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Scientific Approach to Promote Response Fluency Viewed from Social Intelligence: Is It Effective?

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Abstract: This study was aimed at investigating whether or not there is an interaction between learning approach and social intelligence towards response fluency. A number of 126 eighth grade students (M = 13.9; SD = 0.5 years) in Bojonegoro, Indonesia were randomly selected to participate in this study. This research used 2x3 factorial quasi-experiment with the matching static comparison design. The statistical Analysis Of Covariance (ANCOVA) ware implemented for analysis of data in the study. The results show that: there is a significant difference in response to fluency between students who learn with a scientific approach and direct learning approach; there are significant differences in response to fluency between students who have high, medium, and low social intelligence, both in scientific and direct learning approaches, the students with high social intelligence levels have better response to fluency than those with moderate social intelligence or low, and the students with moderate social intelligence have better response to fluency than those with low social intelligence, in all levels of social intelligence, the students who were taught by using scientific approach have better response to fluency than those who were taught by using direct learning approach.

Keywords: *Scientific approach, direct instruction, social intelligence, response fluency.*

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Introduction

The main goals of mathematics learning in the 21st century have 4-Cs characteristics, namely; Communication, Collaboration, Critical Thinking, and Problem Solving, Creativity and Innovation. This is in line with the results of research conducted by more than 250 researchers, the members of the ATC21S (Assessment & Teaching of 21st Century Skills), from 60 institutions worldwide. They grouped 21st-century skills in 4 categories; one of them is creativity (Binkley, et. al., 2012). Creativity is one of the supporting points in developing knowledge and technology in the 21st century. A person who lives in the global society needs skills to develop, act and deliver new ideas to others, open-minded, and responsive towards different new perspectives.

One of the main concerns in mathematics learning in the 21st century is creativity. Creativity provides benefits in the fields of education and economics, supports efforts for personal improvement and fulfillment of social needs (Kampylis, Berki, & Saariluoma, 2009; Marcy & Mumford, 2007). Creativity allows students to effectively solve problems in an educational and personal context. Furthermore, creativity plays a pivotal role in healthy mental status, overcoming change, and emotional growth (Plucker, Beghetto & Dow, 2004; Richards, 2001). Craft (2014) suggests that individuals are facilitated to develop their creative potential and use their creativity to develop other potentials they have.

The structure of the intellectual model from Guilford, which was developed since the 1960s, has until now become the main source of ideas about creativity. Guilford provides an overview of human intelligence which consists of several factors including divergent product operations (divergent thinking) in which the main factors are fluency, flexibility, and elaboration.

Hudgins (1983) provides an explanation of fluency, according to Guilford, by classifying it in three types, namely ideational fluency, associational fluency, and expressional fluency. Ideational fluency is the speed of constructing ideas based on quantity; associational fluency is resolving linkages; it can also be applied in constructing analogies; expressional fluency is the ability to construct sentences.

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A number of studies emphasize fluency as the ability of respondents to give a number of answers correctly. The indicator of fluency that merely considers the time to solve problems is scarce. A study that considers the timing of problem-solving as a fluency indicator was done by Schoenfeld (1992). Meanwhile, the subsequent studies after Schoenfeld's (1992) define fluency as the number of correct answers produced by respondents. This can lead to a similar meaning if it is associated with flexibility so that in this study, fluency was studied more deeply and made a dependent variable.

Students' fluency response is related to learning. A number of studies, such as those conducted by Boyaci, Sahin, Hasirci, & Kilic (2017), Talbert, Hofkens, and Wang (2019), Kilic (2010), Wright (2011), Anyanwu & Fidelia N. Iwuamadi (2015) resulted in the conclusion that student-centered learning provides a better effect on learning. The students are required to be active, creative and innovative in solving life problems. This view is in line with the opinion of Hiebert & Grouws (2007) that from the data collected and analyzed, it turns out that teachers who manage to learn differently will produce different levels of students' learning outcomes. Therefore, teachers need student-centered learning that can effectively develop the potential of students' fluency.

One of the factors that influence the success of the learning process, including fluency, which was proposed by Shah (2010) is a learning approach. Learning approach is rooted in the concept of philosophy and the method of teaching and education strategies. This shows the goals of teaching and its guidelines including knowledge development, repetition and reconstruction, implementation, comprehension and observation in a distinct view and thinking (Dart, et al., 2000). The student-centered approach has become the main concern of the Indonesian government. This is confirmed in the Appendix of the Regulation of Minister of Education and Culture No. 65 in the year 2013 concerning process standards that 'the principle of learning is from students being told to students finding out'. Based on the constructivism theory, learning happens when students construct their own knowledge. The government's expectations regarding the implementation of a constructivist-based approach are outlined in 2013-curriculum by introducing the scientific approach.

