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Mathematics Critical Thinking Skills Reviewed by Cognitive Styles and IQ on *Discovery Learning* with SPUR Approach

Siti Riyadhotul Janah✉, Hardi Suyitno, Isnaini Rosyida

Universitas Negeri Semarang, Indonesia

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Abstract

The role of mathematics is to prepare students facing fast - growing challenges of 21st century. The required competence to master is such as critical thinking skill. This research aims to find out mathematics critical thinking skill pattern reviewed by cognitive styles and IQ on *Discovery Learning* with SPUR approach. This *mixed method* research used *sequential explanatory.* The population of this research consisted of seventh graders of Junior High School 2 Demak in academic year 2018/2019. The technique of sampling is *purposive sampling* based on cognitive styles and IQ of seventh graders from A class at Junior High School 2 Demak. The findings showed that mathematics critical thinking skills of students of categories, such as reflective, impulsive, slow and inaccurate, quick and accurate with normal, beyond normal and brilliant IQ levels showed various results. It was found reflective - impulsive, slow and inaccurate, quick and accurate with normal, beyond normal, and brilliant IQ levels whom in interpreting, analyzing, evaluating, and concluding did it very excellently, excellently, sufficiently excellent, and insufficiently. Thus, teacher must consider students' cognitive styles in learning mathematics because there are several discrepancies of students' problem solving ways.

✉Correspondence:
Jl. Kelud Utara 3 Kampus Pascasarjana UNNES Sampangan Semarang, Indonesia, Indonesia
E-mail: sitiriya0@gmail.com

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INTRODUCTION

Critical thinking is a directed process used in mental activity, such as problem solving, making decision, persuading, analyzing assumption, and conducting scientific research (Johnson & Elaine, 2009). Critical thinking is a self-regulation in deciding something which leads to interpretation, analysis, evaluation, inference, or explanation which require evidence, concept, methodology, criteria or contextual consideration as basis to create decision (Facione & Peter, 2015).

Critical thinking is an important component to own by each student because by the fast growing development of technology and economy, individuals are required to think critically. They are not only receiving information but also screen the information and search the cause and the evidence logically and rationally (Firdaus *et al,* 2019). Critical thinking skill could be developed by providing problem and question which are investigating in nature so it triggers them to solve problem and make decision based on investigation (Iavokos & Tsiplakides, 2011).

Wijaya (2011) stated that a third of Indonesian learners, 33.1%, only could work on questions if all required information were given. Only 0.1% of them could work on a mathematics model which required critical thinking skill. It is in line with Kurniasih (Rifqiana, Masrukan., & Susilo*,* 2016) that Indonesian learners could only recognize meanwhile Taiwan learners had been able to think higher. This low critical thinking skill of learners becomes a crucial problem in mathematics education.

Survey result of Public Junior High School 2 Demak showed that the students' mathematics critical thinking skills on one variable linear equation were still low because their mathematics critical thinking skill average score was 59.63. Thus, the researcher is interested to analyze students' mathematics critical thinking skills as how the role of mathematics is. It is to prepare students facing fast-growing live challenges in 21st century as one competence to be mastered. It is critical thinking skill (Kivunja & Charles, 2015).

Critical thinking skill implementation in a mathematics lesson does not only create critical thinking students in solving problem but also to empower their memories about what they have learned (Noor, 2019). Considering mathematics critical thinking skill is a skill to have by students, then it is important for teachers to follow up in determining appropriate strategy to develop students' critical thinking skills. One of them is by *Discovery Learning* with SPUR approach. *Discovery learning* provides freedom for students to think critically in which in that stage, students solve problems and conclude independently, directionally, and clearly. It assists them to have curiosity because in the implementation, the students are invited to find various theories and concepts by themselves (Afrida, Sugiarto., & Soedjoko, 2015).

The strength point of *Discovery Learning* may cover: (1) facilitating students to revise and improve their skills and cognitive processes, (2) obtaining knowledge through this model is personal in nature and strengthens students' definitions, memories, and transfer, (3) being able to improve students' skills in solving problems, (4) facilitating students to strengthen their self-concept, (5) motivating students' active participations, (6) encouraging students to think intuitively and formulate hypothesis by themselves, (7) training students to be independent, (8) making them active in learning because they will think and use their skill to determine the final results. By having *Skill, Property, Use,* and *Representation* (SPUR), it trains students to be skillful in utilizing, applying, and representing mathematics (Thompson & Bleiler*,* 2013).

