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HYPOTHETICAL LEARNING TRAJECTORY IN THE MATERIAL OF ORDERING FRACTIONS

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ABSTRACT

Learning to order fractions is often challenging for elementary school students because they have not yet understood the relationship between the numerator, the denominator, and the value of a fraction. This study aims to develop and examine a Hypothetical Learning Trajectory (HLT) designed to support fourth-grade students in understanding fraction ordering through a series of gradual activities, ranging from concrete to symbolic. The study employed a qualitative approach using Design-Based Research (DBR). Data were collected through observations, student worksheets, and documentation of the learning process. The findings show that the HLT contributed to improving students' understanding, as reflected in their ability to identify equivalent fractions, find common denominators, use least common multiples (LCM), and order fractions with both equal and different denominators. These results indicate that HLT is an effective instructional approach that enhances the quality of fraction learning in elementary schools.

Keywords: Primary Students, Fraction Ordering, Hypothetical Learning Trajectory

ABSTRAK

Pembelajaran materi mengurutkan pecahan menjadi tantangan bagi siswa sekolah dasar karena mereka belum memahami hubungan antara pembilang, penyebut, dan nilai pecahan. Penelitian ini bertujuan mengembangkan dan menguji *Hypothetical Learning Trajectory* (HLT) untuk membantu siswa kelas IV memahami pengurutan pecahan melalui rangkaian aktivitas bertahap dari konkret hingga simbolik. Penelitian menggunakan pendekatan kualitatif dengan *Design-Based Research (DBR)*. Data diperoleh melalui observasi, lembar kerja, dan dokumentasi proses pembelajaran. Hasil penelitian menunjukkan bahwa HLT membantu peningkatan pemahaman siswa, terlihat dari kemampuan mereka mengidentifikasi pecahan senilai, melakukan penyamaan penyebut, menggunakan KPK, serta mengurutkan pecahan dengan penyebut sama maupun berbeda. Temuan ini menunjukkan bahwa HLT efektif digunakan sebagai pendekatan pembelajaran yang meningkatkan kualitas pembelajaran pecahan di sekolah dasar.

Kata Kunci: Sekolah Dasar, Mengurutkan Pecahan, *Hypothetical Learning Trajectory*

A. Introduction

The concept of fractions is one of the mathematical topics that often poses challenges for students (Rahma et al., 2025). This difficulty arises from the lack of mastery over basic fraction concepts, such as simplifying fractions (Maghfiroh et al., 2024). A fraction represents a number in the form a/b, where a serves as the numerator and b as the denominator (Maghfiroh et al., 2024).

Understanding fractions at the elementary level includes addition, subtraction, multiplication, and division (Rohmah et al., 2024). One of the essential skills students need to master is ordering fractions using the concepts of equivalent fractions and the Least Common Multiple (Ritawati et al., 2024).

Fractions are difficult for students to comprehend because they are abstract in nature and challenging to grasp, especially without the support of concrete learning media (Rahma et al., 2024). Many elementary students still view mathematics as a difficult, boring, and even intimidating subject due to unengaging instructional approaches (Amanda et al., 2024). Ideally, mathematics learning should not only train computational skills but also foster critical thinking, creativity, and collaboration (Dahlia et al., 2020). Mathematics plays an important role in developing logical thinking, which is essential for facing future challenges (Sari et al., 2025).

The Hypothetical Learning Trajectory (HLT) is a theoretical model consisting of three main components: learning goals, a sequence of activities, and hypothetical learning processes (Lerman, 2020). HLT is necessary in mathematics instruction because it helps design learning experiences aligned with students' thinking patterns and classroom characteristics (Sinaga, 2024).

Based on the study conducted by Pramesti et al. (2019) students' low ability to solve word problems involving fractions is attributed to the lack of active engagement and contextual learning experiences during instruction. In addition, the use of lecture-based methods without actively involving students has resulted in 75% of learners failing to meet the minimum mastery criteria in their assessments (Albert et al., 2022). Furthermore, research by Riswari et al. (2023) found that elementary students continue to face difficulties in solving fraction problems due to limited mathematical problem-solving skills and insufficient creative thinking. Therefore, an error analysis is needed to identify the types and sources of mistakes students make when working on fraction problems (Kusuma et al., 2022).

Observations in Grade IV at SDN 185 Gresik indicate that many students still struggle to compare fractions with different denominators,

revealing weak comprehension of fundamental concepts. One contributing factor is the limited use of concrete learning media, such as fraction models or simple games that help students visualize fractions more effectively. The predominantly one-way instructional approach also results in minimal student participation, reducing opportunities for questioning, discussion, or hands-on exploration. These conditions collectively influence students' low learning outcomes and hinder their overall understanding of fraction concepts.

