Mathematical Strategic Thinking Ability Using Quantum Learning Based on Creative Problem Solving in Terms of High School Students Gender

J Julita[1,2,3*], D Darhim[1] and T Herman[1]

[1]Postgraduate Program of Mathematic Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
[2]Faculty of Economics, Universitas Pakuan, Bogor, Indonesia
[3]Teacher of Bogor 10 High School, Pinang Raya Street Sector VI, Bogor, Indonesia

*julita@student.upi.edu

Abstract. Mathematical strategic thinking ability is one of the strategic thinking aptitude which is needed to confront the challenge in this globalization era. It is because the strategic thinking is useful for problem solving and decision making. The object of this research is the impact quality of Quantum Learning Based on Creative Problem Solving (QBCPS) for the escalation of Mathematical Strategic Thinking Ability (MSTA). This research focused on the gender differences (Boy and Girls) between the students who are received QBCPS with those who got the direct learning. The method of this research is quasi experiment with the population is all of High School students in Bogor City. The research sample is the first year students in one of Bogor City High School with total of 140 students from four class. The result study showed that MSTA on boy and girl students didn't have any significant difference, whether the QBCPS learning or the other one. But, there is a discrepancy in the increasing of every MSTA learning of boy and girl students for both learning treatment. And also, there is a distinction of significant increasing in MSTA between the boy students with QBCPS learning and the other one, as well as girl students. The MSTA's enhancement of boy and girl students with QBCPS learning is higher than those with direct learning. This uplift didn't influenced by diverse gender, but only affected by the learning model treatment.

1. Introduction

Mathematical strategic thinking ability is one of skill which is needed to confront the challenge in this globalization era, because strategic thinking ability is advantageous in problem solving and decision making [1]. The poor ability of mathematical strategic thinking can affect the student competency in problem solving. When the student solving the problem, the brain is thinking. In mathematics, problem solving is the main focus of learning process [2]. This ability is one of the thinking ability needed in challange from globalization era because benefit of strategical thinking is problem solving and decision making, also thinking to the future [1].

Weak strategic thinking skills have an impact on students ability to solve problems. When students do mathematical problem solving, then there is activity of thinking inside the brain. Though problem solving is a focus in learning mathematics [2]. When students solve mathematical problems using problem solving skills, at the same time, they will make decisions, think critically, and think creatively

[3]. Strategic thinking, according to Henry Mintzberg, is a process of synthesizing problems by utilizing intuition and creativity [1]. Strategic thinking involves the synthesis of information to identify problems, connections, and rules (patterns) that encourage intuitive, innovative and creative thinking. [4] views strategic thinking as a process of synthesis, creative and divergent. A similar opinion was expressed by [5] who viewed strategic thinking as a combination of thinking synthesis, divergent, creative, intuitive, and innovative. From several views on strategic thinking, it is concluded that mathematical strategic thinking is the combination of analysis and synthesis of mathematical problems which are critical ways of thinking with variations of solutions from creative ways of thinking.

Beaufre views strategic thinking as an abstract and rational thought process in problem solving [6]. This thought process depends on the large capacity of the analysis and synthesis of the problem being carried out. Analysis is needed to collect data that can be used as alternative solutions, while synthesis is needed to choose alternative solutions to get the best solution.

The process of strategic thinking in problem solving begins with compiling problems into simple problems, then analyzed to look for possible problem-solving steps to be taken, then proceed with the process of synthesis by drawing the truth from each step of resolution taken [6]. The indicator of mathematical strategic thinking in this research is being able to design, analyze, and synthesize problems.

Given the importance of mathematical strategic thinking skills in problem solving, it is necessary to design a pleasant and conducive learning atmosphere for mathematics that builds creativity. The active learning model and stimulating students express creative ideas in solving problems, as well as a pleasant and effective learning atmosphere. Effective learning is a learning process that is able to actively involve all students [7]. One learning model that fits this goal is quantum learning based on creative problem solving (QBCPS). The effectiveness of quantum learning based on creative problem solving in improving learning outcomes, students' ability to understand concepts and mathematical problem solving is reflected in the results of [8] and [9] research.

