Improving mathematical lateral thinking ability of high school students through quantum learning based on creative problem solving

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Abstract. The aim of this study is to comprehensively analyse the improvement of mathematical lateral thinking ability of high school students as an outcome of quantum learning based on creative problem solving, both viewed as a whole and each level of initial mathematical ability (high, medium, and low), and gender (male and female). This study used a quasi-experimental method with a pretest-posttest control group design. The study population was high school students in the city of Bogor, while the sample was taken from four classes in a school. The data obtained through tests of lateral thinking skills and mathematical initial ability data, as well as the results of observations and interviews. The results showed that students who received quantum learning based on creative problem solving had a higher mathematical lateral thinking ability than students who received direct learning, whether as a whole and each level of initial mathematical ability or as every gender.

1. Introduction

Thinking is information processing mentally or cognitively. Information processing occurs through the rearrangement or cognitive manipulation of information from the environment, as well as symbols stored in longterm memory [1]. Thinking activities according to Santrock [2], aiming for forming concepts, reasoning, critical thinking, making decisions, thinking creatively, and solving problems. Thinking activities like this are carried out activities in mathematics and known as mathematical thinking.

Mathematics is taught to students at every level of education with the aim for developing the logic and thinking abilities of students. This is considered necessary because the way of thinking developed in mathematics uses the right rules of reasoning, so that it is seen to be effective in training to solve problems inside and outside mathematics. Through mathematics education, it is expected to be able to create students who are able to answer human resource needs under globalization. The challenges of 21st century education, are able to create thinkers resources that have thought breakthrough (breakthrough thinking process) in dealing with problems [3].

Lateral thinking is useful in problem solving and in generating new ideas [4]. Mathematical lateral thinking skills can be trained with learning that gives students freedom of thought, so students can analyze from a variety of possible perspectives [5]. Giving freedom of thought accompanied by guidance will develop students thinking skills. One technique that can be done to practice lateral thinking skills is by brainstorming in group activities [6]. The ability to think must be trained, because it is not a talent or innate ability.
The four main principles of lateral thinking, according to [4], are: (1) recognizing the dominant idea of the problem at hand; (2) looking for different ways of looking at a problem, (3) loosening the control of rigid thinking (flexibility); and (4) use random ideas to generate new ideas. The purpose of lateral thinking is to view problems from different perspectives, to reorder patterns, and to generate alternative solutions.

One of solving problem methods that can train the mathematical lateral thinking ability is creative problem solving (CPS) method. According to Pepkin [7], CPS is a learning method that focuses on problem solving skills and is accompanied by strengthening creativity. Students are invited to identify problems, create ideas as a solution strategy through brainstorming, to find the best strategies to be applied in solving problems. Through the CPS method students can analyze and synthesize problems from various possible perspectives in brainstorming.

The CPS method needs to be combined with a learning model that can optimize students abilities in problem solving, that is quantum learning. Through quantum learning, a comfortable and pleasant learning atmosphere can be created, and can optimize students thinking abilities. According to DePorter & Hernacki [8], quantum learning is learning that seeks to create a conducive learning environment that is comfortable and pleasant by combining confidence, learning skills, and communication skills.

2. Method
This research uses quasi-experimental designs method, because subject for experiment and control are not randomly selected but researcher accepts the situation as it is [9, 10]. This is due to a system that does not possible to random selection the subject. This research take place in real life so that sample groups cannot be identical. The designs of quasi-experimental are pretest-posttest, nonrandomized control group refers to Ruseffendi’s [9] opinion.

The each group of experiment and control consist of two class. Experiment class get QBCPS learning treatment, and control class get direct learning (PL). Each class is given KBLM pretest at the beginning of learning. Hereafter, each class is given KBLM posttest at the end. The instrument that use of KBLM test is same at pretest and posttest. The purpose is more measurable in seeing presence or absence of treatment.

This research takes into account KAM factors (high, medium, low) and gender of student (male, female) to see more deeply the effectiveness of application of learning. KAM data of student are taken from average scores of daily test on previous basic competencies. Other than that, the research uses three variables: independent variable, dependent variable, control variable. Independent variable consist of QBCPS learning and PL, whereas dependent variable is KBLM. Mathematical initial abilities (KAM) and gender are control variable.