Based on the findings of Lantakay et al. (2023) HLT plays an important role in facilitating the learning process. Furthermore, the study by Hajriyanto et al. (2024) indicates that learning barriers depend on students' levels of mathematical ability. Research conducted by Mahmud et al. (2024) shows that the RADEC model can overcome students' conceptual learning obstacles, particularly those who have previously understood LCM and GCD only at the procedural level. Meanwhile, Febriani & Susanti (2023) found that the use of HLT in fraction learning, supported by concrete media, helps students gain a clearer understanding of numerators, denominators, and equivalent fractions. In addition, the study by Nurafifah et al (2021) demonstrates that developing an HLT design for fraction material encourages greater enthusiasm, active participation, and improved comprehension of fraction concepts among students.

Theoretically, this study aims to broaden understanding of learning to order fractions through a Hypothetical Learning Trajectory (HLT) and to contribute to the field of mathematics education. Practically, the study seeks to produce a set of learning activities that can help teachers teach fraction ordering more meaningfully through real-life contexts and visual representations. It is also intended to serve as an alternative instructional approach capable of enhancing the quality of classroom learning.

B. Research Methods

This study employs a qualitative research approach conducted in a natural setting to understand, interpret, and describe social phenomena in depth (Fadli, 2021). The research design used is Design-Based Research (DBR), which aims to develop, implement, and revise a

learning trajectory for the topic of ordering fractions.

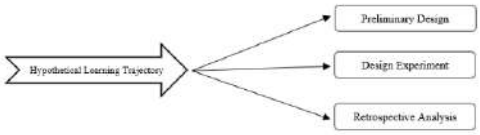

Figure 1. Research Design

Based on Figure 1, this research design refers to three main stages: Preliminary Design, Design Experiment, and Retrospective Analysis (Mahmud et al., 2024). In this stage, the researcher prepares the initial design by collecting preliminary data, one of which comes from the latest exam results of Grade IV students at SD Negeri 185 Gresik. The developed HLT design is presented in Table 1.

Table 1. Hypothetical Learning Trajectory (HLT) (Modified Idea)

Activity	Sub - Activity	Task Item	HLT Prediction
A. Comparing fractions with the same denominator $\frac{a}{b}$ and $\frac{c}{b}$	A1. Introducing the basic concept of fractions $\frac{a}{b}$ which consists of two parts: numerator and denominator A2. Introducing the concept of equivalent fractions such as $\frac{a}{b} = \frac{A}{B}$	Understanding the explanation of the basic concept of fractions, for example in $\frac{1}{2}$ the number 1 is the numerator and 2 is the denominator Understanding the explanation that $\frac{1}{2}; \frac{2}{4}; \frac{4}{8}$ are equivalent fractions Understanding the explanation that comparing fractions with the same denominator only requires comparing the numerators	Students are expected to conclude that a fraction $\frac{a}{b}$ has two parts: numerator and denominator Students are expected to understand equivalent fraction $\frac{a}{b} = \frac{A}{B}$ Students are expected to be able to compare fractions with the same denominator
B. Comparing fractions with different denominators	B1. Comparing fractions $\frac{a}{b}$ that are greater than or less than $\frac{x}{y}$	Finding a way to compare fractions with different denominators (example: $\frac{1}{2} < \frac{3}{4}$)	Students are expected to be able to compare fractions with different denominators, whether $\frac{a}{b} < \frac{x}{y}$ or $\frac{a}{b} > \frac{x}{y}$
C. Ordering fractions with the same deno	C1. Ordering fractions with the same denomi	Understanding how to order fractions with the same denominator	Students are expected to be able to order fractions with the

	minator	nator $\frac{k}{b}$; $\frac{l}{b}$; $\frac{m}{b}$	such as $\frac{1}{4}$; $\frac{2}{4}$; $\frac{3}{4}$	same denominator $\frac{k}{b}$; $\frac{l}{b}$; $\frac{m}{b}$
D.	Ordering fractions with different denominators	D1. Ordering fractions with different denominators $\frac{a}{b}$; $\frac{k}{l}$; $\frac{x}{y}$	Finding a way to order fractions with different denominators (example: $\frac{1}{2}$; $\frac{3}{4}$; $\frac{5}{6}$)	Students are expected to be able to order fractions with different denominators $\frac{a}{b}$; $\frac{k}{l}$; $\frac{x}{y}$
E.	Ordering fractions with both same and different denominators	E1. Ordering fractions with both same and different denominators such as $\frac{a}{b}$; $\frac{k}{l}$; $\frac{x}{y}$; $\frac{c}{b}$	Finding a way to order fractions with both same and different denominators (example: $\frac{1}{2}$; $\frac{3}{4}$; $\frac{5}{6}$; $\frac{3}{2}$)	Students are expected to be able to order fractions with both same and different denominators $\frac{a}{b}$; $\frac{k}{l}$; $\frac{x}{y}$; $\frac{c}{b}$

The implementation phase of the design was carried out through two cycles. In the first cycle, an initial trial was conducted to evaluate the feasibility of the HLT within the learning process. In the second cycle, the revised HLT was implemented once again to collect the main research data, particularly to observe how students understood the concepts of comparing and ordering fractions, both visually and symbolically.

