

Development of a Learning Design for Fractions Based on Rice Field Context

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Abstract

Fraction material is a prerequisite for algebraic fractions and is often used in other materials. However, in reality, many students still usually make mistakes when learning fractions. This is due to students' lack of conceptual understanding of the material provided. Therefore, learning activities are needed that emphasize students' understanding of concepts by applying everyday life in the learning process. Researchers use the context of rice fields in learning fraction material. The approach used by researchers is PMRI. This research aims to produce a learning trajectory, namely local instructional theory (LIT) in fraction material. This research had two cycles, namely cycle 1 involving 6 students and cycle 2 involving 37 students and a model teacher at elementary school. Data was obtained from student worksheets, pre-tests, post-tests, and interviews. Data is analyzed by comparing the Hypothetical Learning Trajectory (HLT) and what has happened in the learning process. The results indicate that integrating the rice field context into fraction learning significantly supports students' conceptual understanding, helping them progress from informal to formal mathematical thinking.

Keywords

Fraction, PMRI, Rice Field Context, Learning Trajectory.

Introduction

Mathematics is a science that plays an important role in various disciplines. Mathematics is also a science that is no less important in improving the quality of life of the nation (Hadi, [2017](#)). One of the materials in mathematics taught in elementary school is fractions. According to Ilahiyah, et al. ([2019](#)), fractions are defined as part of something whole. According to Kristanto ([2016](#)), the term fraction can be used to refer to a number written in the form a/b and the number a/b where b is not equal to 0.

Fraction material is a prerequisite material for algebraic fractions and is often used in other materials (Suwanto, [2018](#)). Therefore, fraction material is very important for students to

understand fraction concepts, so that students are able to apply fraction material in mathematics and everyday life.

To solve fraction material problems, students still have difficulties and still make mistakes in solving fraction form problems (Gustiani & Puspitasari, [2021](#)). Students' errors in solving problems are caused by a lack of understanding of the concept. Students have difficulty understanding the concept of fraction material because there has been no application of the work in everyday life. This opinion is by the expectations of mathematics learning where on every occasion, mathematics learning should begin with the introduction of problems that are appropriate to the situation (contextual problems) from asking contextual problems, students are gradually guided to master mathematical concepts (Zabeta, Hartono & Putri, [2015](#)).

In addition to the problem of students' lack of conceptual understanding, based on the results of pre-observations and interviews conducted by researchers with grade V teachers, the problems that were seen were that the methods used by teachers were still conventional, the material given to students was not complex enough, and there was one-way communication that made the classroom atmosphere monotonous. Students looked busy with what they were doing, which should not have been done during the learning process. In addition, there were still several problem factors faced by students during the learning process, namely: According to Nurhayanti, Hendar, and Kusmawati ([2022](#)) stated that these problems arose because: 1) The learning method used was still conventional; 2) Not connecting the material with the real world; 3) The presentation of the concept of fractions was not explained in detail; 4) Learning communication was only one way; 5) The monotonous atmosphere in the classroom made students less enthusiastic in participating in the learning process; 6) Lack of learning media.

One of the efforts that can be made to overcome mathematical problems is through innovation. According to (Sulaeman, [2022](#)) learning innovation is that teachers need to make improvements in their learning process, positioning teachers as designers and organizers of learning. So that students can learn enthusiastically and meaningfully because they can understand mathematical concepts through learning activities.

Learning innovations in learning approaches for students who are at the concrete operational stage must be able to change the way of looking at mathematics from abstract to real. One of the learning approaches that can be used to improve mathematics learning is the Indonesian Realistic Mathematics Education (PMRI) approach (Diana, Ratnasari & Nurvicalesi, [2023](#)). The PMRI approach is a mathematics learning approach that emphasizes student activities and is based on real things (contextual) for students (Dewi & Agustika, [2020](#)). PMRI is an adoption of the Realistic Mathematical Education (RME) learning approach that has been developed in Indonesia according to its context (Hadi, [2019](#)). In PMRI learning, students as individuals (subjects) who have knowledge and experience according to their interactions with the environment. According to Zulkardi ([2002](#)), the PMRI approach has 3 principles in learning, namely rediscovery (Guided Reinvention) progressive mathematization (Progressive Mathematics), and the development of other models themselves (Self Developed Models). Mathematics learning with the PMRI approach starts from the "real" context or situation that students have experienced, which is a bridge to connect students from the real stage to formal mathematics (Siligar, Somakim, & Hapizah, [2018](#)).