The scientific approach is a way of learning to facilitate students to get knowledge or skills with scientific procedures, such as by experimenting or investigating an idea to obtain logical conclusions (Ministry of Education and Culture, 2013; Kurnik, 2008). The steps are observing, questioning, gathering information, reasoning, and communicating (Ministry of Education and Culture, 2013; Hosnan, 2014). Implementing scientific approach in learning is expected to be able to familiarize students with hypotheses and experiment with everything around them. Unfortunately, some teachers are still confused about implementing this approach in class (Mulyasa, 2013).

Based on the results of interviews with several teachers in a mathematics subject teacher meeting in Bojonegoro, Indonesia, 52 out of 100 mathematics teachers had not applied the scientific approach; they used to implement direct learning approach. Azimigaroosi, Zhiean, and Farahmand (2015) concluded in a study that the direct instruction is an educational method in which the teacher communicates the information within definite stages. Direct learning applied in Indonesia is learning where the teacher delivers material directly to students through the opening stages, delivering material, giving examples and giving practice questions.

This study investigated social intelligence as one of the factors that should be considered in learning. Students' social intelligence plays an important role in teaching with a scientific approach and direct learning. In detail, the research questions are: 1) are there any differences between the scientific approach and direct learning approach in students' fluency in mathematical problem-solving?; 2) are there any differences of students' fluency in solving mathematical problems between students who have high, medium and low social intelligence?; 3) are there any differences of students' fluency in problem-solving between students with high, medium, and low levels of social intelligence in each learning approach?; and 4) are there any differences of students' fluency in problem-solving between students who were taught by using a scientific approach and those who were taught by using direct learning approach at each level of social intelligence?

Methodology

The research design used in this study was quasi-experimental. This research was conducted by giving treatment to the experimental group and providing a control group as a comparison. The determination of this type of quasi-experimental research is based on the reason that this research is in the form of educational research involving humans as the subject of research.

The research design used was the Comparison Group Design Matching Pretest – Post-test form. The steps in this design are as follows.

a. The consideration of two sample groups used stratified cluster random sampling based on the data from the eighth-grade students in all Bojonegoro districts, East Java, Indonesia.
b. The members in the two groups were given a pre-test to ensure the ability of the two sample groups are balanced,
c. The two balanced sample groups were given instruments to measure the level of social intelligence. Social intelligence data is used as one of the independent variables. Social intelligence in this study is categorized into

high, medium, and low. The determination of social intelligence levels based on Budiyono (2004), namely high if the social intelligence score is more than $\bar{X} + \frac{1}{2}s$, moderate if the social intelligence score is more than or equal to $\bar{X} - \frac{1}{2}s$ and less than or equal to $\bar{X} - \frac{1}{2}s$, while s is low if the social intelligence score is from $\bar{X} - \frac{1}{2}s$. With $\bar{X}$ is the average social intelligence value of all sample member, and s is the standard deviation of the average value of all members.

d. The experimental class was taught using scientific learning, while the control class was taught using direct instruction.

e. After the material about the number was studied by all members of the sample group, all members of the sample group were given posttest. The test was used twice in this study. The first test aims to determine the initial ability of members of the sample group. The second test aims to measure the fluency response produced by students.

Research Goal

Fluency is one of the indicators of creativity. The main concerns of this study was to prove 1) whether or not there are differences between scientific approach and direct learning approach of students' fluency in mathematical problem solving; 2) whether or not there are differences of students' fluency in mathematical problem solving between students who have high, medium and low social intelligence; 3) whether or not there are differences of students' fluency in mathematical problem solving between students with high, medium, and low levels of social intelligence in each learning approach; and 4) whether or not there are differences of students' fluency in mathematical problem solving between students who were taught by using scientific approach and those who were taught by using direct learning approach on each level of social intelligence.

