The analysis of application of learning materials based on inquiry based learning and its effect on critical thinking skills of students in solving fractions problems

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Abstract. Critical thinking skills are needed to improve mathematical abilities in 21st century. However, with the current learning model, showing students' critical thinking skills did not increase significantly. This study aims to analyze usage inquiry-based learning and find out their effects on students' critical thinking skills in solving fractions problems. Research design using research a mixed methods that is a combination of quantitative research and qualitative research. Research respondents from class 3 were divided into a control class of 22 students and an experimental class of 20 students. Data collection is done through observation sheets, tests, documentation and interviews. The results showed that after the implementation of inquiry-based learning, the percentage of students' critical thinking for the control class was a very critical of 0%, critical 9%, 45% for quite critical, and 46% for less critical and not critical. Starting while for the experimental class the results were very critical 25%, critical 50%, quite critical 15%, less critical 10%, not critical 0%. The t-test score of the independent samples from the post-test showed that there was a significant difference between the control class and the experimental class with a sig (2-tailed) value of 0.001 (p = <0.05). It can be concluded that the application of inquiry-based learning can influences students' critical thinking skills in solving fractions problems.

1. Introduction
Mathematics is very important to survive in 21st century. The fact, mathematics is regard as a difficult subject for students, because it is abstract and needs high order thinking to solve problem related to it [1]. Actually the abstract concept of mathematics is derived from everyday reality which is then taken from the essence and then generalized to an abstract formula [2]. Fractions are a part of mathematics [3]. fractions are numbers that represent parts of a whole or a part of an object [4]. Fractions are denoted by the symbol a/b where a is the numerator and b is the denominator [5]. Types of Fractions consist of: ordinary fractions (c/d), mixed fractions (c  4  b), decimal fractions (c, d) and percent (c%) [6]. In class 3, there is material in the order of fractions. In this material students are asked to sort fractions that are the same meaning one type of fractions that is ordinary fractions. Here the researcher tries to do research by asking students to sort fractions of different types in one problem. Previously described the types of fractions and how to do it. either, way by changing all fractions into regular fractions, or converting them to decimals or changing all fractions to percent and then sorted. In the process of work, some children tend to be quiet because they feel difficulties, embarrassed to ask questions, and some
even do not know how to do it because of forgetting or not paying attention during the previous explanation. A few more children did as best they could and were careless because the way described was too difficult. And students feel bored when the explanation takes place so that they do not pay attention properly and students are not actively involved. And only one or two children who dare to ask to make sure the method used is correct or not or just to confirm their answers. It proves that students’ critical thinking skills in the sorting fraction problem still low. Even thought, important aspect in mathematics is the ability to think critically [7].

Critical thinking skills are needed to improve mathematical abilities in 21st century. Critical thinking skills are the essential skills required to adapt with the competitions today and future [8]. However, the current learning model shows that students' critical thinking skills have not improved significantly. Facione states that critical thinking is self-regulation in deciding something that results in interpretation, analysis, evaluation and inference, as well as exposure using a proof, concept, methodology, criteria, or contextual considerations on which decisions are made [9]. With critical thinking proficiency level is expected that students can solve the problem with fractions properly. Four from six Indicators and sub-indicators of critical thinking include:

Table 1. Indicators of critical thinking [10].

| No | indicator  | Sub indicator                               |
|----|------------|---------------------------------------------|
| 1  | Interpretation | Categorize                                 |
|    |            | Decode significance                        |
|    |            | Clarify meaning                            |
| 2  | Analysis   | Examine ideas                              |
|    |            | Identify arguments                         |
|    |            | Identify reasons and claim                  |
| 3  | Inference  | Query evidence                             |
|    |            | Conjecture alternative                     |
|    |            | Draw logically valid or justified conclusion|
| 4  | evaluation | Asses credibility of claim                  |
|    |            | Asses quality of argument                  |

The low critical thinking skills of students can affect learning outcomes students. Observation result show that of the 20 students only a quarter had a score above 70 (KKM) while others varied under the KKM. Alternative in accordance with these problems is by inquiry-Based Learning (IBL). With the IBL it is expected that students will be able to actively participate and be able to critically solve the fractions problems they learn so that learning outcomes improve.