The final stage is the retrospective analysis, which involves a comprehensive examination of all data collected during the learning activities.

The participants in this study were all 20 fourth-grade students at UPT SD Negeri 185 Gresik. The sampling technique used was saturated sampling, involving the entire population of fourth-grade students at UPT SD Negeri 185 Gresik. This technique was chosen because the population size was relatively small, consisting of fewer than 30 students, making it appropriate to include all members of the population as research samples.

This study collected data through test instruments, learning activity observation sheets, and documentation in the form of photos and video recordings. In addition, interviews were conducted to obtain in-depth information related to students' experiences and difficulties during the learning process.

Data analysis was carried out by examining the learning process using the Hypothetical Learning Trajectory (HLT) to map the development of

students' understanding in ordering fractions, starting from the initial stage to the final stage of instruction.

C. Results and Discussion

In this study, learning activities related to ordering fractions were carried out through five sequences of activities (A–E).

A. Comparing fractions with the same denominator ($\frac{a}{b}$ and $\frac{c}{b}$)

The teacher began the lesson by asking students to draw or write anything they already knew about fractions as an initial assessment. After that, the teacher showed an image of sliced pizza to help students understand fractions as parts of a whole.

Figure 2. Teacher introducing the concept of fractions

In activity A1, the teacher introduced the fraction form $\frac{a}{b}$ by explaining the roles of the numerator and denominator through visual examples, such as a cake or a circle divided into equal parts. Students then learned that the numerator represents the number of parts taken, while the denominator indicates the total number of equal parts that make up the whole.

In activity A2, the teacher introduced equivalent fractions by showing that a fraction retains the same value even when its numerator and denominator are multiplied or divided by the same number. After that, the teacher taught students how to compare fractions with the same denominator by simply comparing their numerators.

Figure 3. Students presenting the results of comparing fractions with the same denominator

In this activity, students then presented their comparison results to the class, such as comparing $\frac{1}{4}$ and $\frac{2}{4}$, while explaining the steps they used.

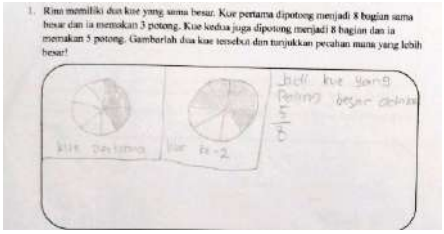

Figure 4. Students' work on comparing fractions with the same denominator

Based on the students' work shown in the figure, they illustrated a cake divided into eight equal parts to compare $\frac{3}{8}$ and $\frac{5}{8}$. The greater number of shaded parts, five sections, indicates that $\frac{5}{8}$ is larger than $\frac{3}{8}$. This finding aligns with the prediction in the HLT, which states that visual representations help students understand that when fractions have the same denominator, the numerator determines the relative size of the fractions.

B. Comparing fractions with different denominators

In activity B1, the teacher taught students how to compare fractions with different denominators. Using circle diagrams, students observed that even when the numerators are the same, the size of each part differs. For example, the pieces in $\frac{1}{2}$ are larger than those in $\frac{1}{3}$ After students understood the role of the denominator, the teacher introduced the step of equalizing denominators by finding the Least Common Multiple (LCM)..

Figure 5. Students presenting the results of comparing fractions with different denominators

In this activity, the students explained the comparison between $\frac{1}{2}$ and $\frac{4}{5}$ by finding the LCM of 2 and 5, which is 10. They converted $\frac{1}{2}$ into $\frac{5}{10}$ and $\frac{4}{5}$ into $\frac{8}{10}$, then concluded that $\frac{4}{5}$ is greater because the numerator 8 is larger than 5 after the denominators have been equalized.

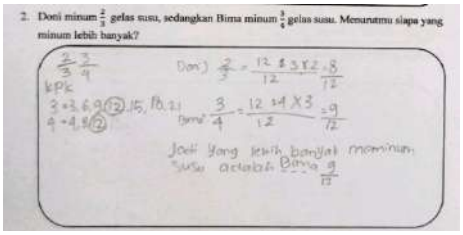

Figure 6. Students' work on comparing fractions with different denominators

In the students' work, a similar process is shown for the fractions $\frac{2}{3}$ and $\frac{3}{4}$. The students determined that the LCM of 3 and 4 is 12, then converted the fractions into $\frac{8}{12}$ and

$\frac{9}{12}$. With the denominators now the same, they concluded that $\frac{9}{12}$ is larger, meaning $\frac{3}{4}$ is greater than $\frac{2}{3}$. These findings demonstrate that the students have understood the step of equalizing denominators as a foundation for comparing fractions with different denominators.