In actual field, there are still many students utilizing their memories in working on mathematics questions so there are many of them have not been done correctly in committing *property* approach. Thus, to create mathematics critical thinking skill, such students are still incapable. Other factors influencing thinking ways of students is cognitive style and IQ. It is in line with Peker (2009) that in-class learning is influenced by learning style. Learners' ways in learning to understand and elaborate problems, mostly are depended on correlated formation of personality and cognition, in which are called as cognitive styles. Cognitive style is an individual's ways in obtaining and processing information inside of his brain (Hidayat, Siti., & Yusuf*,* 2017).

Students' cognitive styles are considered excellent if students like challenging problems and involve them directly to find or solve problems. Based

on the explanations, it could be concluded that cognitive style is a determinant factor of students' learning mathematics successes. Besides cognitive style, intelligence also influence the speed of knowledge acceptance. Guilford (1982), *Intelligence Quotient* is a score obtained from intelligence test by measuring convergent critical thinking process. It is a skill to provide a logic answer or conclusion based on given information. Intelligence is a basic factor predicting academic achievement at school and is an important role in influencing students' successes in the future (Anggi, 2015). Learners whose high intelligence will receive and understand the materials given by teachers easily (Putra & Wulan, 2015).

Based on observation at Junior High School 2 Demak, the students' IQs were classified into *superior, bright normal,* and *average* so there is a need of researcher to take those with *bright normal,* average, and superior levels. Based on cognitive style results, it showed that most students tended to have reflective-impulsive cognitive style. They were active in answering the questions quickly but the answers were not always correct. Thus, this style is called as impulsive cognitive. There were also some of them taking time in answering but they had correct answers. This is called as reflective cognitive style (Warli, 2012).

Based on the background, this research aims to (1) test students' mathematics critical thinking skills in achieving accomplishment on *Discovery Learning* with SPUR approach, (2) test students' mathematics critical thinking skills taught by *Discovery Learning* with SPUR approach were higher than those taught by PBL, (3) describe mathematics critical thinking skill of learners reviewed by cognitive style and IQ.

METHOD

This mix method research used sequential explanatory design. Sequential explanatory is research design which requires researcher to conduct qualitative phase. Then, it is continued by exploring qualitative data from IQ score and MFFT results of the students. Then, it is continued by quantitative as the second phase (Creswell, 2016).

This research was carried out at JUNIOR HIGH SCHOOL 2 Demak with population taken from seventh graders of the school in academic 2018/2019. The sample was random sampling to select. It was obtained VII A students as experimental group and VII B students as control group. The students in this research were taken by purposive sampling. There were 12 students of VII A, representing 32 students whom would be interviewed based on cognitive styles and IQ. They were classified into 7 reflective cognitive students with average IQ, 10 impulsive cognitive students with average IQ, 3 reflective cognitive students with bright normal IQ, 5 impulsive cognitive style students with bright normal IQ, 2 reflective cognitive style students with superior IQ, 1 impulsive cognitive style student with superior IQ, 1 slow cognitive style , inaccurate, and average IQ, 1 slow cognitive style, inaccurate, and bright normal IQ, and 2 quick cognitive style, accurate, and average IQ.

The research data sources were from Intelligent Quotient (IQ), Matching Familiar Figure Test (MFFT), and mathematics critical thinking skill test answer scores of the learners. The IQ scores were obtained from counseling teachers and MFFT scores were obtained by giving test. The test had specific features. There were a standard picture and eight various pictures. Seven of the various pictures was different with the content or standard picture. Meanwhile, there was only a picture which was same with the origin. The same pictures to the origins had greater scores and should be sought by learners (Warli, 2013).

This research refers on critical thinking skill indicators of Facione.The consideration was - there were many researches using Facione indicators in measuring critical thinking skills, such as Chukwuyenum & Asuai (2013). In his research titled Impact of Critical Thinking on Performance in Mathematics among Senior Secondary School Students in Lagos State, Kriel & christo(2013) titled Creating a Disposition for Critical Thinking in the Mathematics Classroom. Those six critical thinking skill indicators developed by Facione were focused on four indicators. They were interpretation, analysis, evaluation, and inference (Facione, 2015).