Inquiry is a strategy used in learning that can increase student participation in learning through observation, research, making an explanation of the data obtained, concluding and communicating the findings [11]. The inquiry learning model is a series of activities that involve learning activities systematically, critically, logically, analytically, so that they can formulate their findings with confidence [12]. From the two opinions above it can be concluded that the inquiry learning model is a learning model that can activate students and foster critical thinking skills through the process of self discovery through its stages. Syntax or stages of inquiry based learning model process according to Sanjaya: (1) Orientation, is a step taken by the teacher to condition that students are ready to carry out the learning process, (2) Formulate the problem, Is a step to bring students to an issue, (3) Propose a hypothesis is Determine the temporary answer of a problem that occurs, (4) Collecting data is Activities to capture the information needed to test the proposed hypothesis, (5) Test the hypothesis, The process of determining the answers considered acceptable in accordance with the data and information obtained based on data collection, (6) Formulating conclusions is The process of describing the findings obtained based on the results of hypothesis testing [13].
Some of the advantages of teaching with inquiry learning models according to Bruner: Vol4) include: (1) Students will be able to understand basic concepts and ideas better, (2) assist students in using memory and transfer to new learning process situations, (3) encourage students to think and work on their own and (4) encourage students to think initiative and formulate their own hypotheses [12]. By Inquiry based learning model is a form of active learning where student are taught to find the information needed independently [14].

Based on the description above, the research problem can be formulated: first, How are the results of the analysis of the implementation of Inquiry based learning in improving students' critical thinking skills in solving fractions problems?. Second, is there any influence of inquiry-based learning of students' critical thinking skills in solving fractions problems?. Based on the formulation of the problem, the objectives of this study are as follows: (1) analyzing of the implementation of Inquiry based learning in improving students' critical thinking skills in solving fractions problems, (2) Analyze the effect of inquiry-based learning on students' critical thinking skill in solving fractions problems.

2. Method

Researchers use a mixed method of triangulation design for analysis critical thinking skill in solving fractions problem under the implementation of inquiry based learning. Triangulation design in mixed research methods aimed at simultaneously collecting quantitative and qualitative data, combining data and using the results to understand the research problem [15]. The triangulasi design can be seen in Figure 1. And for experiment process can be seen in table 2.

2.1 Population

The research sample was taken by purposive sampling based on utility balance. where class 3A (20 students: 10 women and 10 men) as an experimental class using IBL, and class 3B (22 students: 10 women and 12 men) as a control class did not use IBL. This research was conducted in grade 3 at the Baitul Makmur Elementary School, Balung, Jember. school year 2019/2020.

2.2 Instrument

Instruments including: tests, observations, questionnaires and interviews. The test used for pre-test and post-test is in the form of an essay. Observations made during teaching and learning activities take place to observe the learning process clearly and accurately. The questionnaire sheet contains statements with closed answers using a linkert scale with five categories: Very critical (score 4), critical (score 3), quite critical (score 2), less critical (score 1), and not critical (score 0). for activity is Very active (score 4), active (score 3), quite active (score 2), less active (score 1), and inactive. (score 0)Finally, the interview is completed with an open questionnaire for students' worksheets.

| Class     | Pre-test | treatment | Post-test |
|-----------|----------|-----------|-----------|
| Experiment | R1       | X         | R3        |
| Control   | R1       | -         | R2        |

Table 2. Pre-test and post-test control group design [16].
Figure 1. The design triangulation of mix method research in inquiry based learning.
2.3 Task
This research is encouraged to be able to sort fractions of different types easily. The technique used in sort different fractions in this study is "Area Shading Technique". Technical steps for sort different fractions by "Area Shading Technique":

1. Change all the Fractions into the draw same rectangle (it's easier if each rectangle, is length ten centimeters)

2. **For ordinary fractions**: divide as many boxes as the denominator, then shade or color as many as the numerator.
   Example: \( \frac{1}{3} = \)
   
3. **For mixed fractions**: consists of integers and fractions ordinary: for integers, draw boxes as many integers, then shade or color all. for ordinary fractions, draw a boxes, then divide as many denominators, then shade or color as many numerators.
   Example: \( \frac{12}{5} = \)

4. **For decimal fractions**: consists of numbers before the comma and numbers after the comma. For numbers before the comma: draw as many boxes as the numbers in front of the comma, then shade or color them all. For numbers after the comma: just draw a box, then divide it into ten parts, If after the comma is only one number, then each box is worth one, if behind the number 2 numbers then each part of the box is worth ten, if behind the comma there are 3 numbers then each part of the box is worth 100 and so on. Then shade or color the parts or the box worth the numbers after comma.
   Example: \( 2,70 = \)

5. **For percent**: draw a box as large as the previous fractions, then divide the box into 10 parts, each part is worth 10. If the percentage of units or tens of percent eat enough to make one box. If more than 100, then every 100% is one whole box shaded.
   Example: \( 25\% = \)

6. Then sort the fractions, if the shading or coloring is the most, it means the biggest, if the shading is the least, it means the smallest value.