Sample and Data Collection

The sample of this study consisted of the State Junior High School students in Bojonegoro, Indonesia. The sample in this study had an average age of 13,4 years (the age of 13 years old is 63, the age of 13,1 years old is 14, the age of 13,2 years old is 16, the age of 13,5 years old is 28, the age of 13,6 years old is 37, the age of 14 years old is 8, the age of 14,1 years old is 22, the age of 14 years old is 18). The sample consisted of 206 eighth grade students (104 boys and 102 girls) of State Junior High School in Bojonegoro, East Java, Indonesia. The sample consisted of 206 eighth grade students (104 boys and 102 girls) of State Junior High School in Bojonegoro, Indonesia. More specifically, 69 of them have high social intelligence, 70 of them have moderate social intelligence, and 67 students have low social intelligence.

This study used two types of instruments, namely, 1) questionnaires and 2) multiple-solution tasks. Questionnaires in this study were used to measure students' social intelligence. While the multiple-solution tasks were used to measure the dependent variable as a direct effect of treatment. Multiple-solution tasks were used in the pre-test and post-test. The results of the pre-test served as the initial test to collect prior knowledge which is positioned as a covariate variable. The aim of measurement of the initial ability is if there are differences in fluency scores after treatment, they are not because of different initial abilities but due to differences in treatment. While the results obtained through the post-test were analyzed to prove the hypothesis.

The respondents' social intelligence, in this study, was measured using the Social Intelligence Scale (SIS) by Mathur (2007). This test has been widely used to measure social intelligence. The results of calculations with Cronbach alpha show that all items in this instrument of tryout have reliability index of 0.80.

The procedures for developing multiple-solution tasks are as follows: 1) identifying basic competencies, 2) identifying fluency indicators, 3) formulating learning objectives, 4) designing test items based on fluency indicators, 5) writing test items planned in the test matrix, 6) writing test questions, 7) writing research rubrics, 8) expert assessments, 9) field tests, 10) analyzing the results of field tests, 11) revision of test questions and 12) completing writing multiple solution tasks. Multiple-solution tasks function to measure the fluency of students in solving problems of a polyhedron. Multiple-solution tasks were designed in essay tests. The multiple-solution tasks for the pre-test were the same as the post-test, only item numbers are randomized.

The developed Multiple-solution tasks consist of 10 essay items. The content validation was carried out by involving 2 measurement experts, 2 mathematicians, and 3 mathematical education experts. The results of the validation were in the form of scores from 1 to 5 and were analyzed using V 'Aiken. While the tryout results show that the numbers of items that meet the level of difficulty and discrimination index are forty with Cronbach's Alpha from learning achievement for multiple choices.

The procedures of this study are as follows: 1) before the treatment is given to all subjects, they were given a social intelligence test and pre-test, 2) after the subject has finished the test, the treatment begins in the class. The experimental class was taught using the scientific approach and the control group was taught using direct instruction learning. The two groups of subjects in this study learned the same material, polyhedron, and 3) after being treated, the subjects were given a post-test.

Data Analysis

This research used 2x3 factorial quasi-experiment with the matching static comparison design. Based on the procedure, the 2x3 factorial experiment design (Ary, 2010) used is as shown in table 1. With the factorial design such as this, the main effect and the interaction effect of all of the treatment variables can be determined.

Table 1. Pattern of 2 x 3 factorial experiments

		Type of social intelligence		
		High social intelligence	**Middle social intelligence**	**Low social intelligence**
Learning Approach	Scientific	Group 1	Group 2	Group 3
	Direct intruction	Group 4	Group 5	Group 6

Table 1 shows that the types of social intelligence used in this research have three dimensions, i.e., high, middle, and low. Learning approach has two dimensions, i.e., scientific and direct instruction. Thus, the main effect and the effect of interaction between treatment variables can respectively be found and sorted into two groups and three groups.

The main effects, i.e., 1) the effect of the variables of the types of learning approach and 2) the effect of social intelligence variables. In the first main effect, the effect of scientific and direct instruction would be found without looking at the effect of social intelligence. While for the second main effect, the effect of high, middle, and low social intelligence would be found without looking at the effect of the variables of the learning approach (scientific and direct instruction). The effect of the interaction of the treatment variables consisted of 1) the effect of scientific and direct instruction on the group of students with high, middle, and low social intelligence and 2) the effect of with high, middle, and low social intelligence on the group with scientific and direct instruction treatment.