Population in this research is all of public high school student in Bogor city. Selection of high school student is based on consideration that KBLM them still low, national exam scores, and TIMSS (Trends in International Mathematics and Science Study) survey result and PISA (Programme for International Student Assessment). Furthermore, selection sample in this research using cluster sampling method, random sampling based on groups, not based on members and the groups have same characteristics [10]. The sample is student of senior high school 10 Bogor grade X Science that consist of six class. Then, four of them is taken through an analysis of the similarity of the KAM average taken from an average of twice the daily results of the male and female tests. Class selection based on homogeneity of male and female students in experiment class and control class. Finally set X-1 Science class and X-2 Science class as experiment class and X-3 Science class and X-4 Science class as control class, so that is four class.

Selection student grade X as sample based on consideration, they are new students still easy to arrange. Other than that, this research conducted at schools that did not apply superior classes and in each class quantity of male and female almost balanced.

3. Result and Discussion
Samples distribution in experimental class (KE) and control class (KK) based on KAM categories and gender (male (LK), perempuan (PR)) is presented in the following table 1.
Table 1 presents the samples distribution based on KAM.

| KAM Category | LK-KE | PR-KE | Sum | LK-KK | PR-KK | Sum | Total |
|--------------|-------|-------|-----|-------|-------|-----|-------|
| High         | 11    | 10    | 21  | 9     | 8     | 17  | 38    |
| Medium       | 15    | 16    | 31  | 17    | 16    | 33  | 64    |
| Low          | 9     | 9     | 18  | 11    | 9     | 20  | 38    |
| **Total**    | 35    | 35    | 70  | 37    | 33    | 70  | 140   |

Table 1 presents that many students in experimental class and control class based on gender and KAM categories.

3.1. Research Result
First, data analysis of initial mathematical abilities (KAM) obtained from average daily scores at odd semester in experimental class (KE) and control class (KK). Trigonometry is a subject matter of research. The purpose of taking this KAM data is to know the average equality of initial mathematical abilities in experimental class (KE) and control class (KK), also to grouping the students based on gender. Table 2 shows the results of descriptive analysis of KAM data based on research class and gender.

Table 2. Descriptive of KAM Student Data Based on Research and Gender Classes

| Gender | Descriptive Statistics | KE | KK | Combination (KE U KK) |
|--------|------------------------|----|----|-----------------------|
| Male   | Sample Size            | 35 | 37 | 72                    |
|        | Average                | 70,00 | 70,00 | 70,00                 |
|        | Standard Deviation     | 21,53 | 20,82 | 21,02                 |
| Female | Sample Size            | 35 | 33 | 68                    |
|        | Average                | 70,00 | 70,45 | 70,22                 |
|        | Standard Deviation     | 21,27 | 20,62 | 20,80                 |
| Combination | Sample Size  | 70   | 70   | 140                   |
|        | Average                | 70,00 | 70,21 | 70,11                 |
|        | Standard Deviation     | 21,25 | 20,57 | 20,84                 |

Descriptively, the average KAM students of the experimental class and control class were almost the same, both of male and female students, which was equal to 70.00. This shows, there is no difference in KAM both of male and female in experimental class and control class. Inferentially, results of similarity of KAM average for male and female students in experimental and control classes are shown in Table 3.

Table 3. KAM Average Similarity Test Results

| Groups | n | Mean rank | dk | Sig. | Interpretation |
|--------|---|-----------|----|------|----------------|
| LK CPS  | 35 | 70,93     |    |      |                |
| P CPS   | 35 | 70,40     |    |      |                |
| L PL    | 37 | 70,05     | 3  | 1.00 | No difference  |
| P PL    | 33 | 70,65     |    |      |                |

Table 3 shows similarity average of male and female test results in experimental and control class using Kruskal-Wallis Test have no differences. In general, it can be concluded that there is no difference in KAM between experimental and control class seen from gender. Because KAM students and KAM of each gender on both of research class is not different. It is qualifies to provide different treatment for each research class. If there is difference of KBLM in the end of learning, then this is the
effect of different treatments in each class and due to differences in mathematical abilities before learning.

