students should be motivated to select and to solve more exercises by theirselfes on mathematical HOT ability and or on mathematical critical thinking ability. In order students attained meaningfull mathematical critical thinking ability, it was suggested students asked to write the formulas and rules which used on each step in solving the problems as well.

To improve better students' mathematical self concept, it was suggested four ways as follow: Be aware of students to the importance of having mathematical self concept; teacher should perform having behavior as wished in mathematical self concept; students should be accustomized having behavior as wished in mathematical self concept; teacher should carry out integrated and continous mathematics teaching process.Pada bagian ini, ditulis ucapan terima kasih. Ini adalah contoh paper yang akan ditulis di IOP. Kalimat yang ditunjukkan adalah kalimat hasil karangan indah Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

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