



Mathematics Critical Thinking Skills based on Learning Styles and Genders on *Brain-Based Learning* Assisted by *Mind-Mapping*

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Abstract

Critical thinking skill in mathematics aims to sharpen calculating skill. It is also to develop higher order critical thinking, such as critical thinking skill. This research aims to find mathematics critical thinking skill patterns based on *gender* and learning styles: visual, auditory, and kinesthetic. This qualitative method research used sampling technique by using *purposive sampling* based on *gender* and high score achievement from each learning style classification of eighth graders of a Junior High School in Semarang. The research instruments cover learning style assessment, mathematics critical thinking skill test, and interview guideline. The findings concluded that male and female students' mathematics critical thinking skills with visual, auditory, and kinesthetic styles were varied. There were found male and female students with visual, auditory, and kinesthetic styles whose different critical thinking skills in interpreting, analyzing, evaluating, concluding with excellent, sufficiently excellent, and poor categories.

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INTRODUCTION

The importance of critical thinking skill in mathematics is supported by various studies reviewing on critical thinking skills. Kalelioglu & Gilbahar (2013), Gueldenzoph dan Snyder (2008), Facione (2015) and Aizikovitsh-Udi & Cheng (2015) stated that critical thinking skill is an important component to have by each 21st individual. It is also supported by Svecoba *et al* (2013) stating the importance of developing critical thinking skill in learning process. Then, it is reasserted by Chukwuyenum (2013), Peter (2012), and Jacob (2012) whom concluded that effective learning process for students referred to learning which developed thinking skill, moreover critical thinking skill.

According to Peterson & Fennema (in Happy & Widjajanti, 2014), students during mathematics lesson only used 15% of their time to learn developing higher order thinking skill, 62% were used to develop lower order thinking skill, while 13% were used to learn any irrelevant matter to mathematics. It is in line with *Trends in International Mathematics and Science Study* (TIMSS)'s research, as stated by Mullis *et al* (2012) that in 2011 Indonesia was reported to be at 39th rank concerning with mathematics from 43 countries. According to *Program for International Student Assessment's* report (PISA) in 2015, Indonesia was in 67th rank from 72 countries participating in mathematics problem solving competition which required higher order thinking skill. It showed that Indonesian students still had lower critical thinking skills.

It still remains as problems for Indonesia education that in reality most of students do not like mathematics. Lestari (2014), Wulandari (2014), Nahdi (2015), and Prayogi & Widodo (2017) found that students' mathematics critical thinking skills were still low. The problem was due to students had not understood completely how real thinking worked and the delivered mathematics concept by teachers.

Based on observation and interview in a Junior High School in Semarang, February 2019, it was found that one of difficult materials in mathematics for students was geometry. The underlying factors were abstract problems given by teachers, having difficulties in understanding a story question, requiring time to think logically and scientifically in understanding questions, requiring carefulness in answering the questions, irrelevant learning to daily life problems, and lacking of interest to study calculation. Based on the observation, it

was found that students still had poor higher critical thinking skill.

Effort to improve the students' mathematics critical thinking skills could be done by creating proper learning situation for students' learning styles. Each student has his own learning ways in which it is something supporting learning process when he obtains information assisted by modality. It is the easiest way for student to absorb information which is mostly dominated by brain which regulates and process information. Deporter & Hernacki (2015) classified learning styles into 3 types: visual, auditory, and kinesthetic.

Dimayanti & Paritis (2012) in their research stated that male and female students had strong correlation between learning style in understanding each main information in learning mathematics. *Gender* or sex type means difference os male and female biologically, socioculturally, and psychologically (Alifani, Suyitno, & Supriyadi, 2018). Female students tend to have low motivation in studying mathematics than male students in which influence their mathematics learning outcomes (Gross & Thompson, 2007). The difference may turn oppositely in other researches which stated that male students would have lower or equal mathematics achievement to female students. Therefore, there is strong correlation between learning style and gender which influence learning outcomes.

On research study, it is mentioned that low learning and thinking interests of students are caused by not optimal brain functions. During inputing memory process, human requires to activate right and left hemisphere functions. Thus, there is brain equilibrium in receiving each information. Such character learning could be implemented into *Brain - based learning* model which offers an adjusted learning concept to brain's work and learn scientifically so it provides mathematics learning impression for students whom usually memorize. They will turn such habit into meaningful learning (Lestari, 2014; Caine & Caine in Sucoko, 2016).

It is in line with Wisudawan & Anggaryani (2014). It concludes that the use of *Brain-based learning* model could improve students' critical thinking skills which are influenced by six activities as stated by Jensen, a brain - based learning expert. They are physical movement, relaxation, environment, emotion, music, and motivation. Dewi & Masrukan (2018) showed that students argued learning entailed by music provided positive impact and spirit to learn a certain material. Wulandari (2014) and Nahdi (2015) who concluded that

students' learning outcome improvements after being intervened by *Brain - based learning* were better than those taught by lecturing.