Descriptive Analysis of Mathematical Lateral Thinking Ability (KBLM) Data

This analysis of KBLM students data was conducted descriptively. KBLM students data obtained through pretest and posttest, then calculated the gain normality (N-gain). This data is analyzed based on factors of learning model (QBCPS, PL), gender students (male, female), and mathematical lateral thinking abilities of students (high, medium, low). KBLM students data based on learning model is presented in table 4 below.

Table 4. KBLM Data Description Based on Learning Model

| Descriptive Statistics | Pretest KE | Posttest KE | N-gain KE | Pretest KK | Posttest KK | N-gain KK |
|------------------------|------------|------------|-----------|-----------|------------|-----------|
| Sample Size            | 70         | 70         | 70        | 70        | 70         | 70        |
| Average                | 128,39     | 265,89     | 0,52      | 129,11    | 230,54     | 0,38      |
| Standard Deviation     | 26,74      | 51,86      | 0,15      | 25,78     | 55,52      | 0,18      |

Information: KBLM student test ideal score (maximum) is 400

Descriptive statistics data in table 4 shows that increase in KBLM students who obtain QBCPS learning model is higher than students who obtain direct learning (PL), that is equal to 0,52 for QBCPS and 0,38 for PL. According [11] increasing 0,52 and 0,38 are medium of category. Increased KBLM in QBCPS and PL learning for each aspects of mathematical lateral thinking abilities are shown in table 5 below.

Table 5. KBLM Aspect Data Description Based on Learning Model

| Lateral Thinking Aspects | N-pre KE | N-post KE | N-N-gain KE | N-pre KK | N-post KK | N-N-gain KK |
|--------------------------|----------|----------|-------------|----------|----------|-------------|
| Idea Identification      | 45,36    | 85,54    | 0,77        | 43,75    | 76,61    | 0,61        |
| Flexibility              | 30,89    | 65,36    | 0,51        | 31,61    | 53,39    | 0,33        |
| Development              | 28,21    | 63,21    | 0,50        | 29,64    | 57,14    | 0,40        |
| Originality              | 23,93    | 51,79    | 0,37        | 24,11    | 43,39    | 0,26        |

Information: each aspect lateral thinking ideal score is 100

Table 5 shows that KBLM enhancement for each aspect has increased, both of QBCPS or PL learning. KBLM students enhancement who obtain QBCPS learning have higher than PL learning. Increase for each aspect of KBLM is medium category, except increase of aspect to identify the idea in QBCPS learning which is high and increase of originality aspects in PL which is low (Hake, 1998). Average enhancement of each KBLM students aspect of pretest and posttest results show that there is increase of each KBLM students aspect who obtained QBCPS learning have higher than students who obtain PL. Then, KBLM enhancement in terms of learning model and gender students, male and female, is shown in the table 6 below.

Table 6. KBLM Data Description Based on Learning Model and Gender

| Gender | Descriptive Statistics | Pretest KE | Posttest KE | N-gain KE | Pretest KK | Posttest KK | N-gain KK |
|--------|------------------------|------------|------------|-----------|-----------|------------|-----------|
| Male   | Sample Size            | 35         | 35         | 35        | 37        | 37         | 37        |
|        | Average                | 126,4      | 261,8      | 0,50      | 127,0     | 229,7      | 0,38      |
|        | Standard Deviation     | 27,58      | 44,86      | 0,12      | 25,95     | 46,95      | 0,14      |
| Female | Sample Size            | 35         | 35         | 35        | 33        | 33         | 33        |
|        | Average                | 130,4      | 270,0      | 0,53      | 131,4     | 231,4      | 0,38      |
|        | Standard Deviation     | 26,13      | 58,41      | 0,18      | 25,79     | 64,58      | 0,21      |

Information: KBLM student test ideal score (maximum) is 400
Table 6 shows that there is an increase in KBLM both of male and female students who obtain QBCPS and PL learning which are all classified as medium [11]. But, KBLM enhancement of male and female who obtain QBCPS learning is higher than male and female students who obtain direct learning (PL). KBLM average enhancement of male and female students based on pretest and posttest are show that there is KBLM enhancement after the treatment.