**Problems example:**
Sort fractions \( \frac{1}{3} ; \frac{12}{5} ; 0,5 ; 20\% \) from the biggest:

**The answer**
**Is known**: \( \frac{1}{3} ; \frac{12}{5} ; 0,5 ; 20\% \)
**Asked**: sequence of the largest fractions
**Hypotheses**: the biggest is \( \frac{12}{5} \) and the smallest one is 25%
**answer**:
**Ordinary Fractions** \( \frac{1}{3} = \)

**Mixed Fractions** \( \frac{12}{5} = \)
Decimal Fractions \(0.5 = \frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{4}{8} = \frac{5}{10}\)

Percent \(20\% = \frac{1}{5}\)

Conclusion:

So the sequence of the largest fractions is: \(\frac{2}{5} < 0.5 < \frac{1}{3} < 20\%

2.4 Data collection and data analysis

Data collection using pre-test and post-test both in the experimental class and the control class. In addition, researchers also conducted observations and interviews with research subjects. Pre-test and post-test results are used for quantitative analysis using t-test, while the results of observation and interviews are used for qualitative analysis. Quantitative data were analyzed inferential statistics. Qualitative data were analyzed descriptively. The results of inferential statistical analysis are frequency, average, and standard deviation. And for different tests researchers used an independent sample t-test to test the differences between the experimental class and the control class with a significance level 0.05. Quantitative analysis was carried out statistically using SPSS 23 for windows.

3. Result and Discussions

The results of the reliability and validity of the post-test instrument are shown in table 3. Based on table 3, it can be seen that the \(r_{count}\) value of problem number 1 is 0.950, number 2 is 0.928, problem number 3 is 0.921, number 4 is 0.899, problem number 5 is 0.649, all items produce a value of \(r_{count} > r_{table}\) with \(N = 15\) so that all items are declared valid.

| Table 3. The results of the validity of the pre-test and post-test question. |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|
| item1                           | item2          | item3          | item4          | item5          |     Total      |
| Pearson                         | 1              | 1.925**        | 1.924**        | 1.871**        | 1.456          | 1.950**       |
| Correlation                     | Sig. (2-tailed)| .000           | .000           | .000           | .087           | .000          |
| N                               | 15             | 15             | 15             | 15             | 15             | 15            |
| Pearson                         | 1.925**        | 1              | 1.840**        | 1.890**        | 1.500          | 1.928**       |
| Correlation                     | Sig. (2-tailed)| .000           | .000           | .000           | .058           | .000          |
| N                               | 15             | 15             | 15             | 15             | 15             | 15            |
| Pearson                         | 1.924**        | 1.840**        | 1              | 1.931**        | 1.366          | 1.921**       |
| Correlation                     | Sig. (2-tailed)| .000           | .000           | .000           | .180           | .000          |
| N                               | 15             | 15             | 15             | 15             | 15             | 15            |
| Pearson                         | 2.924**        | 1.921**        | 1.931**        | 1.899**        | 1.349          | 1.899**       |
| Correlation                     | Sig. (2-tailed)| .000           | .000           | .000           | .202           | .000          |
| N                               | 15             | 15             | 15             | 15             | 15             | 15            |
| Pearson                         | 1.456          | 1.500          | 1.366          | 1.349          | 1.349          | 1.649**       |
| Correlation                     | Sig. (2-tailed)| .087           | .058           | .180           | .202           | .009          |
Table 4. Reliability test results from pre-test and post-test questions.

| Reliability Statistics | Cronbach’s Alpha | N of Items |
|------------------------|------------------|------------|
| Total score            | 5                | 906        |

The overall reliability value based on table 4 is 0.906 and \( r_{table} \) of the 5% significance level with \( dk = N-1 = 14 \) and \( r_{table} = 0.514 \) because \( r_{count} > r_{table} \) can be concluded that the instrument was declared reliable.

Next we show the results of the distribution of students' critical skills pre-test results from the control class and the experimental class are as follow:

**Figure 2.** distribution of critical skills from the control class based on the pre-test.

**Figure 3.** distribution of critical skills from the experimental class based on pre-test.
Based on the results of the pretest analysis shown in Figures 2 and 3, it shows that both classes have the same variant. Critical skills of students in the control class showed very critical 0%, critical 9%, quite critical 46%, less critical 36%, and not critical 9%. Whereas in the experimental class the critical skills of students showed that 0% were very critical, 5% critical, 35% quite critical, 40% less critical, and 20% not critical. Next, we will carry out homogeneity and normality tests which are then analyzed for average differences using independent sample t-tests.