This research focuses on gender differences on students, because gender differences are found in diverse classes. Differences between men and women in verbal and mathematical abilities, as well as the way men and women socialize. This gender difference needs to be carried out research to review these differences as a result of nature (environment) or differences in treatment. Diane Halpern's research results concluded that women are superior in language arts, reading comprehension, and written and oral communication, while male students are superior in mathematics and mathematical thinking [10].

2. Experimental method

The method used in this study is quasi-experimental designs, that is the subjects for the experimental and control classes are not randomly selected, but researchers accept the state of the subject as it is [11; 12]. This is due to the school system which makes it impossible to do random selection of subjects. This research was conducted in real life where the two sample groups could not be identical. This study uses a quasi-experimental designs with pre-test–post-test, non-randomized control group (pre-test–post-test design) which refers to the opinion [11; 12].

The research sample was the first grade students of one of the state high schools in the city of Bogor, totaling 140 people or four classes. Two classes as an experimental group and two more as a control group. The experimental group was given quantum learning based on creative problem solving (QBCPS), while the control group was given direct learning. The study was conducted in the even semester in first grade with Trigonometry subject matter. Each research group was given KBSM post-test. KBSM test instruments used in the pre-test and post-test in this study are the same. The goal is to be more measurable in seeing whether there is an increase in treatment or not.

3. Result and discussion

The distribution of the research sample in the experimental group (EG) and control group (CG) based on the gender of students (male (M), female (F)) is presented in Table 1 below.

Table 1. Distribution of research samples based on student gender

Gender	Class		Total
	Experiment	Control	
Male	35	37	72
Female	35	33	68
Total	70	70	140

Furthermore, the data of 140 students were analyzed to make a conclusion and reported as a result of research.

3.1. Results

The first step is to do a descriptive and inferential analysis of students' initial mathematical ability (IMA) data based on gender and overall data (combined) in the experimental group (EG) and control (CG). It aims to determine the average equivalence of IMA of the two research groups. IMA data were obtained from the average value of twice the daily tests of the experimental and control group students in odd semester.

Descriptively the results of IMA data analysis based on gender and overall (combined) students are shown in Table 2 below.

Table 2 Descriptive IMA Data for Students Based on Research and Gender Groups

Gender	Statistics Descriptive	EG	CG	Combination (EG ∪ CG)
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

Note: IMA's ideal student score is 100

Table 2 shows that the average IMA of the experimental and control group students for each gender is relatively the same, as is the standard deviation. Overall it can be seen that the IMA data of the experimental and control group students also have the same average and standard deviation.

Inferential results of the average IMA equality analysis based on gender and overall (combined) students show that each sample group has a Significance value of more than 0.05. This means that there is no difference in the average IMA between students in the experimental and control groups based on gender and their mix. The details are shown in Table 3 below.

Table 3 Results of the Average Equality Statistical Test of the Research Group Based on Gender and Overall Students

Gender	Class	N	Statistic Test					
			Mann Whitney Test		t Sample Independent Test			
			Z	Asymp. Sig. (2-sides)	t	Db	Sig. (2-sides)	
Male	EG	35	-0.085	0.933				
	CG	37						
Female	EG	35			-0.089	66	0.929	
	CG	33						
Combination	EG	70	-0.048	0.962				
	CG	70						

Statistical test results show that there is no significant difference in IMA averages based on gender or overall. If after conducting research there are differences in average equivalence, then it was not caused by students' initial mathematical abilities but it was caused by the provision of learning models.

3.1.1. Analisis Descriptive Analysis of Mathematical Strategic Thinking Ability (MSTA)
Analysis of student MSTA data obtained through pre-test and post-test, then the normalized gain (N-gain) was calculated. This data was analysed descriptively based on the gender factors of students (male, female) and research groups (EG, CG). The results of the MSTA descriptive analysis based on gender and learning groups are presented in Table 4 below.