Furthermore, discussed about descriptive analysis of KBLM data in terms of learning model and initial mathematical ability of students, that is high, medium, and low are presented in the table 7 below.

**Table 7. KBLM Data Description Based on Learning Model and KAM**

| KAM     | Descriptive Statistics | Pretest KE | Posttest KE | N-gain KE | Pretest KK | Posttest KK | N-gain KK |
|---------|------------------------|------------|-------------|-----------|------------|-------------|-----------|
| High    | Sample Size            | 21         | 21          | 21        | 17         | 17          | 17        |
|         | Average                | 152,38     | 319,6       | 0,68      | 158,1      | 306,6       | 0,62      |
|         | Standard Deviation     | 21,87      | 38,03       | 0,13      | 17,08      | 38,81       | 0,15      |
| Medium  | Sample Size            | 31         | 31          | 31        | 33         | 33          | 33        |
|         | Average                | 129,4      | 258,1       | 0,48      | 129,6      | 216,7       | 0,32      |
|         | Standard Deviation     | 13,52      | 26,92       | 0,09      | 13,91      | 31,20       | 0,12      |
| Low     | Sample Size            | 18         | 18          | 18        | 20         | 20          | 20        |
|         | Average                | 98,61      | 216,7       | 0,40      | 103,8      | 188,8       | 0,29      |
|         | Standard Deviation     | 19,12      | 41,12       | 0,11      | 20,32      | 30,59       | 0,07      |

Information: KBLM student test ideal score (maximum) is 400

Table 7 shows that after learning process there is an average enhancement of KBLM in all KAM category. An average enhancement of KBLM student who obtain QBCPS learning for high, medium and low KAM category is 0,68; 0,48; and 0,40, which is medium (Hake, 1998). An average enhancement of KBLM students who obtain PL for high, medium, and low KAM category is 0,62; 0,32; and 0,28, which is medium, except for low KAM category which is low (Hake, 1998).

**Inferential Analysis of Mathematical Lateral Thinking Ability (KBLM) Data**

Analysis of KBLM data was followed by a statistical test which first tested the normality of the N-gain KBLM data from the two learning groups based on a combination of all samples to find out the distribution of the data. This normality test uses the Lillifors normality test (Kolmogorov-Smirnov). The results of the KBLM data distribution normality test for the two learning groups showed that the distribution of N-gain KBLM data in the two learning groups was not normally distributed. Furthermore, the differences in the average KBLM were tested based on the learning group using non-parametric statistics, it is the Mann-Whitney test. The formulation of hypotheses is as follows.

H$_0$ : There is no difference in an average enhancement of KBLM rank between groups of students who obtain QBCPS and PL learning

H$_1$ : There is difference in an average enhancement of KBLM rank between groups of students who obtain QBCPS and PL learning.

Criteria for testing hypotheses based on p-value (sig.). H$_0$ is rejected if sig.$<\alpha$, for $\alpha = 0,05$ and H$_0$ is accepted if the opposite. The results of hypotheses testing are presented in the table 8 below.

**Table 8. KBLM Differences Test Results Based on Learning Groups**

| Learning Groups | Mean Rank | Mann-Whitney | Sig. | Interpretation |
|----------------|-----------|--------------|------|----------------|
| QBCPS          | 88,94     | 1159,00      | 0,000| H$_0$ rejected |
| PL             | 52,06     |              |      |                |
The results of KBLM difference test in table 8 show there were significant differences in KBLM between groups of students who received QBCPS and PL learning. Because average score KBLM rank of students who receive QBCPS learning is greater than PL, it is generally concluded that the enhancement in KBLM students who obtain QBCPS learning is better than PL.

Statistics test to find out differences in an average enhancement of KBLM rank based on gender and learning groups, first step is normality test. The data used were the average N-gain KBLM of male and female students from two learning groups. Because the data of male and female in each learning group is less than 50, the normality test uses Shapiro-Wilk.