Table 5. Homogeneity test results.

| Test of Homogeneity of Variances | Levene Statistic | df1 | df2 | Sig. |
|----------------------------------|------------------|-----|-----|------|
|                                  | .188             | 1   | 40  | .667 |

Homogeneity test results in table 4 shows the significance value is 0.667 greater than 0.05. So it can be concluded that the results of the distribution of mathematical pretest value data are homogeneous.

Table 6. The results of the average value of control between the experimental class and the control class.

| Statistic | Mean | Std. Error | Std. Deviation |
|-----------|------|------------|----------------|
| Class A   | 43.0000 | 4.65098 | 20.79980 |
| Class B   | 64.5455 | 3.70604 | 17.38288 |
| Valid N (listwise) | 20 |

Based on the pre-test average above, there are significant differences in the results of the pre-tests, it can interpret that students' critical thinking skills in solving fraction problems also different between the experimental class and the control class. then analyze the results of the post-tst using inferential statistics. The analysis starts with the normality test. The normality test results appear in table 6 below:

Table 7. Post-test normality test results of the experimental class and the control class.

| Statistic | Kolmogorov-Smirnov | Shapiro-Wilk |
|-----------|--------------------|--------------|
| Class A   | .169               | .136         |
| Class B   | .159               | .152         |
| Valid N (listwise) | 20 |

a. Lilliefors Significance Correction

Normality test results for each group, obtained a significance value of 0.082 for the experimental class and 0.032 for the control class, the significance value of the two groups is greater than the value of α = 0.005, which proves that the two study samples were normally distributed.

In table 7 shows the results of the experimental class post-test that is 82.50 (sd = 12.92692). While the control class was 67.27 (sd = 13.51606). Table 9 also shows a significant difference between the two classes [t (42) = 0.001, p <0.005. Table 8 shows that the results of the t-test sig. (2-tailed) independent sample test against the post test were 0.01 (p = <0.05) significant. This shows that the implementation of IBL can significantly affect students' critical thinking skills in solving fractions problems.
Table 8. Average results of post-test scores between control class and experimental class.

| N Statistic | Mean Statistic | Std. Error | Std. Deviation Statistic |
|-------------|----------------|------------|--------------------------|
| Class A     | 20             | 82,5000    | 2,89055                  | 12,92692                |
| Class B     | 22             | 67,2727    | 2,88163                  | 13,51606                |
| Valid N (listwise) | 20 |              |                         |                          |

Table 9. Comparison of the post-test scores of the experimental class and the control class using independent sample tests.

| Levene's Test for Equality of Variances | t-test for Equality of Means |
|----------------------------------------|-----------------------------|
| Equal variances assumed                 | Equal variances not assumed |
| F                                      | t                           | df  | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
| .035                                    | ,852                        | 3,723 | .00 | 15,2272 | 7 | 4 | 6,96019 | 23,4943 |
| 3,731                                  | 39,887                      | .00 | 15,2272 | 7 | 5 | 6,97742 | 23,4771 |

Figure 4. The development of critical thinking skill post-test result in the control class.
Based on the picture above, students critical thinking skill post-test result in the control class show that very critical is 0%, critical is 9%, quite critical is 45%, less critical is 41% and 5% for not critical. While the post-test results on critical thinking skills in the experimental class, based figure 5 shows that very critical is 25%, critical is 50%, quite critical is 15%, less critical is 10% and 0% for not critical. Based on figure 4 and 5 their description, prove that the critical thinking skill of the experimental class students are superior or improved than the control class. It proves that inquiry based learning materials can influence students critical thinking skill. In addition to conducting a post-test, the researcher also observed student activities during inquiry based learning. These observations were made with the aim of conciving the results of the study. The observation instrument uses a likert scale encompassed inactive (score 0), less active (score 1), quite active (score 2), active (score 3) and very active (score 4). The distribution of the observation result on the students activities under the implementation of inquiry based learning. observation results can be show in the following chart.
Figure 6 shows the observations of 20 students in the eksperimental class who used inquiry based learning. Observations results show that the higest score is on the criteria of very active students in the learning process by 45%, the second level is occupied by the criteria of active students which is 40%, and the remaining 15% occupies a level of quite active, less active and not active in the learning process. From this explanation, it can be concluded that learning using IBL can be influence and enhance students critical thingking skills in solving fractions problem.