The data were collected and analyzed using the statistical analysis of variance (ANACOVA). One of the reasons for using ANACOVAis because it is the alternative to gain scores, focuses on differences between the treatment groups at posttest while holding constant pretest differences. The ANCOVA, then, does not inform about how the groups changed over time (Smolkowski, Danaher, Seeley, Kosty, & Severson, 2010). ANCOVA was used to test the three-research hypothesis. The pre-test was used as a covariate. Before doing the hypothesis testing, variance homogeneity test and data linearity test were done. The normality testing was done using the Kolmogorov-Smirnov statistical test and Shapiro-Wilk test while homogeneity test was done using Levene's test method. All of the tests used a 5% level of significance (alpha = .05). All statistical analyses were done by using statistical product and service solutions version 22 for Windows software.

Findings / Results

The number of students involved in the sample was 206 students. The distribution of the sample based on treatment group and spatial ability is presented in Table 2.

Table 2. Distribution of sample of research based on the type of visualization and spatial ability

	Learning		Number
	Scientific based learning	**Direct instruction**	
high social intelligence	34	35	69
middle social intelligence	35	34	69
low social intelligence	35	33	68
Total	104	102	206

Table 2 shows that the distribution of the sample was even enough in each group of treatment. The number has met the criterion recommended for 2x3 factorial analysis, that is, each cell minimally has a sample of 200 (Hair, 2006).

The description of the condition of the variable of response fluency in each group of treatment is presented in Table 3.

Table 3. Statistical description of the post-test

Learning	Social intelligence	Mean	Standard deviation	N
Scientific	High	79,375	6,21	34
	Middle	67,886	6,41	35
	Low	53,486	7,64	35
	Total	66,915	8,89	104
Direct	High	73,8	7,91	35
	Middle	57,882	8,21	34
	Low	41,212	7,74	33
	Total	57,14	8,78	102

The results showed that the level of fluency response from the answers produced by students in the types of learning approaches (scientific and direct instruction) and social intelligence (high, medium and low) levels are different. It can be seen in Table 3 that students who were taught using scientific learning approach provide higher fluency-based answers (M = 66.915; SD = 8.89) than the students who were taught using direct instruction learning (M = 57,140; SD = 8.78).

Based on Table 3 above, it also can be seen that the students who have high social intelligence and were taught using scientific approach provide higher fluency-based answers (M = 79.375; SD = 6.21) than students who have moderate social intelligence (M = 67.886; SD = 6.41) and low social intelligence (M = 53,486; SD = 7.64). The students who have moderate social intelligence and were taught using scientific approach provide higher fluency-based answers (M = 67.886; SD = 6.41) than students who have low social intelligence (M = 53.446; SD = 7.64).

The students who have high social intelligence and were taught using direct instruction provide higher fluency-based answers (M = 73.80; SD = 7.91) than students who have moderate social intelligence (M = 57.882; SD = 8.21) and low social intelligence (M = 41,212; SD = 7.74). The students who have moderate social intelligence and were taught using direct instruction provide higher fluency-based answers (M = 57.882; SD = 8.21) than students who have low social intelligence (M = 41.212; SD = 7.74).

Before making a hypothesis testing using a 2x2 factorial covariance (ANCOVA) analysis, a test was conducted to find out whether there is a correlation between the Pre-test and post-test. To determine covariates, the Pearson Correlation Test was carried out. Pearson Correlation Test results are shown in Table 4.

Table .4 Result of Pearson correlation test

		Pre_test	Post_test
Pre_test	Pearson Correlation	1	,969**
	Sig. (2-tailed)		,000
Post_test	Pearson Correlation	,969**	1
	Sig. (2-tailed)	,000	

**. Correlation is significant at the 0.01 level (2-tailed).

The results of the analysis showed that the pre-test score had a significant correlation with the post-test score after treatment was given ($r = 0.969$; $p < 0.05$). Correlation shows pre-test as a covariate. Based on this, the hypothesis test used is the analysis of covariance (ANCOVA).

The 2x3 ANCOVA factorial tests were performed using SPSS 22 for Windows at a 5% significance level. The use of ANCOVA based on the test results of requirements analysis has met the requirements. The ANCOVA test results are explained based on the results of the Interaction Test to see whether there are differences in the dependent variable individually in the treatment group. To test the null hypothesis, the effectiveness test between variables between Subjects was used. The results are shown in Table 5.

