Learning Trajectory of Rate Material Using the Context of Plowing Rice Fields

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ABSTRAK	ABSTRACT
Banyak siswa kesulitan memahami konsep laju karena pembelajaran masih bersifat teoritis dan kurang relevan dengan pengalaman mereka. Sehingga penelitian ini ditujukan untuk menghasilkan *learning trajectory* materi laju menggunakan konteks membajak sawah. Penelitian ini melibatkan siswa kelas VII di salah satu SMP negeri di Belitang. Pengumpulan data melalui lembar aktivitas siswa dan lembar observasi. Penelitian menggunakan *design research* tipe *validation studies* yang terdiri dari tiga tahap penelitian yakni *preparation experiment, design experiment dan retrospective analysis*. Penelitian memberikan hasil bahwa *learning trajectory* materi laju terdiri dari tiga tahapan yakni mengeksplorasi kegiatan membajak sawah dengan mencari perbandingan antara luas sawah dengan waktu membajak sawah; menentukan satuan dari luas sawah dengan waktu membajak sawah, dan mendiskusikan definisi laju serta melakukan penyelesaian masalah tentang laju. Konteks membajak sawah memudahkan siswa untuk memahami konsep laju secara lebih konkret dan aplikatif. Melalui hasil penelitian ini memberikan masukan bahwa dalam mengajarkan materi laju, perlu mengintegrasikan dengan konteks realistis yang berada disekitar siswa.	Many students have difficulty understanding the concept of rate because learning is still theoretical and less relevant to their experience. So, this research is aimed at producing a learning trajectory for rate material using the context of plowing rice fields. This research involved class VII students at one of the state junior high schools in Belitang. Data collection through student activity sheets and observation sheets. The research uses validation studies type design research which consists of three research stages, namely preparation experiment, design experiment and retrospective analysis. The research shows that the learning path for rate material consists of three stages, namely exploring the activity of plowing rice fields by finding a comparison between the area of the rice field and the time for plowing the field, determining the unit of area of the rice field with the time for plowing the field, and discussing the definition of rate and solving problems regarding rate. The context of plowing rice fields makes it easier for students to understand the concept of rate in a more concrete and applicable way. The results of this research provide input that in teaching rate material, it is necessary to integrate it with realistic contexts that surround students.
Kata Kunci: Design research; laju; learning trajectory; membajak sawah; PMRI	**Keywords**: Design research; rate; learning trajectory; plowing rice fields; PMRI

How to Cite:

Sari, F. Y., Zulkardi, Putri, R. I. I. & Susanti, E. (2025). Learning Trajectory of Rate Material Using the Context of Plowing Rice Fields. *Plusminus: Jurnal Pendidikan Matematika, 5*(1), 141-154.

1. INTRODUCTION

Rate is an important topic in mathematics learning at the secondary school level (Watanabe, 2024). Rate is a comparison between two variables with different units (Petit et al., 2020). However, there are some experts who define rate as a special ratio that compares two quantities with different units, while ratio is a comparison of any two quantities (Watanabe, 2024). So it can be said that rate is included in a certain type of ratio by comparing two things with different units.

Mathematics learning at junior high school level still faces challenges in explaining abstract concepts (Lestari et al., 2022; Andrian et al., 2024), one of which is the concept of rate. Research by Nuraida et al., (2023) states that the problem in comparative or rate material is the low ability of students to solve comparative problems. Many students have difficulty understanding the concept of rate because learning is still theoretical and less relevant to their experience (Petit et al., 2020; Hidayat & Nuraeni, 2022). Students tend to memorize formulas without understanding their meaning, which results in low application in real life (Diba & Prabawanto, 2019; Afriansyah et al., 2023; Salsabila & Hajizah, 2024). In addition, the lack of a context-based approach causes students' learning motivation to be low.

Mathematics learning in schools often emphasizes procedural understanding over conceptual comprehension, particularly in abstract topics such as the concept of rate (Petit et al., 2020). This condition leads to students' difficulties in making sense of mathematical ideas, especially when the learning is detached from their real-life experiences. Rate, which involves understanding relationships between two quantities (e.g., distance and time, work and time), is a fundamental component of proportional reasoning that students must master for future mathematical competence (Lamon, 2007; Weiland et al., 2021).

An alternative solution that can be used is to link mathematics learning using real contexts that are close to students. The use of realistic contexts can help students understand mathematics material by building their own understanding of concepts and solving problems so that learning becomes more interesting and meaningful for students (Mubharokh et al., 2022; Lestari el al., 2022). Using the context of plowing rice fields in learning can make the concept of rate more real and easy for students to understand.