With the PMRI approach, researchers use the context of rice fields for fraction material, because the majority of the population in East OKU Regency work as farmers. For students, the existence of context in a discourse plays a role in students' mathematical thinking process (Fatimah, [2020](#)). Fundamental mathematical activities are basic mathematical activities that are related to the school environment and social environment. Basic mathematical activities include Counting, Locating, Measuring, Designing, Playing, and Explaining. The knowledge of the agricultural context possessed by students can support students' mathematical understanding (Fatimah et al., [2020](#)) and students' creative mathematical reasoning (Fatimah et al., [2019](#)). In addition, agricultural contexts can be used to identify students' number sense abilities (Fatimah & Wahyudin, [2020](#)). In the concept of rice fields that are often used by farmers in measuring land, there are several fractional numbers including $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$. The concept of rice fields as explained can be easily understood by students. With the context of rice fields, it is hoped that students can understand the mathematical concept of fractional material.

The difference between previous research and the researcher is slightly significant in improving conceptual understanding, especially by integrating the context of rice fields. This approach not only provides practical insight to students but also strengthens the relationship between mathematical theory and their daily lives. Some of the advantages that can be found in this study are: 1) The researcher ensures that every mathematical concept of fraction material taught is closely related to the context of rice fields, making it easier for students to understand and relate it to their daily lives. 2) Students get the opportunity to learn directly by observing the concept of fractions through activities related to life in the rice fields so that it can help them form a deeper and more real understanding. 3) Students are encouraged to be actively involved through various interactive activities, such as direct observation in the rice fields, experiments, and group discussions. Therefore, students can develop their understanding in groups. 4) Utilizing the context of rice fields as a local resource of East OKU in creating relevance, and also building a sense of pride in the heritage and environment around students. 5) The development of student's critical thinking skills begins to be stimulated because they are given situations that require problem-solving and the application of mathematical concepts in real contexts. 6) In addition to the above, this study can also increase students' motivation to learn mathematics.

Based on the problems by the background description above, the purpose of this study is "to produce a learning trajectory in understanding concepts in fraction learning using the context at SD Muhammadiyah 048 Sumber Asri".

Methods

This study uses a design research method, which is a study that aims to develop local teaching theory (theory about the student learning process on a particular mathematical material and the methods/tools used to support the learning process), concerning learning activities that can encourage mental activity and student thinking which is part of the learning process (Gravemeijer & Cobb, [2006](#); Gravemeijer & Van Erde, [2009](#)). The design research method in the world of mathematics education is one form of qualitative education research development by fundamental techniques in the Netherlands in developing the RME theory.

This research consists of three stages of implementation proposed by Bakker (2004), namely: preparing for the experiment, the design experiment, and the retrospective analysis. In the preparation for the experiment stage, the researcher conducted a literature review on fraction material, the ability to understand concepts with fraction material situations, the use of rice field contexts, and the use of PMRI as a learning approach. In addition, the researcher also conducted interviews with several students to determine the extent of students' understanding of the learning prerequisite material. The interviews conducted in this study were unstructured or open interviews, namely interview guidelines that were only in the form of an outline of questions. This interview technique was intended to obtain direct data from students in the learning process using the discovery learning method through a deep learning approach and solving critical thinking and problem solving questions. This interview was conducted on 12 research subjects by considering the test results with subjects who obtained high, medium, and low test scores, 4 subjects each. The results will be used to design learning activities containing hypothetical learning trajectories. The HLT that is designed is dynamic so that a cyclic process is formed that can change and develop during the teaching experiment process. In detail, the things done in this stage are (1) analyzing learning objectives, (2) determining and establishing initial research conditions, (3) designing and discussing the conjecture or HLT that is developed, and (4) determining class character and teacher role.