IQ score, MFFT, and learner work sheet were used as qualitative research data source. Meanwhile, mathematics critical thinking skill test was used as quantitative research data. The assessment rubric was used to measure students' mathematics critical thinking skill. Researcher also used rubric from Ismainuza and Musdalifah (2013), each of them had 1 to 5 score scale

interval indicators. 0 score means very poor; 1 means very poor; 2 means sufficient; 3 means excellen. Then, 4 means very excellent. After finding out the score of each learner, then the researcher conducted interview based on each representation of IQ level and cognitive style. The quantitative data test used normality, homogeneity, individual accomplishment, proportional accomplishment, variance comparison tests. The qualitative data analysis was done by data reduction, display, and verification.

FINDINGS AND DISCUSSION

Based on the assessment of the learning process, it showed that mathematics critical thinking skill test result of learners assisted by SPSS that the data was from normal distributed population in which the results were from *Kolmogorov - smirnov* test. It showed Sig > 0.05. The mathematics critical thinking skill result data of both variants were homogeneous in which the result of *Levene* test showed that Sig core > 0.05.

Based on the individual accomplishment test, the obtained average was 71.9. By using SPSS with *One - Sample Test* showed that Sig < 0.000. It means that the average score of mathematics critical thinking of students on *discovery learning* with SPUR approach had passed actual accomplishment threshold 60. The proportional test result obtains z_{hitung} about 2.03 and z_{table}about 1.64. It shows that $z_{count} > z_{(0,5-\alpha)}$. It is concluded that students in *Discovery Learning* with SPUR approach passed the actual accomplishment threshold with 75%.

Based on the calculation of two variance average, it was obtained t_{hitung}5.618 and $t_{(1-\alpha),dk}$2.039. Because it is $t_{count} > t_{(1-\alpha),dk}$, it could be concluded that mathematics critical thinking skill on *Discovery Learning* with SPUR approach obtained higher average score than those taught by PBL.

Based on MFFT, it was obtained 12 reflective cognitive style typed students, 16 impulsive cognitive style typed students, 2 slow cognitive style typed and inaccurate students, and 2 quick cognitive style and accurate students. Here is the categorization of learners seen from cognitive styles and IQ, shown in Table 1.

Table 1. Categorization of Cognitive Styles and IQ of Students

Cognitive Style	IQ	Students' Numbers	Percentage
Reflective	Superior	2	6.25
	Bright Normal	3	9.38
	Average	7	21.88
Impulsive	Superior	1	3.12
	Bright Normal	5	15.63
	Average	10	31.25
Slow and Inaccurate	Superior	-	-
	Bright Normal	1	3.12
	Average	1	3.12
Fast and accurate	Superior	-	-
	Bright Normal	-	-
	Average	2	6.25
Total		32	100

Mathematics Critical Thinking Skill of Learners Reviewed by Critical Thinking Skills and IQ

MFFT and IQ results showed there were 7 reflective cognitive style and normal IQ students. Students with reflective category and average IQ had sufficiently excellent interpretation, analysis, evaluation, and conclusion indicators. Dealing with interpretation indicators, the students were sufficiently able to write information of the questions. Dealing with analysis indicator, the students were sufficiently able to determine initial strategy but when they were not capable to draw the sketch. Dealing with evaluation and conclusion, the students were found to be less capable in solving drawing sketch. However, they could operate the determine strategy.

Mathematics critical thinking skill of 10 impulsive and average IQ typed students showed sufficient performance on interpreting indicator.

However, dealing with analysis, evaluation, and conclusion indicators were still insufficient. Started from interpretation indicators, the students were sufficiently able to write information of the questions. Dealing with analysis indicator, the students were not able to determine the initial strategy for each figure sketch and to change the question into mathematics model. Dealing with evaluation and conclusion, the students were found to be less capable in solving drawing sketch in operating the determine strategy.

Mathematics critical thinking skills of three reflective and bright normal typed students on the indicators were excellent. Dealing with interpretation indicator, the students could write the information from the questions. There were only some of them writing the information incompletely. Dealing with analysis indicator, students could determine initial strategy and change questions into mathematics model. Dealing with evaluation and conclusion indicators, the students could operate the determined concept. However, on figure sketch type, there were still some of them had not been able to do it.