The use of local contexts in mathematics learning, such as the activity of plowing rice fields, is an approach that is in line with the principles of Indonesian Realistic Mathematics Education (PMRI). PMRI emphasizes the importance of real contexts that are close to students' lives to build a deep understanding of mathematical concepts (Sari et al., 2024). PMRI emphasizes the use of real situations as a starting point for learning, encouraging students to construct their own understanding through a process of guided reinvention (Zulkardi & Putri, 2019). Research conducted by Rawani et al., (2023) and Samura et al., (2024) has proven that the use of the PMRI

approach is effective in helping students understand mathematical concepts through familiar contexts.

Previous research shows that a contextual approach can improve students' understanding of mathematics. For example, research (Sanita et al. (2024) emphasizes that the use of a real context can help students' conceptual understanding. Research using an agricultural context has also been carried out by Muttaqin et al., (2017), the use of the Komering dam discharge context helps students understand the concept of ratios. Sukasno et al., (2024) research provides results that the use of the Watervang dam discharge context helps students understand the concept of fractions.

Several studies have examined context-based learning, but rarely use agricultural activities, especially plowing fields, as a medium for understanding the concept of rate. Apart from that, there are not many studies that design learning trajectories for the concept of rate in the context of plowing rice fields. Therefore, this research fills the gap by developing a learning trajectory for the concept of rate based on the activity of plowing rice fields.

This research offers novelty in developing a learning trajectory for the concept of rate by linking it directly to the activity of plowing rice fields. This approach allows students to understand the concept of rate in a more real and applicable way, and connect it to their daily lives. In addition, this research contributes to innovative learning methods that are more relevant to students' environments, especially students who live in rural areas where the majority of the population work as farmers.

2. METHOD

This research applies the Design Research method with validation studies type to answer the problem formulation that has been formulated. This method aims to develop and validate theories related to learning processes, strategies or materials in order to overcome educational problems and improve the quality of learning. This approach is carried out through collaboration between teachers and researchers (Akker & Gravemeijer, 2020; Bustang et al., 2013; Gravemeijer & Cobb, 2006).

In this study, a learning trajectory for the concept of rate was developed by utilizing the context of plowing rice fields as a learning medium for junior high school students. The research was conducted during the odd semester of the 2024/2025 academic year, spanning from September to November 2024. The participants were seventh-grade students from a public junior high school in Belitang. Research subjects were divided into two categories, namely small class subjects consisting of 8 students at the pilot experiment stage. Students in this small class are grouped based on ability level: 2 students with high ability, 4 students with medium ability, and 2 students with low ability. They were then divided into two groups, where each group

consisted of one student with high ability, two students with medium ability, and one student with low ability.

Apart from that, this research also involved a large class of subjects consisting of 31 class VII.4 students in the teaching experiment stage. The context of plowing rice fields is used as a means to help students understand concept of rate in a more real and applicable way. By integrating mathematical concepts into real-world situations, such as agricultural activities, students not only gain a better mathematical understanding but also realize the relevance of mathematics in everyday life, especially in the practice of plowing rice fields.

This research was carried out in three main stages, namely experimental preparation, experiments design, and retrospective analysis (Plomp & Nieveen, 2013). In the Experimental Preparation Stage, researchers conducted literature studies and designed learning activities and instruments. The literature review covers the topics of rate, PMRI approach, and independent curriculum. The results of this stage are Hypothetical Learning Trajectory (HLT) along with student activity sheets, learning tools and evaluation instruments. The HLT prepared can be revised based on feedback during the research. The Design Experiment Phase tests learning trajectories in real classroom situations to understand students' strategies and thinking patterns. The design experiment comprised two phases: the Pilot Experiment, conducted with eight students of varying abilities to refine the learning trajectory, and the Teaching Experiment, implemented in a full classroom to assess the effectiveness of the designed instruction. The third stage, Retrospective Analysis was carried out by comparing the initial HLT with the results of the design experiments. This analysis aims to understand how students learn the concept of rate in the context of plowing rice fields based on findings in the field.

Data collection in this study used student activity sheets to determine student learning trajectories during rate learning and observation sheets to determine student responses during learning. Data analysis was carried out using qualitative descriptive methods, namely describing the findings from each stage of research regarding the learning trajectory of rate material using the context of plowing rice fields. In this study, the researcher only described one student's answer sheet on the rate activity sheet which represented other students' answers and described the various solution methods that appeared when students worked on the activity sheet.