At the design experiment stage, there are two stages at this stage, namely the pilot experiment as stage 1 and the Teaching experiment as stage 2. In stage 1, 6 students from a class that is not the subject of the study were involved, 2 students with high ability, 2 students with medium ability, 2 students with low ability, and the researcher as a teacher. In stage 2, the researcher involved one class of students as the subject of the study and the teacher involved as a teacher while the researcher observed each activity in the learning process, the researcher collected the necessary data during the learning process in the classroom such as the student's thinking process, mathematical activities and social norms in the classroom.

At the retrospective analysis stage, this stage all data obtained during the teaching experiment are analyzed. *Hypothetical Learning Trajectory* (HLT) serves as the main reference to determine what things are the focus of the analysis. The results of the analysis

are used to develop designs for subsequent learning activities. HLT is compared with the real state of students (Actual Learning Trajectory) in answering the formulation of research problems. The purpose of retrospective analysis is to develop LIT.

Data collection was carried out through several things, namely classroom observation techniques and group observations aimed at finding out the teacher's teaching methods, the arrangement of student teaching and learning time, and the initial abilities of students who were used as research subjects. Interview techniques with teachers aimed at obtaining adequate information between directly observed classroom interactions, for example, teacher difficulties in teaching mathematics in class, teacher understanding levels and teacher experience using the PMRI approach, in addition to discussing the designed HLT or learning design to be applied in class. The technique of giving initial and final tests aimed at finding out how students solve the problems given, so that the level of student understanding of the material taught with the designed design can be known, and the documentation technique aimed at obtaining data in the form of photos and student work results.

The technique of analyzing the written results the researcher used the paired sample t-test only result analysis technique. The paired sample t-test is one of the testing methods used to assess the effectiveness of treatment, marked by the difference in the average after treatment is given. This different test model is used to analyze the results of pre-test and post-test research tests. Data analysis techniques are followed by validity and reliability. Validity is used to measure the quality and validity of a set of data in concluding this study. Reliability describes research conducted to obtain reliable information by the truth in the field so that the relationship between the data sources produced can be used to balance the drawing of conclusions.

Result and Discussion

This study aims to produce a learning trajectory (LT) in fraction learning using the context of rice fields and to find out the role of the rice field context in helping students understand fraction learning. This study went through 3 stages, namely, Preliminary Design, Design Experiment, and Retrospective Analysis. In the early stages of this study, the

activities carried out were reviewing the literature, and designing the Hypothetical Learning Trajectory (HLT). The literature reviewed in this study includes all the instruments used. From this study, HLT, LKS (Student Worksheets), Pre-test questions, Learning Implementation Plans (RPP), Teacher Instructions, and Scoring Rubrics were produced.

The researcher conducted observations on students to carry out pilot experiment activities, previously the researcher conducted interviews with teachers who were used as model teachers. The interviews contained learning curriculum, students' mathematical abilities, attitudes, interests, learning models, and student interactions during mathematics learning, in addition the researcher also asked for input on the learning instruments that had been created by the researcher then the researcher also explained the stages used during the research. The researcher also asked the teacher to choose 6 students with different categories, namely high, medium, and low abilities, so that 6 students were obtained with 2 high-ability students, 2 medium-ability students, and 2 low-ability students. At this stage, the researcher also collected data used as research subjects, namely one class for the implementation of the teaching experiment. The data collected were in the form of lesson schedules and discussions conducted with model teachers.

Phase 1 pilot experiment in this trial phase, the researcher himself acted as a model teacher. This phase was conducted on 6 students of Elementary School who were selected according to ability categories, namely 2 students with high abilities, 2 students with medium abilities, and 2 students with low abilities.

Before the six students follow the learning activities, students are first given pre-test questions to determine the extent of students' initial abilities and knowledge about fraction material and to determine students' problem-solving strategies for the problems in the questions. This information is important information to improve HLT, if there is something that is not appropriate then HLT can be improved. So in the Student Worksheet (LKS) activity 1 students are asked to explore their initial abilities first regarding the context of rice fields. The following problems in activity 1 are shown in the following picture 1.



Figure 1. Problems of Activity 1

Students did not have difficulty in completing activity 1 and all students agreed that it was a picture of a rice field, it can be seen in the countryside, on average they have rice fields of different sizes, and the land is suitable for planting crops such as rice, corn, vegetables and beans.