The results of KBLM data distribution normality test based on gender and learning groups are show that all is not normally distributed, so as to test the differences in KBLM based on gender and learning groups use non parametric statistics, it is Kruskal-Wallis test. The hypotheses formulas tested are as follows.

H₀: There is no difference in an average enhancement of KBLM rank in terms of gender and students groups who obtain QBCPS and PL learning.

H₁: There is difference in an average enhancement of KBLM rank in terms of gender and students groups who obtain QBCPS and PL learning.

Criteria for testing hypotheses based in p-value (sig.). H₀ is rejected if sig. < α, for α = 0.05 and H₀ is accepted if opposite. The results of hypotheses testing are presented in table 9 below.

| Learning Groups | Mean Rank | Kruskal-Wallis | Sig. | Interpretation |
|-----------------|-----------|---------------|------|----------------|
| QBCPS Male      | 88.77     |               |      |                |
| PL Male         | 53.11     |               |      |                |
| QBCPS Female    | 89.11     | 139.00        | 0.00 | H₀ rejected    |
| PL Female       | 50.88     |               |      |                |

Table 9 shows that there are significantly difference in an average enhancement of KBLM in terms of gender and learning groups. Then, to find out which groups are different, Kruskal-Wallis advance tests need to be done. The testing criteria are based on the mean difference in rank values of gender and learning groups with critical values. If mean rank difference value is smaller than the critical value, so H₀ is accepted. Conversely, if mean rank difference value is greater than critical value, so H₀ is rejected. The results of KBLM pairing test based on gender and learning groups are presented in table 10 below.

| Pair | Mean Rank Deviation | Critical Value | Interpretation |
|------|---------------------|----------------|----------------|
| \( |R₁ - R₂| \) | 0.34 | 12,833 | Accept H₀ |
| \( |R₁ - R₃| \) | 35.66 | 13,018 | Reject H₀ |
| \( |R₂ - R₃| \) | 37.89 | 12,657 | Reject H₀ |
| \( |R₂ - R₄| \) | 36.01 | 13,018 | Reject H₀ |
| \( |R₃ - R₄| \) | 38.24 | 12,657 | Reject H₀ |
| \( |R₃ - R₄| \) | 2.23 | 12,854 | Accept H₀ |

Information: \( R₁ \) = male QBCPS groups, \( R₂ \) = female QBCPS groups, \( R₃ \) = male PL groups, \( R₄ \) = female PL groups

Table 10 shows that between male and female students who obtain QBCPS learning there was no significant difference in the enhancement in an average KBLM rank. Likewise, between male and female students who obtain PL, there was no significant difference in the enhancement in an average KBLM rank. This show that gender does not affect the improvement of KBLM students.
The different results for testing between male students who obtain QBCPS and PL learning, which is significant difference in the enhancement in an average KBLM rank. Likewise, between female students who obtain QBCPS and PL learning, between male students who obtain QBCPS learning with female students who obtain PL, and between female students who obtain QBCPS learning with male students who obtain PL. All of them there are significant difference in the enhancement in average KBLM rank. This shows that learning model take effect in KBLM enhancement.

Statistical test to find out the differences in increasing the average KBLM rank of students based on KAM and learning groups, the first step that needs to be done is normality test using Shapiro-Wilk. The results of KBLM data distribution normality test based on KAM students and learning groups are showed that only medium KAM data group was obtain QBCPS and PL learning which was not normally distributed, while the other data groups were normally distributed. Then, to test the equality of the average KBLM data based on same KAM category the two learning groups were normally distributed and independent, using a parametric test that is Independent-Samples t–Test. Whereas to compare the KBLM data of the two learning groups which were not normally distributed and independent, using a non-parametric test that is Mann-Whitney test.