3. RESULTS AND DISCUSSION

This research has been carried out in accordance with the design research stage, at the preparing for experiment stage, based on the results of a literature review regarding the concept of rate material, indicators of proportional reasoning ability, and PMRI, HLT design was obtained, a student activity sheet for understanding rate material using the context of plowing rice fields, and also pretest and posttest questions on proportional reasoning ability. The initial design of

HLT rate material which is integrated with the context of plowing rice fields can be seen in Table 1.

Table 1. HLT Rate

Activity	Learning goals	Conjecture of students answer
Explore the activity of plowing rice fields by looking for the ratio between the area of the field and the time of plowing the field	understand the comparison between the area of the rice field and the time it takes to plow the field	- Students can understand the concept of rate as a comparison of two quantities - Some students cannot understand the concept of rate as a comparison of two quantities
Determine the unit of rice field area by the time for plowing the field.	identify the units of the two quantities being compared	-Students understand that at a rate, the two quantities being compared have different units -Some students cannot understand that at a rate, the two quantities being compared have different units
Students discuss and write definitions of rate and solve problems about rate	understand changes in two quantities based on a multiplicative relationship to understand rates and solve problems	- Students can write the definition of rate and solve problems related to rate - Some students can write the definition of rate but have not been able to solve problems related to rate

As shown in Table 1, the researchers identified three key activities that students need to experience to comprehend the concept of rate and apply it to real-life problem solving. Subsequently, the researchers carried out a series of trials during the design experiment phase, which was organized into two stages: a pilot experiment and a teaching experiment.

Implementation of Pilot Experiment

The pilot experiment was carried out by testing a rate activity sheet consisting of seven questions to guide students to understand the meaning of rate and solve problems related to rate in everyday life. The trial was carried out in a small class involving 8 students in class VII.3 at one of the junior high schools in Belitang who were selected through purposive sampling by considering the different types of students' abilities. Before carrying out the pilot experiment, the researcher first carried out a pretest to determine students' initial abilities before being given learning using student activity sheets with rate material. The researcher then formed two groups of four students, ensuring each group included a mix of abilities: one high-achieving, two moderate, and one low-achieving student. In one group, students with medium abilities are given two students because there are more students with medium abilities in class VII.3. At this stage, the researcher becomes a model teacher who carries out learning using rate activity sheets, while the mathematics teacher acts as an observer who will observe student responses during the lesson. After the learning was completed, the researcher together with the teacher carried out an

analysis related to the teaching that had been conducted. Suggestions for improvement according to results of the retrospective analysis between researchers and teachers regarding learning using rate activity sheets are summarized in Table 2.

Table 2. Summary of Suggested Improvements for Rate Learning

No	Activity on activity sheet	Improvement suggestions
1	The activity simplifies the comparison between the area of the rice field and the travel time for plowing.	Improve the question narrative using clear command sentences. Use even simpler numbers.
2	Calculating the time to plow a field if you know the area of the field to be plowed	It is necessary to simplify the area of the field to be plowed further, because students have difficulty dividing decimal numbers, so it needs to be adjusted to the students' abilities, but the difficulty level of the questions remains the same.
3	Overall activity sheet	The overall student activity sheet has helped students understand the meaning of rate and be able to solve problems about rate.

Based on the suggestions given by the teacher, the researcher then revised the rate activity sheet before implementing it at the experimental teaching stage.

Implementation of Teaching Experiment

The experimental teaching stage is a stage to determine the learning trajectory of the learning material through work on revised student activity sheets. This stage was carried out in one class, namely class VII.4, totaling 31 students in one of the state junior high schools in Belitang. Mathematics teachers become model teachers who facilitate students in carrying out the learning process using speed material activity sheets and researchers act as observers who observe the implementation of learning according to the teaching modules that have been prepared previously. At this teaching stage, students work on a student activity sheet which consists of three activities with seven questions that students must answer. The following is a description of each activity in the rate activity sheet along with examples of student answers.

Activity 1: Explore the activity of plowing rice fields by looking for the ratio between the area of the field and the time of plowing the field

The aim of this activity is for students to understand the comparison between the area of the rice field and the time it takes to plow the field. Figure 1 represents an example of the majority of students' answers to the first activity.

Figure 1. Examples of Student Respon in 1st Activity Numbers 1,2,3

Based on Figure 1, can be known that students recognize the context used for speed learning as evidenced by students being able to write the names of activities and tools used by farmers in the pictures presented. Furthermore, students can understand that the process of plowing a rice field is related to the ratio between the area of the field and the length of time it takes to plow. Through this activity, students can understand that concept of rate involves the comparison of two quantities.

