The analysis of the implementation of scientific approach 5M to improve the elementary students’ critical thinking skills in solving a fraction sorting problem

Rofika¹,², Dafik³, and T D Prastiti²
¹SDN Kemirian 1, Bondowoso, Indonesia
²Universitas Terbuka, Jember, Indonesia
³Department of Mathematic Education, University of Jember

Email: fika.edris.96@gmail.com

Abstract. This study aims to investigate the analysis of the implementation of scientific approach 5M to improve the elementary students’ critical thinking skills in solving a fraction sorting problem. Students’ critical thinking skills are important, even though the current condition is not as well taught. The method used in this study is a mixed method. Quantitative methods were used to analyze the students’ learning outcomes, while qualitative methods were used to analyze students’ critical thinking skills. Respondents in these study are two classes, divided into experimental class consisting of 26 students and the control class consisting of 24 students. The result showed that the implementation of the scientific approach 5M had better learning outcomes and critical thinking skills to solve a fraction sorting problem. The experimental students showed 74% interpretation skill, 72% analytic skill, 72% evaluation skill, and 71% inference skill while the control showed lower outcomes with 65% interpretation skill, 63% analytic skill, 62% evaluation skill and 60% inference skill. Furthermore, the independent sample t-test from the post-test showed that there is a significant difference between the control class and the experimental class with the sig (2-tailed) value was at 0,00 (p<0,05). It can be concluded that the implementation of scientific approach 5M can improve the elementary school students’ critical thinking skills in solving a fraction sorting problem.

1. Introduction

Critical thinking is a process of thinking that involves testing, connecting and evaluating all aspects of a problem, gathering, organizing, remembering, and analyzing information to conclude the data set obtained [1]. The student-oriented learning process is the right process to improve students' critical thinking skills. Mathematics in elementary schools is a subject that is beneficial to develop communication skills by using numbers, symbols, and sense of reasoning that can help to clarify and to solve problems of daily life [2].

Critical thinking refers to four important skills, namely: (a) Interpretation, (b) Analysis, (c) Evaluation, and (d) Inference. Interpretation is a skill in understanding and expressing the purpose or meaning of various experiences, situations, data, events, opinions, rules, beliefs, norms, procedures or criteria. An analysis is a student's skill in identifying relationships between various statements, concept questions, and descriptions. Evaluation is a skill to assess the credibility of a statement and the truth of
a relationship between various statements, concept questions, and descriptions. The conclusion is the skill to conclude the supporting reasons [3]. Indicators of critical thinking skills [4] can be seen in Table 1 below.

Table 1. Indicators of Critical Thinking Skills

| Indicator | Aspects |
|-----------|---------|
| Interpretation | Write down information based on the problem |
| Analysis | Using appropriate information and concepts |
| Evaluation | Assess concepts and information in problem-solving |
| Inference | Write down the conclusion of problem-solving |
| | Gather information related to the solution |
| | Solve problems with the correct concept |
| | Assess statements related to solution |
| | Write conclusions based on true concepts |

Most students still have a low ability in sorting fractions. The reasons are the students have difficulty understanding the problems and they cannot identify the information. Therefore, the researcher analyses a scientific approach 5M. Scientific learning based on 5M is a learning concept that applies the steps of the scientific method, through a designed learning process so that students actively construct concepts, laws or principles through the stages of observing, formulating problems, proposing or formulating hypotheses, collecting data with various techniques, analyzing data, drawing conclusions and communicating the concepts, laws or principles found [5]. The 5M scientific-based learning process consists of five main learning experiences [6] namely: 1) Observing, 2) Asking, 3) Gathering information/experiments, 4) Associating / processing information, 5) Communicating

A scientific approach can improve learning outcomes, academic achievement, and build knowledge through the steps of the scientific method [7]. In 5M scientific learning, students are not only given knowledge and information but also directed to have a higher level of thinking skills, namely critical thinking and communication. Critical thinking skills are a medium for students to construct abilities and find the best alternative in problem-solving.

Sorting fractions requires critical thinking and reasoning ability. Critical thinking is needed when we try to understand and process information, put forward ideas or ideas objectively, and develop deeper insight [8]. These ideas are developed from the results of reflective thinking when analyzing and evaluating the collection of information obtained. The ability to think in identifying and constructing formulas in Mathematics is required to foster students' understanding of the material and accrue meaningful learning [9].