Statistical test for data that normally distributed use an independent samples t-test. Homogeneity test needs to be done to test the similarity of two groups of data previously. Homogeneity test of the variances of two groups of data used the levene’s test and the results showed that high and low KAM category all had homogenous variances. Therefore, testing the hypotheses of KBLM differences for high and low KAM category using t-test, with following hypotheses formulation.

\[ H_0: \text{There is no difference in average KBLM in each category of KAM students who obtain QBCPS and PL learning} \]

\[ H_1: \text{There is difference in average KBLM in each category of KAM students who obtain QBCPS and PL learning.} \]

Summary of the test results to difference in average KBLM students in two learning groups based on KAM category are presented in table 1 below.

| KAM Categories | Learning Groups | N  | T-Test Independent Sample | Mann-Whitney Test | Interpretation |
|----------------|----------------|----|--------------------------|-------------------|----------------|
| High           | QBCPS PL       | 21 | 1.379 0.176              |                   | H0 accepted    |
|                |                | 17 |                         |                   |                |
| Medium         | QBCPS PL       | 31 | 65.00 0.000              |                   | H0 rejected    |
|                |                | 33 |                         |                   |                |
| Low            | QBCPS PL       | 18 | 3.666 0.001              |                   | H0 rejected    |
|                |                | 20 |                         |                   |                |

KBLM students average difference test results with high KAM, there is no KBLM average difference on students who obtain QBCPS and PL learning. It means students who have high KAM (clever) is given QBCPS and PL learning there is no difference in average increase KBLM rank. Then, for medium and low KAM students, there is difference in average of KBLM students who obtain QBCPS and PL learning. It means there is difference in increase KBLM in students with medium and low KAM who is given QBCPS and PL learning.

Analysis about presence or absence of the interaction effect between learning groups (QBCPS and PL) and gender (male and female) on KBLM using two ways Anove test or multivariate. Through the calculation obtained value of F = 0.239 with probability value of 0.629 and the results of analysis show that there is no interaction effect between learning model and gender on KBLM.

Graphical explanation of the absence of interaction effect between learning groups and gender to mathematical lateral thinking ability is presented as follows.
Figure 1. Interaction Between Used Learning Group and Gender to KBLM Achievement

Figure 1 shows that in male and female who obtain QBCPS learning model have a greater KBLM than students who obtain PL, and there is no interaction effect between the learning model used and gender. KBLM students is only effected by learning model while gender does not affect.

Analysis about presence or absence of the interaction effect between learning model (QBCPS and PL) and KAM students (high, medium, and low) on KBLM using The Adjusted Rank Transform Test [12]. From the calculation obtained value of F = 2.134 with probability value of 0.1222 and the results of analysis show that there is no interaction effect between learning model and KAM students on KBLM.

Graphical explanation of the absence of interaction effect between learning groups and KAM students to mathematical lateral thinking abillity is presented as follows.

Figure 2. Interaction Between Used Learning Group and KAM to KBLM Achievement

Figure 2 shows that in KAM students who obtain QBCPS learning model have a greater KBLM than students who obtain PL, this enhancement occured in all KAM categories. The curve in the figure shows that there is no interaction effect between learning model used and the KAM category of teh students. KBLM students is only effected by learning model while KAM does not affect..
3.2. Discussion

Based on the results of descriptive analysis of the data that average KBLM of all students, male and female, and each category of KAM has increased, both for QBCPS learning (experimental class) and direct learning (control class). This shows that the learning activities in two research classes have been able to stimulate the development of KBLM students. This situation is natural thing as an effect of learning process.

The statistical test results in table 9 show that there are significant difference in enhancement in KBLM in terms of gender and learning groups. However, the enhancement in students KBLM is not affected by gender, but is more affected by learning model (according to statistical test results in table 12). This is showed by figure 1 that there is no interaction effect between learning model used and gender. The students KBLM are only affected by learning model, while gender does not affect. Male and female students who study through QBCPS have greater KBLM than students who study through PL. This situation is consistent with [13] view that gender differences in mathematical problem solving are affected by certain biological, psychological, and environmental factors. The QBCPS learning environment has a better effect on difference gender in improving KBLM of students.