Activity 2: Determine the unit of rice field area by the time for plowing the field.

The second activity aims to enable students to identify the units of the two quantities being compared. Figure 2 represents an example of the majority of student answers for the second activity.

Figure 2. Examples of Student Respon in 2nd Activity Numbers 4

In Figure 2, students can understand that in the process of plowing a rice field, two things are compared, namely the area of the rice field and the plowing time in different units, namely hectares and hours. Through the process of determining the units of the two things being

compared, students will understand that at rate, the two quantities being compared have different units.

Activity 3: Students discuss and write definitions of rate and solve problems about rate

The aim of this activity is for students to understand changes in two quantities based on a multiplicative relationship to understand rates and solve problems. In this activity, students and their group of friends are asked to discuss what rate is. Figure 3 shows examples of answers that represent all the definitions written by class VII.4 students when working on the rate activity sheet.
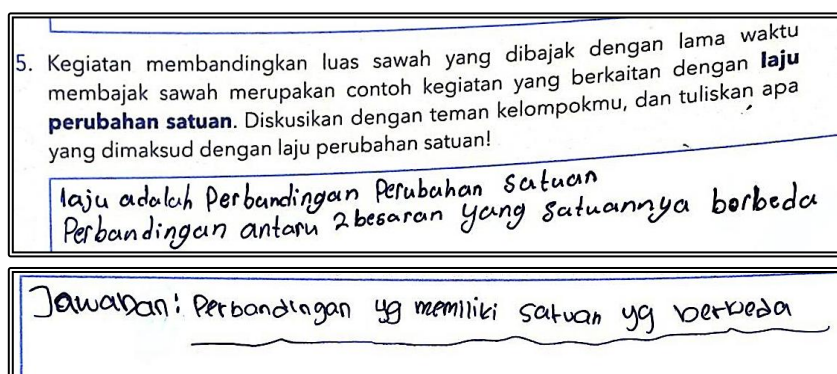

Figure 3. Examples of Student Respon in 3th Activity Numbers 5

Based on Figure 3, can be known that there are three answers that appear when students are asked to write the definition of rate. Of the three answers written by students, in general the answer is correct, namely that rate is a comparison between two quantities or quantities with different units. This proves that using the context of plowing a rice field supports students in comprehending the definition of rate.

Next, students are asked to solve rate problems with different amounts of land area, then students calculate the time needed to plow the rice field. Figure 5 shows an example of an answer that represents all the solution steps written by class VII.4 students when working on the rate activity sheet.
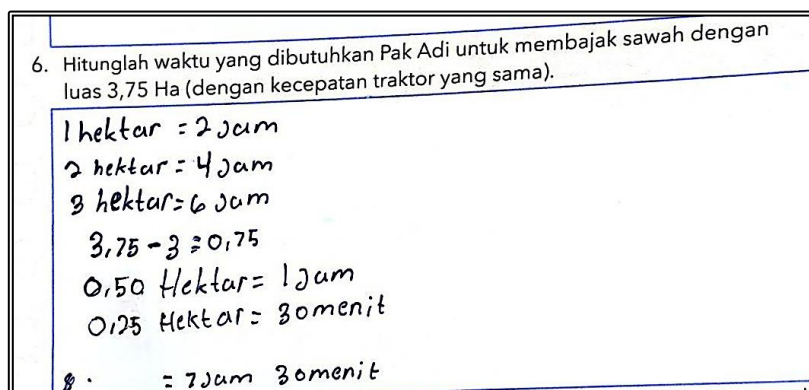
1 Hektar : 2 Jam
2 Hektar = 4 jam
3 Hektar : 6 jam
0,50 Hektar → 1jam
0,25 Hektar = 30 menit

Jadi 3 Hektar + 0,50 Hektar + 0,25 Hektar = 6 jam + 1 jam + 30 menit
                                           = 7 jam 30 menit

2 Hektar = 4 jam
1 Hektar = 2 jam
0,5 Hektar = 1 jam
0,25 Hektar = 0,5 jam   +
————————————————————
3,75 Hektar = 7,5 jam

Figure 4. Examples of Student Respon in 3th Activity Numbers 6

In Figure 4 can be known that students solve rate problems using different strategies but produce the same correct answer. Through the information obtained in previous activities, students can solve the problems given. In their written responses, students demonstrated an understanding of the concept that a change in one quantity corresponds to a change in another, with both changes maintaining a consistent multiplicative relationship.

To deepen their understanding of rate, students are also given a different type of question, namely students are asked to determine the area of the rice fields if they know the time for plowing the fields. Figure 5 shows an example of an answer that represents all the solution steps written by class VII.4 students when working on the rate activity sheet.