The reasoning process is used to improve the ability of generalization and abstraction in determining the certainty of problem solving and conclusions. Generalization and abstraction both play an important role in the mind of mathematics students as they are a good modality for studying higher-level mathematical concepts [10].

A fraction is a symbol that contains sequential pairs of integers p and q (q ≠ 0), written with p/q. In the p/q form, p is called the numerator, and q is called an enumerator [11]. Examples of fractions in everyday life are ⅓, where the number 1 is the numerator and the number 3 is the denominator.

The purposes of this study are: 1) To find out that the process of scientific approach 5M can improve the critical thinking skills of elementary school students’ in solving a fraction sorting problems. 2) To find out that the results of the development scientific approach 5M can improve students' critical thinking skills in solving sorting fraction problems. 3) To find out the effectiveness of the implementation scientific approach 5M can improve critical thinking skills of elementary school students in solving a fraction sorting problems 4) To analyze students’ activities when scientific approach 5M is applied and 5) To analyze phase portraits of critical thinking skills students in solving a fraction sorting problems through the implementation of scientific approach 5M.
2. Methods
The research method used is mixed method. The mixed-method is a research method that combines qualitative and quantitative methods [12]. Quantitative methods are used to analyze student learning outcomes, while qualitative methods are used to analyze students' critical thinking skills. The mixed research model with the triangulation model [13] can be seen in figure 1.

![Model of Triangulation of Mixed Method](image)

The analysis of the implementation of scientific approach 5M to improve the elementary students’ critical thinking skills in solving a fraction sorting problem

**Figure 1.** The Model of Triangulation of Mixed Method
2.1 Population and Sample
The research subjects were grade VI elementary school students of SDN Kemirian 1 Bondowoso consisting of 26 students as the experimental class and 24 students as the control class. The sampling technique used is cluster random sampling.

2.2 Instrument
The research instruments used were tests, observations, interviews, and questionnaires. The test instrument used was an essay question given at the pre-test and post-test. The observation instrument used a Linker scale which includes 3 categories: very active (score 3), active (score 2), and quite active (score 1), interview instruments that are equipped with an open questionnaire on student worksheets.

The research design using mixed methods [14] can be seen in the following table 2.

| Group | Pre-test | Independent Variable (X) | Post-test |
|-------|----------|---------------------------|-----------|
| EC    | Y1       | X                         | Y2        |
| CC    | Y1       |                           | Y2        |

Note:
EC = Experimental class
CC = Control class
X = Treatment with a scientific approach 5M
- = Treatment with conventional learning devices
Y1 = Pretest
Y2 = Posttest

Quantitative data were obtained from student learning outcomes in the pre-test and post-test. In the pre-test, data homogeneity tests were conducted to determine the uniformity of the two classes of research. In the post-test results, a normality test was performed to determine the normality of student scores, and an independent t-test to determine differences in student learning outcomes in the two study classes. Qualitative data were obtained from the results of the analysis using observations and interviews.

2.3 Tasks
The task is given to measure critical thinking skills by giving problems to sort random fractions written, starting from the largest fraction or vice versa. Task illustration can be described as follows:

a. Task instructions:
1. Sort the fraction numbers below from the largest fraction to the smallest fraction number, use the Cuisenaire rods that have been prepared.
2. Cut the Cuisenaire rods according to the given fraction numbers.
3. Paste the pieces of Cuisenaire rods into the table provided.
4. Compare the size of the Cuisenaire rods and write the order of the fractions in the available table column.
5. Write the fraction numbers in the order specified in the box provided starting from the largest fraction on the rightmost box.

b. Task
Sort the following fractions from the largest to the smallest!
(2 x ¼), (2 x ⅛), (3 x ⅓), (3 x ¼), (2 x 1/16)
c. Work Steps

| Fraction | Cuisenaire rods strip | Sequence |
|----------|----------------------|----------|
| $2 \times \frac{1}{4}$ | ![Red rod](image1.png) | 3        |
| $2 \times \frac{1}{4}$ | ![Yellow rod](image2.png) | 4        |
| $3 \times \frac{1}{3}$ | ![Green rod](image3.png) | 1        |
| $3 \times \frac{1}{4}$ | ![Blue rod](image4.png) | 2        |
| $2 \times \frac{1}{16}$ | ![Purple rod](image5.png) | 5        |

\textbf{Figure 2. Student Worksheet 1}

3. Results and Discussion

3.1 Result

Before the research is carried out, a validity test, reliability test, and homogeneity test are carried out to ensure that the post-test question instrument and the research class are feasible and meet the requirements for research.