Table 4 MSTA Data Description Based on Gender and Research Groups

Gender	Statistics Descriptive	Pre-test EG	Post-test EG	N-*gain* EG	Pre-test CG	Post-test CG	N-*gain* CG
Male	Sample Size	35	35	35	37	37	37
	Average	116.4	237.9	0.68	116.0	225.7	0.60
	Standard Deviation	26.56	37.07	0.15	25.21	31.17	0.13
Female	Sample Size	35	35	35	33	33	33
	Average	118.6	244.3	0.71	118.9	234.9	0.66
	Standard Deviation	23.56	31.41	0.15	23.20	31.68	0.15
Combination	Sample Size	70	70	70	70	70	70
	Average	117.5	241.1	0.69	117.86	230.0	0.63
	Standard Deviation	24.95	34.26	0.15	24.13	31.52	0.14

Note: the ideal score (maximum) of a MSTA student test is 300

Table 4 shows that there was an increase in MSTA students in the experimental and control groups, both male and female students and overall students. The increase in the average KBSM descriptively occurred in students who received QBCPS and direct learning with the same relative magnitude for each gender. The increase in the average KBSM for all research groups, both men and women, and their combinations ranged from 0.60 to 0.69 which is in the moderate category [13]. Specifically for the increase in the average MSTA of female students in the experimental group, the amount was 0.71 which was classified as high [13].

3.1.2. Inferential Analysis of Mathematical Strategic Thinking Ability (MSTA)
Data analysis was continued with an inferential test for the improvement of students' MSTA in both learning groups based on a combination of all samples and gender. Statistical tests of the increase in the average MSTA used pre-test and post-test data. Pre-test and post-test data groups which are both normally distributed are Paired-Samples T-Test or One-way Anova, whereas for pre-test and post-test data pair groups that are both not normally distributed using the Wilcoxon Signed-Rank Test Test). The results of the MSTA's increase statistical tests of the two research groups based on gender and overall students are shown in Table 5 below.

Table 5 Test Results for Improvement of MSTA in Research Groups Based on Gender and Overall Students

| Gender | Class | N | Statistic Test | | | | |
| | | | Mann Whitney Test | | t Sample Independent Test | | |
			Z	Asymp. Sig. (2-sides)	t	db	Sig. (2-sides)
Male	EG	35	-5.169	0.000			
	CG	37	-5.320	0.000			
Female	EG	35			-38.753	34	0.000
	CG	33	-5.022	0.000			
Combination	EG	70	-7.289	0.000			
	CG	70	-7.286	0.000			

The statistical test results in Table 5 show that each sample group has an Asymp value. Sig. and Sig. less than 0.05, which is 0.000. This means that there is a significant increase in MSTA for each research group (experimental and control) and for each gender (male and female).

Then the difference in the MSTA increase in the two learning groups was conducted and based on gender. MSTA data used is normalized data gain (N-gain). The results of statistical tests of differences in the increase in MSTA based on learning groups are shown in Table 6 below.

Table 6 Difference Test Results for Increased MSTA Based on Learning Groups

Learning Groups	N	*t-test*	*Sig.*
QBCPS	70	2.577	0.011
Direct Learning	70		

MSTA difference test results in Table 6 shows the value of Sig. both learning groups are less than 0.05, which is 0.011. This means that there is a significant difference in the increase in MSTA between groups of students who get QBCPS learning with direct learning. Because the average value of MSTA students who received QBCPS learning was greater than direct learning, it was generally concluded that the increase in students' MSTA who received QBCPS learning was significantly higher than direct learning.

The results of statistical tests of differences in the improvement of MSTA based on gender and learning groups are shown in Table 7 below.