Brain-based learning model is innovated by assistance of learning media which have same purposes to optimize right and left hemispheres' performance. It is by *mind-mapping*. Georgi Lozanov (in Jensen, 2011) reported that five hundred subjects exposed by this technique showed better memory than those taught without using color codes. Thus, it is complemented by using *mind-mapping* learning which adjusts learning styles and optimizes brain performance through *Brain - based learning*.

This research refers to Facione critical thinking indicators (2015). They are *interpretation, analysis, evaluation, inference, explanation, and self-regulation*. In this research, only four indicators were used: *interpretation, analysis, evaluation, and inference*. The researcher used Facione's critical thinking skill indicators by considering that many previous studies had not implemented these indicators, such as Zhou, Huang, & Tian (2013), Chukwuyenum (2013), Fitriyah, Sa'dijah, Sisworo (2016), and Hidayati (2016).

This research aims to describe mathematics critical thinking skills based on learning styles and *genders* on *brain-based learning* assisted by *mind-mapping*

METHOD

This research used qualitative methodology. The researcher revealed phenomenon of the students' mathematics critical thinking skill based on learning styles and *genders* which covered critical thinking skill, learning style classifications, and gender types as well as behavior, perception, or action. The results were described into findings in the form of words and standardized language by using various scientific methodologies (Moloeng, 2009).

This research was carried out at a Junior High School in Semarang, academic year 2018/2019. There were 36 subjects of VIII class. The technique of sampling is *purposive sampling*. It was done by determining the subjects based on male and female learning styles.

Techniques of collecting data were test and non-test. The test technique consists of mathematics critical thinking skill test while the non-test technique consists of learning style assessment scale and interview. The interview was grouped based on learning styles: visual, auditory, kinesthetic and *gender* to investigate deeper on how mathematics critical thinking skills based on male

and female learning styles. Qualitative data analysis is based on Miles, Huberman, & Saldana (2014) with three activity plot occurring simultaneously. The data analysis in this research was done through data condensation, display, and conclusion.

FINDINGS AND DISCUSSION

Findings

The whole research result data presented in Table 1.

Table 1. Percentage of Mathematics Critical Thinking Skills

Indicators	Percentage of each mathematics critical thinking skill question number (%)				
	Question-				
	1	2	3	4	5
Interpretation	26.6	28.7	30.2	32.2	31
Analysis	25.8	27.6	26.5	29	28.4
Evaluation	26.2	23.6	23.3	23	22.7
Inference	21.5	20.1	29.9	15.8	17.8

Indicators and sub-indicators of critical thinking skill based on Facione (2015). They are:

Interpretation

Student's skill to understand and express definition of mathematics question problem. Students are expected to be able to write and identify elements, questioned problems, and solution of mathematics problems.

Analysis

Student's skill in clarifying conclusion and mathematics question problems based on connections among information, question, and concept. Students are expected to be able to write concerning concepts to solve and write solution answers.

Evaluation

Student's skill in judging credibility, representation, and assessing logically about connection of information, question, and solution concepts. Students are expected to be able to evaluate their solution answers.

Inference

Student’s skill in identifying elements to create rational conclusion by considering relevant information.

Based on Table 1, it will be analyzed further in term of mathematics critical thinking skill of each indicator which is represented by qualitative research subjects based on learning styles and *gender*. Then, the analysis result could be generalized toward all subjects.

Here is the data analysis done toward 36 students of experimental group. It is obtained subject detail as follows.

Table 2. Subject Learning Style Achievements

Learning Style	Male	Female	Total
Visual	4	12	16
Auditory	4	3	7
Kinesthetic	5	2	7
Mixed	6		6
Students’ Numbers			36

The subjects were selected based on student learning style inventory result continuously and based on their most appearing scores. Based on the analysis of learning style assessment scale, there were 12 subjects to be investigated further in term of their mathematics critical thinking skills. Here is the table of student learning style based on highest learning style assessment scale score.

Table 3. Research subjects based on Learning Styles and genders

Learning Style	Male	Female
Visual	VM-13, VM-30	VF-07, VF-17
Auditory	AM-34, AM-35	AF-03, AF-36
Kinesthetic	KM-08, KM-33	KF-12, KF-32

The subjects were selected before providing the learning by *brain-based learning* assisted by *mind-mapping*. It was done to analyze mathematics critical thinking skills of learning style possibilities which they had previously. Here are the descriptions of mathematics critical thinking skills of students based on learning styles of five test questions arranged. On each question, there are four indicators of critical thinking skills.