3.1.1 The result of the validity test

Based on table 3, it can be seen that the calculated $r$-value for question number 1 is 1.000, number 2 is 0.472, number 3 is 0.449, number 4 is 0.392, and number 5 is 0.453. It is known that the calculated $r$-value for all items is greater than the $r$ table (0.388) with $N = 26$, so it can be said that the five items are valid and it can be used.
|       | item_1 | item_2 | item_3 | item_4 | item_5 | total |
|-------|--------|--------|--------|--------|--------|-------|
|       | m_1    | m_2    | m_3    | m_4    | m_5    |       |
|       | Pearson Correlation | 1    | .47    | .44    | .39    | .45    | .763** |
|       |        | 2*    | 9*     | 2*     | 3*     |       |
|       |        | .91   | .02    | .40    | .02    | .000   |
|       |        | 5     | 1      | 8      | 0      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |
|       | Pearson Correlation | .47   | 1      | .26    | .26    | .26    | .621** |
|       |        | 1      | 5      | 8      | 0      |       |
|       |        | .01   | .19    | .09    | .47    | .001   |
|       |        | 5     | 8      | 4      | 1      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |
|       | Pearson Correlation | .44   | .26    | 1      | .78    | .38    | .806** |
|       |        | 1      | 2**    | 9*     | 9*     |       |
|       |        | .02   | .19    | .00    | .04    | .000   |
|       |        | 1     | 8      | 0      | 9      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |
|       | Pearson Correlation | .39   | .33    | .78    | 1      | .22    | .770** |
|       |        | 2*    | 5      | 2**    | 0      |       |
|       |        | .04   | .09    | .00    | .27    | .000   |
|       |        | 1     | .4     | 0      | 9      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |
|       | Pearson Correlation | .45   | .14    | .38    | .22    | 1      | .618** |
|       |        | 3*    | 8      | 9*     | 0      |       |
|       |        | .02   | .47    | .04    | .27    | .001   |
|       |        | 0     | 1      | 9      | 9      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |
|       | Pearson Correlation | .76   | .62    | .80    | .77    | .61    | 1      |
|       |        | 3**   | 1**    | 6**    | 0**    | 8**    |       |
|       |        | .00   | .00    | .00    | .00    | .00    |
|       |        | 1     | 0      | 0      | 1      |       |
| N     | 26     | 26     | 26     | 26     | 26     | 26    |

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).
3.1.2 The result of the reliability test

Table 4. The test result of the reliability question

| Item       | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Tot Item Correlation | Cranach’s Alpha if Item Deleted |
|------------|---------------------------|-------------------------------|------------------------------------|---------------------------------|
| VAR0000    | 14.8462                   | 7.415                         | .614                               | .687                            |
| VAR0000    | 14.5000                   | 8.020                         | .393                               | .762                            |
| VAR0000    | 15.1538                   | 7.015                         | .670                               | .664                            |
| VAR0000    | 15.2308                   | 6.985                         | .596                               | .689                            |
| VAR0000    | 14.7308                   | 8.045                         | .388                               | .764                            |

From Table 4, it can be inferred that there are five (5) questions with the value of Cranach’s Alpha of 1st question is 0.687, 2nd question is 0.762, 3rd question is 0.664, 4th question is 0.689 and 5th question is 0.764. Cranach’s Alpha value of all the items about > 0.06, it can be concluded that all of the questions are reliable and consistent.

3.1.3 Homogeneity Test

Table 5. The test result of the homogeneity

| Test of Homogeneity of Variances | Levene Statistic | df1 | df2 | Sig.  |
|---------------------------------|-----------------|-----|-----|-------|
| Based on Mean                   | .263            | 1   | 48  | .611  |
| Based on Median                 | .186            | 1   | 48  | .668  |
| Based on Median and with adjusted df | .186       | 1   | 47.800 | .668 |
| Based on trimmed mean           | .243            | 1   | 48  | .625  |

Based on homogeneity test results above, it can be seen that $r_{count} > r_{table} (0.625 > 0.05)$ so it can be said that both classes of research are homogeneous.