Furthermore, in activity 2 students are given problems related to land division, to find out that fractions are part of the whole. The following are the problems in LKS Activity 2.

Pada hari minggu sore Doni diajak ayahnya pergi berkeliling didusun sebelah untuk melihat lahan sawah. Sesampainya di sana Doni melihat sekelilingnya banyak sekali lahan sawah dengan luas dan bentuk berbeda-beda. Ayah Doni memiliki sawah berbentuk persegi panjang. Sebagian lahan tersebut akan ditanami dengan jagung dan sebagian lagi akan ditanami kacang tanah.

Figure 2. Problems of Activity 2

Students did not have difficulty in completing activity 1 and all students agreed that it was a picture of a rice field, it can be seen in the countryside, on average they have rice fields

of different sizes, and the land is suitable for planting crops such as rice, corn, vegetables and beans.

Furthermore, in activity 2 students are given problems related to land division, to find out that fractions are part of the whole. The following are the problems in LKS Activity 2:

Di sebuah desa kecil yang subur, terdapat seorang petani bernama Budi. Budi memiliki sebidang tanah berbentuk persegi panjang. Suatu hari, Budi memutuskan untuk membagi sebidang tanahnya menjadi 4 bagian yang sama besar. Beberapa bagian untuk menanam beberapa jenis tanaman. Sebagian lahan Budi akan ditanami ubi jalar dan singkong. Sisa lagi akan ditanami jagung dan kacang tanah.

Figure 3. Problems of Activity 3

When solving the problems in activity 3, students first work on it by making a sketch of the division of land to be planted, it can be seen that students still use the knowledge they have when solving the problems in activity 2 in the previous meeting. This can be seen in the conversation transcript below:

- Peneliti* : "Ok Rizka, kaliankan sudah melakukan kerjasama dengan kelompoknya. Jawabannya berapa untuk kegiatan 3?"
- Siswa MF*: "Dalam bentuk pecahan luas bagian lahan yang ditanami masing-masing tanaman dari semua lahan yang dimiliki Budi adalah $\frac{1}{4}$ "
- Peneliti* : "Iya, oke didapat darimana?"
- Siswa MF*: "Didapat dengan cara membuat sketsa pembagian lahan masing-masing tanaman"
- Peneliti* : "Oh dibuat sketsa, jadi dapatnya $\frac{1}{4}$ bagian"
- Siswa MF*: "Iya bu"
- Peneliti* : "Yang lainnya ketemunya $\frac{1}{4}$ sama iya? (bertanya kepada kelima siswa?)"
- 5 Siswa* : "Iya bu, sama bu"
- Peneliti* : "Ok benar ya? tidak ada kekeliruankah?"
- 6 Siswa* : "Benar bu, tidak ada"
- Peneliti* : "Ok untuk jawaban soal no 12, apakah luas masing-masing lahan sama?"
- 6 Siswa* : "Sama bu"
- Siswa MF*: "Jawaban no 12 jadi sama besar bu, jika dibuat dengan konsep pecahan maka didapatkan $\frac{1}{4}$ "
- Peneliti* : "Ok siap sepakat yaa semuanya? (bertanya kepada kelima siswa)"
- 5 Siswa* : "Sepakat"

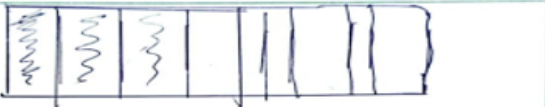
Figure 3: Transcript 1 Students present the results of their answers to activity 3.

In transcript 1, it is clear that students already understand the purpose of the problem and students can already use the general concept of fractions in the context of rice fields, where the results of students making sketches are the same as the results of students using the context of rice fields in fractions. The purpose of students being asked to solve this problem is so that students know and are sure that the context of rice fields is the right and fast strategy to solve problems related to fractions. In activity 4, students are given problems related to everyday life. Activity 4 contains 3 questions and students are asked to solve the problems individually. The purpose of activity 4 is so that students better understand and can use the concept of fractional forms that they have found in solving fraction problems related to everyday life.