Male Students’ Skills with Visual Learning Styles

Conclusion of male critical thinking skills with visual learning style, shown in Table 4.

Table 4. Conclusion of Male Visual Typed Critical Thinking Skill Result

Male	Indicators			
	Interpretation	Analysis	Evaluation	Inference
VM-13	Excellent	Sufficient	Sufficient	Sufficient
VM-30	Sufficient	Excellent	Sufficient	Sufficient

On *interpretation* indicator and analysis of VM-13 and VM-30 subjects, they were able to interpret and analyze properly and sufficiently. Meanwhile, dealing with *evaluation* and *inference* indicators, VM-13 and VM-30 subjects could evaluate and conclude properly.

Both subjects, VM-13 and VM-30 with visual learning styles, had same characteristics in solving a problem. It could be seen based on analysis of VM-13 and VM-30 works that students’ characteristics with visual learning style is - they could solve problems systematically and clearly. VM-13 preferred to illustrate tidily so he had been habituated to illustrate first.

Based on the critical thinking skill recapitulation, it could be concluded that male visual typed critical thinking skill in solving the faced problems showed abilities, such as being able to interpret, analyze, evaluate, and conclude properly.

Female Visual Typed Learning Style Skill

Conclusion of female critical thinking skills with visual learning style, shown in Table 5.

Table 5. Conclusion of Female Visual Typed Critical Thinking Skill Results

Female	Indicators			
	Interpretation	Analysis	Evaluation	Inference
VF-07	Excellent	Excellent	Sufficient	Sufficient
VF-17	Excellent	Excellent	Sufficient	Sufficient

Dealing with interpretation and analysis indicators, VF-07 and VF-17 subjects could interpret and analyze properly. Meanwhile, dealing with evaluation and inference indicators, VF-07 and VF-17 subjects could evaluate and conclude properly.

Both subjects with visual learning style had same characteristics while creating problem solution. The visual typed female students could write the solution systematically and clearly. Based on the analysis, it could be concluded that visual typed female learning style skill in answering the solution was realized into interpreting and analyzing properly. They also could evaluate and conclude properly.

Male Students’ Skills with Auditory Learning Styles

Conclusion of male critical thinking skills with Auditory learning style, shown in Table 6.

Table 6. Conclusion of Male Auditory Typed Critical Thinking Skill Results

Male	Indicators			
	Interpretation	Analysis	Evaluation	Inference
AM-34	Sufficient	Sufficient	Insufficient	Insufficient
AM-35	Excellent	Sufficient	Excellent	Insufficient

On *interpretation* indicator, AM-34 and AM-35 subjects were able to interpret, analyze, and evaluate properly. Meanwhile, dealing with second indicator, they were not found excellent.

Both subjects, AM-35 and AM-34 with audio learning styles, had same characteristics in solving a problem just like visual typed students did. It could be seen based on analysis of AM-35 and AM-34's works that students’ characteristic with auditory learning style is - they could write problems systematically and clearly. However, they did not do it completely and tidily. Based on the analysis, it could be concluded that auditory typed male learning style skill in answering the solution was realized into interpreting and analyzing properly. They also could evaluate and conclude properly.

Female Auditory Typed Learning Style Skill

Conclusion of female critical thinking skills with Auditory learning style, shown in Table 7.

Table 7. Conclusion of Female Auditory Typed Critical Thinking Skill Results

Female	Indicators			
	Interpretation	Analysis	Evaluation	Inference
AF-03	Sufficient	Insufficient	Insufficient	Insufficient
AF-36	Excellent	Sufficient	Sufficient	Sufficient

On *interpretation* indicator, AF-03 should be able to interpret properly and AF-36 could interpret well. On *analysis, evaluation, and inference* indicators, AF-03 did not do it properly. Meanwhile, AF-36 subjects could do it properly.

Both female subjects with auditory learning style had similar characteristics. They liked to tell stories in detail. When they were telling, the subjects liked to imitate the styles and tones of the speaking persons. In understanding and solving mathematics problem, especially story question, the subjects were slow to understand and they were not carefully calculating. They were in rush in understanding the information so it influenced to their problem solving progress process.

Based on the analysis, it could be concluded that auditory typed male learning style skill in answering the solution was realized into interpreting and analyzing properly. There were also found students analyzing, evaluating, and concluding insufficiently.

Male Students’ Skills with Kinesthetic Learning Styles

Conclusion of male critical thinking skills with Kinesthetic learning style, shown in Table 8.

Table 8. Conclusion of Male Kinesthetic Typed Critical Thinking Skill Results

Male	Indicators			
	Interpretation	Analysis	Evaluation	Inference
KM-08	Sufficient	Sufficient	Excellent	Sufficient
KM-33	Sufficient	Excellent	Sufficient	Sufficient

On *interpretation* indicator, KM-03 should be able to interpret properly and KM-36 could interpret well. On analysis and evaluation indicators, both subjects could analyze and evaluate properly. Dealing with inference indicator, both subjects could conclude well.