3.1.4 Student Learning Outcomes

The Analysis of student learning outcomes in the form of normality test and independent-sample t-test.
3.1.4.1 The result of the normality test

Table 6. The result of the normality test

| Normal Parameters | Mean | Std. Deviation |
|-------------------|------|---------------|
|                   | .0000000 | 3.82962933 |

**One-Sample Kolmogorov-Smirnov Test**

| Unstandardized Residual | N  |
|-------------------------|----|
|                         | 24 |

Normal Parameters:
- Test distribution is Normal.
- Calculated from data.
- Lilliefors Significance Correction.
- This is a lower bound of the true significance.

Based on the results of the normality test using the SPSS (Statistical Product and Service Solution) application, it can be seen that $r_{count} > r_{table}$ (0.200 > 0.05), so it can be concluded that the scores of students in both classes of research are normally distributed.

3.1.4.2 The result of the independent test for sample t-test

Testing using a sample t-test was conducted to determine the comparison of student achievement in the control class and the experimental class. The results of the independent sample t-test can be seen in table 7 and 8.

Table 7. Group statistic of posttest

| Group Statistics |
|------------------|
| class            |
| N    | Mean | Std. Deviation | Std. Error Mean |
|------|------|----------------|-----------------|
| Res  | Control | 24    | 68.3333      | 5.88784        | 1.20185        |
| ult  | Experimental | 26    | 85.3462      | 3.97937        | .78042         |

Based on table 7, it can be seen that the two classes show different results, i.e. mean of control class is 68.3333 and mean of experimental class is 86.3462.

Table 8. The result of the independent sample t-test

| Independent Samples Test |
|--------------------------|
| Levene's Test for Equality of Variances | t-test for Equality of Means |

| F       | Sig. | t    | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
|---------|------|------|----|-----------------|-----------------|----------------------|-----------------------------------------|
| Res     | Equal variances | 1.96 | .167 | -               | 17.0128         | 19.8505              | 14.1751                                 |
|         | assumed          | 7    | 12.0 | .000            | 17.0128         | 34                   | 19.9091 14.1751                        |
|         | Equal variances  | 5    | 2    | .000            | 17.0128         | 34                   | 19.9091 14.1751                        |
Based on table 8, it can be seen that the t-test shows that sig. (2-tailed) are 0.000 and smaller than 0.05, then both classes have significant differences so that the implementation of scientific approach 5M is significant influences students' critical thinking skills in solving fractions sorting problems.

### 3.1.5 Student Activity

The results of observations about student activities in the learning process as follows:

**Figure 3.** The distribution of observation result on the student activities

Based on figure 3, it can be seen that the result for very active criteria reached 52%, active criteria 36%, inactive criteria 12%. Then, it can be concluded that the implementation of the development of scientific approach based on 5M can increase the activeness of students’ critical thinking in solving the problem of sorting fractions.

### 3.1.6 Critical Thinking Skills

#### 3.1.6.1 Distribution of students critical thinking skills in the control class

**Figure 4.** Distribution of Students Critical Thinking Skills in the Control Class
3.1.6.2 Distribution of students critical thinking skills in the experimental class

![Distribution of Student Critical Thinking Skills in the Experiment Class](image)

Based on figure 5, it can be concluded that the experimental class that was treated by scientific approach 5M was superior to the control class which used conventional learning. It means that the implementation of scientific approach 5M can improve students' critical thinking skills in solving fraction sorting problems.

3.1.7 Student Test Result

The following data is obtained from the work of students who have a very critical skill. The student could also use the easiest and most effective Cuisenaire rods that had been explained by the teacher. Student who had very critical thinking skills could solve the assignment faster than other.

Data obtained through interview activities are transcribed as follows:

**Teacher:** “How do you determine that 3 x 1/3 equals to 1?”

**Student:** “I used Cuisenaire rods which showed 1/3 as many as 3 pieces, then the piece I saw was the same as the number 1 on the white Cuisenaire rods after I compared it turned out to be true, so I think 3 pieces of Cuisenaire rods that read 1/3 the value is equal to 1”

**Teacher:** “What about other fractions? Is the method also the same?”

**Student:** “Yes, the method is the same; I also use Cuisenaire rods to determine the shape of other fractions of the same value”

**Teacher:** “Fraction 3/8 and fraction 6/16 on your work result have the same value, how do you determine that both fractions have the same value?”