Table 7 Difference Test Results of MSTA Improvement Based on Gender and Learning Groups

Learning Groups	Mean Rank	Kruskal-Wallis	Sig.
QBCPS Male	76.40		
Direct Learn Male	56.36	8.50	0.033
QBCPS Female	82.86		
Direct Learn Female	66.98		

The test results in table 7 show a Sig value of less than 0.05, so in general it can be concluded that there is a significant difference in the improvement of CBC in terms of gender and learning groups. Furthermore, to find out which groups are different, it is necessary to carry out further Kruskal-Wallis tests. The hypothesis formula tested is as follows.

H_0: There is no difference in the increase in average MSTA rank in terms of gender and groups of students who get QBCPS and direct learning.

H_1: There is a difference in the increase in the average rank of MSTA in terms of gender and groups of students who get QBCPS and direct learning.

The test criteria are based on the difference in the mean rank of the gender pairs and the learning groups with their critical values. If the mean rank difference is smaller than the critical value, then H_0 is accepted. Conversely, if the mean rank difference is greater than the critical value, then H_0 is rejected. The recapitulation of MSTA paired test results based on gender and learning groups is presented in Table 8 below.

Table 8 Recapitulation of MSTA Paired Test Results Based on Gender and Learning Groups

Pairs	Mean Rank Deviation	Critical Value	Interpretation
$|\overline{R_1} - \overline{R_2}|$	6.46	12.833	Accept H_0
$|\overline{R_1} - \overline{R_3}|$	20.04	13.018	Reject H_0
$|\overline{R_1} - \overline{R_4}|$	9.42	12.657	Accept H_0
$|\overline{R_2} - \overline{R_3}|$	26.49	13.018	Reject H_0
$|\overline{R_2} - \overline{R_4}|$	15.87	12.657	Reject H_0
$|\overline{R_3} - \overline{R_4}|$	10.62	12.854	Accept H_0

Note: R1 = male QBCPS group, R2 = female QBCPS group, R3 = male PL group, R4 = female PL group

MSTA paired test results based on gender and learning groups in Table 8 concluded that between male and female students who received QBCPS learning, there were no significant differences in the increase in MSTA rankings. Similarly, between male and female students who received direct learning, there was no significant difference in the increase in the average MSTA rank. These shows that gender does not affect the increase in student KBSM.

Different results for testing between male students who get QBCPS learning with direct learning, there is a significant difference in the increase in the average MSTA rank. Likewise, female students who received QBCPS learning with direct learning, and between female students who received QBCPS learning and male students who received direct learning. All of them there are significant differences in the average increase in MSTA rank. However, between male students who received QBCPS learning and female students who received direct learning there was no significant difference in the increase in the average MSTA rank. This shows that the learning model influences the improvement of students' MSTA. In general, the results of the test differences in the improvement of MSTA can be concluded that the gender of students does not affect the increase in MSTA. However, the increase in student MSTA is influenced by the learning model used.

3.2. Discussion

Based on the results of descriptive and inferential data analysis, there is a significant increase in MSTA for all students and for each gender, both for QBCPS learning (experimental group) and direct learning (control group). This means that learning activities in the two research groups have been able to stimulate the development of student's MSTA. This situation is a natural thing as an effect of the learning process.

The results of the statistical tests in Table 7 show that there is a significant difference in the increase in MSTA between groups of students who received QBCPS and direct learning. Because the average value of MSTA students who received QBCPS learning was greater than direct, it was generally concluded that the increase in MSTA students who received QBCPS learning was significantly higher than direct learning.

MSTA improvement in terms of gender and learning groups, statistically, there are significant differences. Based on the results of the Kruskal-Wallis test, it was concluded that between male and female students who received QBCPS learning, there was no significant difference in the increase in the average MSTA rank. Likewise, male and female students who received direct. This means that gender does not significantly influence the increase in student's MSTA. This is in line with the conclusion of Linn and Hyde that the difference between male and female students is very small, so it can be ignored [10]. This condition is the impact of teachers who have implemented the learning process by not differentiating the treatment of male and female students. The assignments given are the same between male and female students.