Mathematics critical thinking skill of 5 impulsive cognitive style and bright normal IQ typed students showed sufficient performance on interpreting and analyzing indicators. However, dealing with evaluation and conclusion indicators, they were sufficiently excellent. Dealing with interpretation indicators, the students could write information of the questions. Dealing with analysis indicator, students could determine initial strategy in answering questions. However, they were less able to draw the sketch. Dealing with evaluation and conclusion indicators, the students were sufficiently able to operate the determined strategy.

Mathematics critical thinking skill of 2 reflective and superior IQ typed students showed very excellent performance on interpreting, analyzing, evaluating, and concluding indicators. Overall, dealing with mathematics critical thinking skills, the students could determine information and connect the information, question, and the concept. They also could operate the determined concept orderly and completely.

Mathematics critical thinking skill of 1 impulsive cognitive style and superior IQ typed student showed excellent performance on interpreting and analyzing indicators. However, dealing with evaluation and conclusion indicators, they were excellent. Dealing with interpreting indicator, the students could determine the information completely. However, on evaluation and conclusion indicators, there were some of them writing the information incompletely and not ordered..

Mathematics critical thinking skill of a slow and inaccurate type student with average IQ showed poor performance on all indicators of mathematics critical thinking skills. Started from interpretation indicators, the students were incompletely writing the information of the questions. Dealing with analysis indicator, the students were not able to determine the initial strategy for each figure sketch and to change the question into mathematics model. Dealing with evaluation and conclusion indicators, the students had not been able to draw a sketch. The students were not able to operate the determined concept.

Mathematics critical thinking skill of 1 slow, inaccurate and bright normal IQ typed students showed sufficient performance on interpreting indicator. However, dealing with analysis, evaluation, and conclusion indicators were still insufficient. Dealing with interpretation indicator, the students had not completely determined all information. Meanwhile, dealing with analysis, evaluation, and conclusion indicators, the students could not master them because they were mostly incorrect in determining the concept. Thus, the operation did not run properly.

Mathematics critical thinking skill of 2 students with quick, accurate, and average IQ showed that very excellent performances on interpretation and analysis indicators. Meanwhile, dealing with evaluation and conclusion indicators, the students were not sufficiently excellent because they were not fully operating the determined concepts.

Mathematics critical thinking skill with impulsive cognitive style and average IQ showed that the students could master mathematics critical thinking skill indicators. It is in line with Thomas (Konita, 2017) that: "People who have impulsive cognitive style use short and quick alternatives to accomplish something. They use very short time in responding. However, they tend to make mistake because they do not use all calculation alternatives.

Based on the analysis of the students' worksheets, it showed that Intellectual Quotient (IQ) only slightly influenced skill in solving mathematics

critical thinking skill questions. Gusnawati (2015) stated that intellectual quotient (IQ) only contributed 20% to an individual's success. The other factors are influenced by Emotional Quotient (EQ) with 80%. Therefore, teachers need to consider students' cognitive styles in selecting learning models.

CONCLUSION

It could be concluded that the students' mathematics critical thinking skills reached the accomplishment. It was also found that experimental group was better. Then, 7 reflective and average IQ students had sufficiently excellent performance on mathematics critical thinking skills. Mathematics critical thinking skill of 10 impulsive and average IQ typed students showed sufficient performance on interpreting indicator. However, dealing with analysis, evaluation, and conclusion indicators were still insufficient. Mathematics critical thinking skills of three reflective and bright normal typed students on the indicators were excellent. Mathematics critical thinking skill of 5 impulsive cognitive style and bright normal IQ typed students showed sufficient performance on interpreting and analyzing indicators. However, dealing with evaluation and conclusion indicators, they were sufficiently excellent. Mathematics critical thinking skills of two reflective and superior IQ typed students on the indicators were excellent. Mathematics critical thinking skill of 1 impulsive and superior IQ typed student showed excellent performance on interpreting and analysis indicators. However, dealing with analysis, evaluation, and conclusion indicators were excellent. Mathematics critical thinking skill of one slow, inaccurate, and average IQ typed students on the indicators were insufficient. Mathematics critical thinking skill of 1 slow, inaccurate and bright normal IQ typed students showed sufficient performance on interpreting indicator. However, dealing with analysis, evaluation, and conclusion indicators were still insufficient. Mathematics critical thinking skill of 2 fast, accurate, and average IQ typed student showed excellent performance on interpreting and analysis indicators. However, dealing with analysis, evaluation, and conclusion indicators were sufficiently excellent.

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