**Student:** “When I put 3 pieces of 1/8 fraction on the Cuisenaire rods, those pieces are intact, it turns out to get the right place on 6 pieces of Cuisenaire rods of 1/6, so in my opinion, fraction 3/8 is equal to fraction 6/16”

**Teacher:** “Try to write it down, right to left, the order of fractions starts from the largest to make it easier to read”

**Student:** “Fine, I'll write it down”

---

**Figure 5.** Distribution of Student Critical Thinking Skills in the Experiment Class
3. Discussion

The results of this study are in line with the statement that the scientific approach aims to provide students' understanding in recognizing and understanding various materials using a scientific approach [15]. The learning steps in this approach emphasize student-centered learning by facilitating the teacher to identify problems and develop problem-solving strategies based on the experience of observing, asking, trying, associating and communicating. The series of student activities in learning implies that students actively construct their knowledge through the stages of observing, formulating problems, formulating hypotheses, collecting data, analyzing data, drawing conclusions and communicating concepts that have been found in the learning process.

The utilization of Cuisenaire rods in the process of learning makes it easier for students to understand the material sort fractions with the help of Cuisenaire rods; students can manipulate and visualize [16]. The teacher who facilitate the students can increase student's academic achievement because the quality of education is determined by the teacher [17].

4. Conclusion

The scientific approach 5M can improve the student's activity in learning activities, improve student learning outcomes and improve students' critical thinking skills in solving a fraction sorting problems in order to understand students.

Acknowledgement

I am grateful for the support of the SDN Kemirian 1, Universitas Terbuka and University of Jember.
References

[1] Siswono T Y E 2018 Pembelajaran Matematika Berbasis Pengajuan dan Pemecahan Masalah (Bandung: Remaja Rosdakarya)

[2] Depdikbud 1996 Tujuan Pembelajaran Matematika SD (Jakarta)

[3] Facione P A 2018 Critical Thinking: What It Is and Why It Counts Insight Assess. 1-28

[4] DK Filsaime 2008 Reveals Critical and Creative Thinking Abilities

[5] Daryanto 2014 Curriculum 2013 Learning Scientific Approach (Yogyakarta: Gava Media)

[6] Minister of Education and Culture 2013 Attachment of Minister of Education and Culture Regulation Number 81A Year 2013 Implementation of Curriculum

[7] Rachmono S 2016 The Development of Scientific Approach Learning Material with Fun, Active, Realistic, Structured and Innovative Strategies in the Material System of Two-Variable Linear Equations (Universitas Terbuka)

[8] Mukhlis M, Dafik D and Hobri 2018 Student critical thinking in solving two dimensional armetics problems based on 21st century skills International Journal of Advanced Engineering Research and Science(IJAERS)Vol-5, Issue-4 19-30

[9] Tohir M, Abidin Z, Dafik and Hobri 2018 Students creative thinking skills in solving two dimensional arithmetic series through research-based learning Journal of Physics: Conference Series 1008

[10] Monalisa A, Dafik, Hastuti Y, Hussen, Oktavianingtyas E 2020 The implementation of research-based learning in developing the student mathematical generalization thinking skills in solving a paving block design problem IOP Conf. Series: Earth and Environmental Science 243

[11] Muhsetyo G 2009 Mathematics Learning in Elementary School (Jakarta: Universitas Terbuka)

[12] Sugiyono 2016 Quantitative, Qualitative, and R & D Research Method (Bandung: ALFABETA)

[13] Dafik, Sucianto, Irvan, Rohim 2019 The analysis of student metacognition skills in solving rainbow connection problems under the implementation of research-based learning models International Journal of Instruction, 12(4)

[14] Anggraieni, Dafik, and Tirta 2018 The analysis of the application of discovery learning in improving student's combinatorial thinking skills to solve local super antimagic face coloring problem IOP Conf. Series: Journal of Physics: Conf. Series 1211

[15] Majid, A Rochman.C 2014 Scientific Approach in Implementing Curriculum 2013 (Bandung: Remaja Rosdakarya) hal. 70

[16] Rakoep R 2016 Fraction Learning with Cuisenaire rods Universitas Negeri Yogyakarta ISBN: 978-602-73403-1-2

[17] Mustari M, TaufiqR M and Persada R 2014 Education Management (Jakarta: Rajawali Pers)