Both male kinesthetic typed students in their critical thinking skills tended to have similar information understanding. It was illustrating by using finger movement or imagining by looking above at something. Dealing with carefulness, their works were more detail and careful especially in writing the answers done by KM-33. Meanwhile, KM-35 felt bored to sit longer so the works of critical thinking skill questions had not been completely answered.

Based on the analysis, it could be concluded that male kinesthetic typed learning style students in solving problems were found to be able in interpreting, analyzing, evaluating, and concluding properly.

Female Kinesthetic Typed Learning Style Skill

Conclusion of female critical thinking skills with Kinesthetic learning style, shown in Table 9.

Table 9. Conclusion of Female Kinesthetic Typed Critical Thinking Skill Results

Female	Indicators			
	Interpretation	Analysis	Evaluation	Inference
KF-12	Excellent	Sufficient	Sufficient	Sufficient
KF-32	Excellent	Sufficient	Sufficient	Sufficient

On *interpretation* indicator of critical thinking skill, KF-12 and KF-32 subjects could interpret well. Dealing on *analysis, evaluation, and inference*, KF-12 and KF-32 could do it properly.

Male subjects with kinesthetic learning style quickly and easily understood. They did it by moving his bodies, such as playing their fingers, hands, and feet. Because by doing so, it would ease them to get the information. In writing the answer, KF-12 was more careful toward the details than KF-32. However, KF-32 in solving the illustration was done by using figure to understand.

Based on the analysis result, it could be concluded that female students with kinesthetic style, in solving problems, were found to have better interpretation. There were also found some of them did it well in analyzing, evaluating, and concluding.

Discussion

This qualitative research was done to describe students' mathematics critical thinking skill based on learning styles and *gender*. Several experts concluded

that learning style is an individual's ways to learn based on his own characteristics in getting, regulating, and processing information as an effort to improve learning quality so it will have improved learning outcomes. According to Gilakjani (in Apipah & Kartono, 2017), classification of visual, auditory, and kinesthetic learning is important in supporting correct, quick, and easy learning ways in understanding something.

Students' skill in solving problem could be seen from their independence, students could solve without controlling the other while improving their critical thinking skills. However, when students felt not to be able to solve the problem, they were also brave to express the problems and ask the teachers of those whom are eligible. It is in line with Sundayana (2016), Malyetri & Ansofino (2014) stating that mathematics problem solving has connection between independent learning and learning style which influence students' critical thinking skills. If learning style becomes an important thing to consider during learning at school, it will provide good impacts to improve students' concentration so that they could understand lots of information from what they learn.

Based on the description, it could be known that students mostly were found superior on *interpretation* and *analysis* indicators. Students could identify the known information and understand the problems to be solved from the question. Then, there were found many students being capable in clarifying conclusion from mathematics question problems based on information - question connection with appropriate answer writing based on solution concept.

The findings of this research, which needed to be improved, were solution on *evaluation* and *inference* indicators because from those five given questions, most students were not capable to evaluate and conclude. The *evaluation* stage, which is expected for the students, is to make them able in writing the solution carefully and correctly. They are expected to be able to assess credibility and access information into solution answers. There were also found students insufficiently excellent in evaluating and in creating *inference*. In these indicators, most students did not write the conclusion based on the connection of problem question and student answer results. There were also many of them writing incomplete conclusion or even irrational conclusion without considering relevant information.

The description of students' critical thinking skill showed that male visual typed critical thinking skills were found to be capable in interpreting and analyzing properly. There were also found individuals with proper evaluation and conclusion. Then, female visual typed learning style showed excellent skills on interpreting and analyzing. There were also some of them found sufficiently excellent in evaluating and concluding.

Male auditory typed learning style was found better in interpreting and analyzing. There were also some of them excellently and sufficiently excellent in evaluating and concluding. Then, female auditory typed learning style students were found excellent, sufficiently excellent, and insufficient in interpreting, analyzing, evaluating, and concluding.

Male kinesthetic typed learning style students were found excellent and sufficiently excellent in interpreting, analyzing, evaluating, and concluding. Finally, female kinesthetic typed learning style were found sufficiently excellent in interpreting, analyzing, evaluating, and concluding.

CONCLUSION

Based on the findings, it was found that male and female students with visual, auditory, kinesthetic learning styles were able to interpret and analyze but the evaluation and conclusion were not optimal. Therefore, there is a need a strategy to develop skills in evaluating and concluding by giving more critical thinking skill questions which emphasize on *evaluation and inference*.

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