7. Pak Adi hari ini membajak sawah selama 5,5 jam. Tentukan berapa hektar sawah yang sudah dibajak Pak Adi hari ini?.

5,5 jam = 4 jam + 1,5 jam.
        = 2 hektar + 0,75 hektar
        = 2,75 hektar

1 jam = 0,50 Hektar
2 jam = 1 Hektar
3 jam = 1,50 Hektar
4 jam = 2 Hektar
5 jam = 2,50 Hektar
0,50 jam = 0,25 Hektar

jadi 5 jam + 0,50 jam = 5,5 jam
   = 2,50 Hektar + 0,25 Hektar = 2,50
                                 0,25 +
                                ———————
                                 2,75

2 Hektar = 4 jam
0,5 Hektar = 1 jam
0,25 Hektar = 0,5 jam   +
——————————————————
2,75 Hektar = 5,5 jam

Figure 5. Examples of Student Respon in 3th Activity Numbers 7

In Figure 5, it can be seen that students were able to solve the questions using the right strategy even though the information given in the questions was different from the previous questions. This also strengthens that students understand changes in two quantities based on the multiplication relationship to understand rates and are able to develop strategies for solving real-world problems involving rates.

Retrospective analysis was carried out by comparing HLT with data from the experimental design stage. The comparison results show that the learning trajectory for rate material is structured into three main activities: (1) exploring the activity of plowing a rice field by looking for a comparison between the area of a rice field and plowing time, (2) determining appropriate units for the area of a rice field and plowing time, and (3) discussing the definition of rate and solving problems related to the concept of rate. These findings confirm that a gradual approach to rate learning can help students understand concepts more deeply and contextually.

The three activities given on the rate activity sheet and the use of the context of plowing a rice field are proven to help students understand the concept of rate and make it easier for students to solve problems regarding rate in everyday life. In the first activity, the use of a realistic context, namely plowing a field, helps students better understand the concept of speed. The findings of this study are consistent with those of Sari et al., (2024), who found that using a real-life context, specifically, cooking rice can effectively support students in understanding the concept of ratio. Research by Mubharokh et al., (2022) also states that used of realistic contexts helps students understand the process of mathematization from informal situations to formal mathematical forms. This research involved the design of instructional activities intended to facilitate students' understanding of the rate concept, beginning with informal contexts, such as the activity of plowing rice fields, to formal situations, namely writing rate definitions and solving rate problems.

The second activity asks students to identify units of each quantity being compared. This aims to make students understand that in the concept of rate, the two things being compared have units. The preparation of this activity is based on the definition of rate stated by Chaim et al., (2012) and Petit et al., (2020) that rate is a type of ratio that compares two variables with different units. In the final stage of the activity, students are guided to define rate based on a series of questions completed in the previous activity. Next, students' understanding is tested by giving problems about rate using the context of plowing a rice field. The use of contexts that are realistic and connected to students' daily lives helps make it easier for students to develop problem-solving strategies. This is evident from the students' answers on the rate activity sheet which shows that students can solve rate problems using their respective strategies.

The findings of this research strengthen the research results of Widiastuti & Nindiasari (2022) and Ndiung et al., (2019) that integrating realistic mathematics in learning increases students' problem solving abilities. Research Soleha et al., (2024) shows that the use of real context helps students solve mathematical problems. Apart from that, learning mathematics which is linked to real contexts in everyday life makes learning rate more meaningful for students because students know the use of the concept of rate in students' daily life. This statement is supported by Fitrisyah et al., (2023) that the use of realistic contexts in mathematics learning makes learning more meaningful.

4. CONCLUSION

The research results show that the learning trajectory for the concept of rate can be developed through three main stages, namely: exploring the activity of plowing rice fields by looking for a comparison between the area of rice field and plowing time, determining appropriate units for the area of rice field and plowing time, discussing the definition of rate and solving problems about rate. Used context of plowing rice fields has been proven to help understand concept of rate in a more concrete and applicable way.

This research contributes to the development of a meaningful and contextual learning trajectory for the concept of rate in mathematics education. By using the real-life context of plowing rice fields, the study provides a practical model for designing mathematics lessons that are more relatable and engaging for students. Based on the research results, teachers are encouraged to integrate learning concept of rate with realistic context and relevant to students' everyday lives. Utilizing daily activities, such as plowing rice fields, can increase students' understanding and involvement in instructional process. Furthermore, future research is encouraged to develop similar contextual approaches for other mathematical concepts to improve the effectiveness of mathematics instruction in schools.

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