Petani A memiliki lahan berbentuk persegi. Petani tersebut akan membagi lahannya menjadi 8 bagian sama besar. Petani A akan menggunakan 3 bagian lahannya untuk menanam beberapa jenis sayuran. Dibagian pertama akan ditanami kangkung. Setelah itu, dibagian kedua akan ditanami kacang panjang, dan dibagian ketiga akan ditanami terong. Maka berapakah bentuk pecahan yang menyatakan bagian luas lahan yang digunakan petani A dari bagian luas semua lahan?

Penyelesaian

1. $\frac{3}{8}$



2. Pak Roni mempunyai sebidang tanah. Tanah pak Roni telah dibagi menjadi 6 bagian sama besar. Pak Roni akan memberikan lahan tersebut untuk ke 4 anaknya. Maka masing masing anak akan mendapatkan berapa bagian lahan dari semua lahan pak Roni?

Penyelesaian :

2. $\frac{4}{6}$

Figure 4: Results of students' answers to Activity 4

Based on students' answers regarding the problems in activity 4, students have been able to solve fraction problems related to everyday life in activity 4. The teacher as a facilitator guides and provides direction to students who do not understand the purpose of the questions. After activity 4 is carried out, students are given a final test, namely the Post-test. This test aims to see the extent of students' understanding of the concept of fractions.

The post-test questions given are questions that have the same type as the pre-test questions but with different numbers and more difficult problems compared to the previous pre-test questions. Before carrying out stage 2, there were several improvements, namely in activities 2 and 3 because the questions given were a little confusing. Stage 2, namely the teaching experiment, was carried out in class V of Muhammadiyah Elementary School with a total of 37 students. At this stage, the class teacher acts as a model teacher. This second stage is almost the same as stage 1, starting with giving a pre-test, LKS (Activities 1, 2, 3, and 4), and finally giving a post-test. The results of the post-test for students in the pilot experiment and teaching experiment classes can be seen in the Table 1.

Table 1. Post-test results for the Pilot Experiment and Teaching Experiment classes

Class	The highest score	Lowest Value	Mean
<i>Pilot Experiment</i>	100	100	100
<i>Teaching Experiment</i>	100	50	75,67

The last stage is retrospective analysis, the problem of the pre-test trial results obtained important things, namely students have difficulty in solving problems related to fractional material because they do not understand the concept of fractions. This is evident from several students who still have difficulty in working on the Pre-test questions. In the problem of activity 1, students did not have difficulty in solving it and all students agreed that it was a picture of a rice field, it can be seen in the countryside, on average they have rice fields of different sizes, and the land is suitable for planting crops such as rice, corn, vegetables, and beans. For the second problem, students read and understand the story questions given, then answer some of the questions that have been provided, then students state after the form of the fraction they find matches the part of the land area planted with plants, based on the student's activities, students can conclude what a fraction is. The problem of Activity 3, is not much different from Activity 2, but what distinguishes the problem in this activity

from the previous activity is the number of parts of the land, namely 4 parts of the same size. In activity 3, students can use the general concept of fractions in the context of rice fields, where the results of students making sketches are the same as the results of students using the context of rice fields in fractions. For activity 4, students can solve fraction problems related to everyday life in activity 4. The teacher as a facilitator guides and provides direction to students who do not understand the purpose of the question. Finally, students are given a test, and based on the results of the post-test, it can be concluded that in general students can solve the problems given, because students have found the general concept of fraction forms using the context of rice fields which is the fastest method and gets the right fraction results.

Conclusion

Based on the results of the research and discussion, it can be concluded that the learning trajectory produced in this study is a trajectory using the context of rice fields in the material of fractions, starting from the activity of exploring the context of rice fields, determining land forms, drawing landforms, making sketches of the division of land to be planted, finding fractional forms and solving contextual problems related to fractions.

The resulting trajectory is In the first activity, students determine the shape of the land according to the story, draw the land, and students make sketches of the land to be planted. The second activity, determine the area of each land to be planted. The third activity, determine the area of land in the form of fractions and conclude that fractions are part of the whole. The fourth activity, solve contextual problems related to fractions using the context of rice fields.

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