Furthermore, there is a significant difference in the increase in the average KBSM rank between male students who get QBCPS learning and direct. Likewise for female students who get QBCPS learning with direct, there is a significant difference in the increase in the average MSTA rank. This shows that the learning model influences the improvement of students' MSTA. In general, the results of the test differences in the improvement of KBSM can be concluded that the gender of students does not affect the increase in KBSM. However, the increase in student KBSM is influenced by the learning model used.

KBSM improvement through QBCPS learning is higher than PL. This is due to the QBCPS learning process inviting active students in problem solving which is carried out in a pleasant learning atmosphere. Through QBCPS learning students are invited to solve mathematical problems creatively, so they can make the right decisions. Students learn by collaborating and working together in small groups conveying creative ideas solving mathematical problems. This can make students motivated to think.

The teacher's role in learning is only as a facilitator that guides students to develop their thinking skills independently. Guide students to find out what they have learned. The success of a learning process is strongly influenced by the potential of all those involved in the interactions created in the classroom. The higher the potential of all involved and the more optimal the interaction activities in the learning process with a conducive and pleasant atmosphere, the higher the effectiveness of the learning process that occurs. Riegeluth views, the effectiveness of learning is usually measured by the level of student achievement towards learning goals that have been set [3].

4. Conclusion

Based on data analysis and discussion of the results of research previously described, the following conclusions are obtained:
  a. The improvement of MSTA was not influenced by the gender of students, but was influenced by the learning model used, namely quantum based on creative problem solving and direct learning.
  b. Improvement of MSTA's male and female students who learned through QBCPS learning and who through direct learning there was no difference.
  c. The increase in MSTA's male students who learn through QBCPS learning is higher than male students who learn through direct learning.

d. The increase in MSTA's female students who learn through QBCPS learning is higher than female students who learn through direct learning.
e. The increase in MSTA of students who get quantum learning based on creative problem solving is higher than students who get direct learning.

References

[1] Liedtka J M 1998 Strategic Thinking: Can it be taught? *Long range planning* **31(1)** 120-129
[2] Schoenfeld A H 1992 Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics In D Grouws (Ed.), *Handbook for Research on Mathematics Teaching and Learning* (New York: MacMillan) pp 334-370
[3] Uno H B 2007 *Learning Models Create Creative and Effective Teaching and Learning Processes* (Jakarta: PT. Bumi Aksara) p 138
[4] Heracleous L 1998 Strategic Thinking or Strategic Planning? *Long Range Planning* **31(3)** 481-487, http://doi.org/10.1016/S0024-6301(98)80015-0.
[5] Haycock K, Bluestone K, & Cheadle A 2012 Strategic thinking: Lessons for leadership. *Library Leadership and Management*, **26**(3/4).
[6] Chevallier A 2016 *Strategic Thinking in Complex Problem Solving* (America: Oxford University Press) p 289
[7] Amir Z and Risnawati 2016 *Psychology of Mathematics Learning* (Yogyakarta: Aswaja Pressindo) p 8
[8] Sudarman S W and Vahlia I 2016 Effectiveness of the Use of Quantum Learning Learning Methods on the Ability to Understand Mathematical Concepts of Students in Mathematics *Edu. J.* **7(2)** 275-282
[9] Julita 2017 The Enhancement of Mathematical Problem Solving Ability of Senior High School Students Through Quantum Learning *J. Math. Edu.* **6(1)** *DOI 10.22460/infinity.v6i1.238.*
[10] Arends R I 2013 *Learning to Teach, Learning to Teach. Ninth Edition of Book One*. Translator: Made Frida Yulia (Jakarta: Salemba Humanika) p 81
[11] Ary D, Jacobs L C, and Sorensen C K 2010 *Introduction to Research in Education: Eight Edition* (Wadsworth, Cengage Learning) p 316
[12] Ruseffendi E T 2010 *Fundamentals of educational research and other non-exact fields.* (Bandung: Publisher Tarsito) pp 52–94
[13] Hake R R 1998 Interactive engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses *American J. Phys.* **66** 64 –74