The next, in addition to observing student activity, the researcher also made observations on the results of student worksheets in the post-test. The following are the results of 3A_17 student work.

students work on the questions according to the inquiry stage, is orientation, formulating problems, making hypotheses, collecting data, testing hypotheses and making conclusions
Figure 7. very good skill student’s test result.

The picture above is the best answer from the experimental class students. Of these answers have shown the inquiry stage which also shows students' critical thinking skills in solving fraction problems using “Area Shading Technique”.

Furthermore, the research conducted interviews with 3A_17 students, to find out students' opinions on the implementations of IBL, these students were chosen because they obtained high critical thinking skills criteria.

The results of the interview are as follow:

**Researcher** : What problem did you study today?
**Student** : Today I study the problem of sorting fractions
**Researcher** : What do you know about fractions?
**Student** : The fractions is part of the whole
Researcher : Can you name the types of fractions?
Student : Yes I can, that is ordinary fractions, mixed fractions, decimal fractions and percent.
Researcher : What do you think about sorting different fractions?
Student : Before knowing how, I found it difficult to sort fractions.
Researcher : Why do you say that?
Student : Yes, because sorting different fractions, if you use the method to equalize fractions, the steps are very long and
Researcher : You said before, before knowing how. What is the reason you say that?
Student : The reason is, because I now know, how to easily sort different fractions.
Researcher : Are you sure, you can sort different fractions easily?
Student : Yes, I’m sure of my answer.
Researcher : What method do you use to sort fractions?
Student : I use the “Area Shading Technique”.
Researcher : how do you prove that “Area Shading Technique” can make it easier for you to sort different fractions?
Student : The proof is that I can sort different fractions quickly and correctly
Researcher : So, what can you conclude about sorting different fractions?
Student : In my conclusion, the sorting different fractions is easier by using “Area Shading Technique”. Especially yesterday we studied in groups with worksheets provided by the teacher, so that we could easily remember this material because we were taught to find the answers ourselves.
Researcher : To be more convincing, can you explain how to sort different fractions using drawing techniques?
Student : Yes, first read the problem, do I have to sort from the largest or from the smallest. Second, stack down all the piece. Third, draw a picture of a box of the same size, and divide according to the type or fractions. Then shade or color the part of the box according to the value of the fractions. Finally, sort according to how many parts are colored. If more color means the largest fractions.
Researcher : if you get problem with the same problem, can you do it easily?
Student : Insyaallah, yes I can.

From the above interview, we can depict of the critical thinking process in the following phase portrait

![Phase Portrait](image)

**Figure 8.** The phase portrait student critical thinking process of the criteria critical thinking skill.
4. Discussion
This research was conducted to The Analysis of Inquiry Based Learning implementation and Its Effect on Critical Thinking Skills of Students in Solving Fractions Problems. Our results show that: first, inquiry based learning can improved the critical thinking skill in solving fractions problem. Results of research show that, Critical thinking skills in the control class showed a very critical of 0%, critical 9%, 45% for quite critical, and 46 % for less critical and not critical. Starting while for the experimental class the results were very critical 25%, critical 50%, quite critical 15 %, less critical 10%, not critical 0%. These results indicate that the critical skills of students in the experimental class are higher than the critical skills of students in the control class. Second, Through a different learning experience that is by inquiry based learning implementation has developed students' critical thinking skills. Where in the learning students must find answers actively and critically both individually and in groups by following the IBL. The results of observations of the learning process in the experimental class show that students' critical activities and skills point in a positive direction. The highest score of observation criteria is 45% for students who are very active in solving problems, 40% of students are active and the remaining 15% show doubt, inactive and very inactive. So it can be concluded that inquiry based learning implementation can positively affect students’ critical thinking skills in solving fractions problem.

5. Conclusion
Based on the results of research and discussion that has been described can be concluded that: first, inquiry based learning can improved the critical thinking skill in solving fractions problem. This is evidenced from the results of the experimental class using inquiry models showing the results of critical thinking skills higher than the control class. secondly, inquiry based learning implementation can be increase student activity in solving fractions problem, so that thinking skills critical students develop actively and can improve student learning outcome. It means that inquiry based learning implementation can affect to the skills in solving fractions problem.. It is therefore recommended for future researchers to use this inquiry based learning model in improving students' critical thinking skill.

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