KBLM improvement is in term of KAM students. Descriptively it is shown in table 7 that the average KBLM of students who get QBCPS learning has enhanced higher than students who get PL for each KAM category. The results of the statistical tests in table 11 show that the KBLM of students in all KAM who obtained QBCPS learning enhanced significantly higher than students who obtained the PL, except students with high KAM. KBLM of students with high KAM did not enhance significantly when studying through QBCPS learning compared to studying through the PL. This is because students who have high KAM (clever) will be ready to take part in learning by any method [14], so that there is no significant difference in KBLM improvement for students with high KAM who get QBCPS learning with those who get PL. This situation is also shown in figure 2 that in KAM students who obtain QBCPS learning have higher KBLM than students who obtain PL, this enhancement occurs in all KAM categories. The curve in the figure does not intersect, indicating no influence of interaction between the learning model used and the KAM category of students. Students KBLM is only affected by the learning model, while KAM does not affect.

In addition, the results of the statistical tests in table 8 show that KBLM students who obtained QBCPS learning enhanced significantly higher than students who obtained direct learning. This means that overall QBCPS learning is better at improving students KBLM than through PL. This is because the success of the learning process is greatly affected by the potential of all those involved in the interactions created in the classroom. The higher the potential of all involved and more optimal interaction activities in the learning process with a conducive and pleasant atmosphere, the more effective the learning process will be. Riegeluth views that the effectiveness of learning is usually measured by the level of achievement of students towards predetermined learning goals [15].

4. Conclusion

Based on the result and discussion, it can be concluded that: 1) Enhancement in KBLM of students who obtain greater creative problem solving based quantum learning than students who obtain direct learning; 2) Enhancement in KBLM of students in terms of gender and learning groups are different. But, Enhancement in KBLM of students is not affected by gender, but learning model which used; 3) Enhancement in KBLM of students of male and female who study through QBCPS learning and direct learning are not different; 4) Enhancement in KBLM of students with medium and low KAM who obtain QBCPS learning are greater than students who obtain direct learning. Whereas for students with high KAM there is no difference between students who study through QBCPS and students who learn through direct learning; 5) There is no interaction effect between learning model which used and category of KAM of the students. The enhancement in KBLM of students are only affected by learning model, whereas KAM has no effect.

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References
[1] Khodijah N 2014 Psikologi Pendidikan (Jakarta: PT. Raja Grafindo Persada) p 103
[2] Santrock J W 2009 Psikologi pendidikan Ed.3 Buku ke-2 (Jakarta: Penerbit Salemba Humanika)
[3] Wijaya E Y, Sudjimat D A and Nyoto A 2016 Transformasi Pendidikan Abad 21 Sebagai Tuntutan Pengembangan Sumber Daya Manusia di Era Global Prosiding Seminar Nasional Pendidikan Matematika, Universitas Kanjuruhan Malang. 1 263
[4] De Bono E 1990 Berpikir Lateral. Alih Bahasa: Budi. (Jakarta: Binarupa Aksara)
[5] Rosnawati R 2011 Berpikir Lateral dalam Pembelajaran Matematika Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA, Fakultas MIPA, Universitas Negeri Yogyakarta. 14 Mei 2011
[6] De Bono E 2010 Lateral thinking: a textbook of creativity (UK: Penguin)
[7] Pepkin K L 2004 Creative problem solving in math. Available in http://www.mathematic. transdigit.com/mathematic-journal.html. (Accessed at October 28th 2011)
[8] De Porter B and Hernacki M 1999 Quantum learning. Membiasakan belajar nyaman dan menyenangkan (Bandung: Penerbit Kaifa In Bahasa)
[9] Arikunto S 2010 Prosedur penelitian: Suatu pendekatan praktik. Edisi Revisi (Jakarta: PT. Rineka Cipta)
[10] Ruseffendi E T 2010 Dasar-dasar penelitian pendidikan dan bidang non-eksakta lainnya. (Bandung: Penerbit Tarsito) p 52–94
[11] Hake R R 1998 Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses American Journal Physics 66 64
[12] Leys C and Schumann S 2010 A nonparametric method to analyze interactions: The adjusted rank transform test. Journal of Experimental Social Psychology 46 4 587
[13] Zhu Z 2007 Gender differences in mathematical problem solving patterns: A review of literature. International Education Journal 8 2 187
[14] Sumiati and Asra 2009 Metode Pembelajaran. (Bandung: CV. Wacana Prima)
[15] Uno H B 2012 Orientasi baru dalam psikologi pembelajaran (Jakarta: PT. Bumi Aksara)