Table 5. Result of tests of between-subjects effects

Table 5 Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38446,247[a]	5	7689,249	148,117	,000
Intercept	1017928,425	1	1017928,425	19608,228	,000
Social_Intelligence	8358,777	2	4179,388	80,507	,000
Learning_Approach	19979,244	1	19979,244	384,858	,000
Social_Intelligence * Learning_Approach	11114,714	2	5557,357	107,051	,000
Error	10382,666	200	51,913		
Total	1074252,000	206			
Corrected Total	48828,913	205			

a. R Squared = ,787 (Adjusted R Squared = ,782)

The results of the analysis show that there are significant differences in students' ability to produce fluency-based answers seen from the types of social intelligence ($F = 80.507$; $p < 0.05$). Similar results were also found in students' ability to produce fluency-based answers with direct instruction and scientific learning. The results of the analysis show that there are significant differences in students' ability to produce fluency-based answers seen from the type of learning ($F = 384{,}858$; $p < 0.05$).

The results of testing the third hypothesis show that there is an interaction between the type of learning and social intelligence. The results of the test between the subjects presented in Table 5 show that there is an interaction ($p < 0.05$).

Discussion

This study was intended to prove empirically the presence or absence of the influence of scientific learning on the ability of students to complete multiple solution tasks. This study also proves empirically the presence or absence of the influence of social intelligence on the ability of students to solve multiple-solution tasks. The interaction between types of learning and social intelligence toward students' ability to complete multiple-solution tasks was also taken into account in this study.

Based on the results of the study, it was found that students who were taught using scientific learning have better ability to complete multiple-solutions task than students who were taught using direct instruction. One of the teaching methods that can encourage students' critical thinking is scientific learning (Keyes, 2010). The Scientific approach facilitates students to gain knowledge or skills with scientific procedures. Schwarz et al., (2009) explains that scientific learning facilitates students to construct, use, evaluate, and revise science through practice (learning by doing). Learning by doing provides experience to students so that science can be applied directly in life. Students in scientific learning are directed to be able to solve problems through the ability to think critically and creatively to combine knowledge, material from teachers and other various sources (In'am & Hajar, 2017).

One of the aspects of creative thinking is fluency, so that fluency can be developed by students through scientific learning. This can be seen from the syntax of scientific learning. The syntax of scientific learning generally involves: observing, questioning, collecting data, associating, and communicating (In'am & Hajar, 2017). Students may try to use different models to make predictions or develop explanations at the stage of communicating problem-solving, and observe the effectiveness of the solving model, noting that one model of solving is more effective in one situation than another (Schwarz et al., 2009). At this stage, it will familiarize students to make more than one solution so that the ability of students to complete multiple-solution tasks. Consequently, the fluency response produced is high.

Differ from scientific learning; in direct instruction, the teacher has an active role in learning (Wenno, 2014). Students are given material equipped with sample questions and then given training as material reinforcement. As a result, there are students who only follow the teacher's way of solving problems so that the solutions provided are not varied. This is contrary to the concept of fluency which is measured based on the number of solutions produced by students from solving multiple-solution tasks (Akcanca & Ozsevgec, 2017).

The fluency response that students have in solving multiple-solution tasks is also influenced by social intelligence. Fluency response from the answers produced by students who have high social intelligence is better than students who have lower social intelligence.

Students who have high social intelligence will have high communication skills (Pekdogan & Korkmaz, 2001). Students' skills in communication can make them easier to consult various problems. The survey of the current state of research on social intelligence is based on social neuroscience has shown the importance of non-verbal communication and emotions for satisfying human interactions in general (Wawra, 2009). This makes students have knowledge maturity so that when faced with multiple-solution tasks, students who have more adequate knowledge can produce better fluency responses than those below them.

The results of this study indicate that there is an interaction between the types of learning and social intelligence towards the response of fluency from the answers of students from the completion of multiple solution tasks. Students who have high social intelligence and were taught using scientific learning and/or direct instruction have the same good fluency response. However, the students who have moderate and low social intelligence, scientific learning is better than direct instruction. This can be seen in the average results of the fluency response resulting from solving multiple-solution tasks.

Conclusion

This study concludes that there is an interaction between the types of learning approaches and social intelligence towards response fluency.

Suggestions

The followings are some suggestions based on the results of the study:

1. Scientific learning in this study is directed merely at improving aspects of the fluency response so that it needs to be further investigated related to other aspects of creativity, such as flexibility and originality.
2. The categorization of social intelligence is only based on one source so that deeper research can be carried out regarding social intelligence against fluency responses based on another social intelligence scaling
3. The interaction with the learning approach with social intelligence on response to fluency only involves a scientific approach and a direct approach; this should be studied further using another learning approach.
4. Similar studies must be conducted at various levels of education so that the results of the study are made a reflection by all students.

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