C. Ordering fractions with the same denominator

In activity C1, the teacher introduced the method for ordering fractions that share the same denominator, such as $\frac{k}{b}$; $\frac{l}{b}$ and $\frac{m}{b}$. Since all fractions have parts of equal size, students only need to compare the numerators. Through circle or square diagrams divided into b equal sections, students observed that the larger the numerator, the more parts are taken, which means the value of the fraction becomes greater.

Figure 7. Students presenting the results of ordering fractions with the same denominator

During this presentation activity, students ordered the fractions $\frac{1}{6}$; $\frac{5}{6}$ and $\frac{3}{6}$ by explaining that because all denominators are the same, they only needed to look at the numerators 1, 3, and 5. The students then arranged the fractions in the order $\frac{1}{6} < \frac{3}{6} < \frac{5}{6}$ while clearly explaining the reasoning behind their comparison.

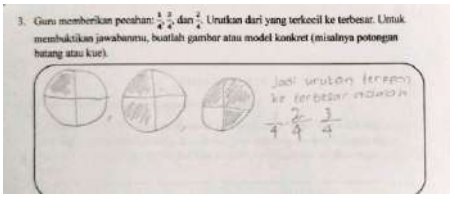

Figure 8. Students' work on ordering fractions with the same denominator

On the worksheet, the students ordered $\frac{1}{4}$; $\frac{2}{4}$ dan $\frac{3}{4}$ from the smallest to the largest. They drew a circle divided into four equal parts and shaded the sections according to each numerator. The drawings showing one, two, and three shaded parts helped them visually recognize that the amount of shading represents the value of each fraction. The answer $\frac{1}{4} < \frac{2}{4} < \frac{3}{4}$ indicates that the students have understood the concept predicted in the HLT, namely that ordering fractions with the same

denominator can be done simply by comparing the numerators.

D. Ordering fractions with different denominators

In Activity D, the teacher guided students to understand how to order fractions with different denominators by showing that the size of one part in each fraction is not the same. Using fraction bar diagrams, students observed the need to equalize the denominators so that the fractions could be compared on the same scale. The teacher then introduced the step of finding the LCM as a method for equalizing denominators. Once the LCM was identified, students converted each fraction into its equivalent form. After the denominators were made the same, they only needed to look at the numerators to determine the correct order.

Figure 9. Students presenting the results of ordering fractions with different denominators

During the presentation stage, the students demonstrated the process of ordering $\frac{1}{2}; \frac{1}{4}$ and $\frac{3}{4}$. They determined the LCM of 2 and 4, then converted $\frac{1}{2}$ into $\frac{2}{4}$, while $\frac{1}{4}$ and $\frac{3}{4}$ remained the same. After the denominators were standardized, the students arranged the fractions in the order $\frac{1}{4}$; $\frac{2}{4}$ and $\frac{3}{4}$.

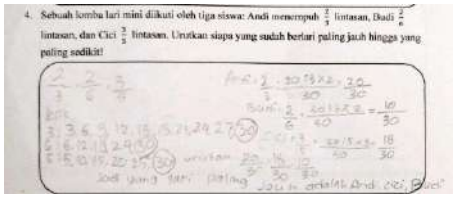

Figure 10. Students' work on ordering fractions with different denominators

On the answer sheet, the students also applied the same steps to the fractions $\frac{2}{3}$; $\frac{2}{6}$ and $\frac{3}{5}$. They found 30 as the LCM and then converted the fractions into $\frac{20}{30}$; $\frac{10}{30}$ and $\frac{18}{30}$. After that, the students were able to arrange the fractions in order with ease. These results indicate that the students have successfully mastered the process of ordering fractions with different denominators, following the learning trajectory planned in the HLT.

E. Ordering Fractions with the Same and Different Denominators

In Activity E, the students learned to combine two skills previously introduced: ordering fractions with the same denominator and ordering fractions with different denominators. The students were first asked to group fractions that had identical denominators, as fractions within this group could be compared directly by examining their numerators. After completing this step, they proceeded to handle fractions with different denominators by using the strategy of equalizing denominators through the LCM. Once all fractions had been converted to equivalent forms with a common denominator, the ordering process could be completed simply by comparing the numerators.

Figure 11. Students presenting the results of ordering fractions with the same and different denominators

During the presentation activity, the students worked on ordering the mixed set of fractions $\frac{1}{2}$; $\frac{1}{4}$; $\frac{3}{4}$ and $\frac{3}{2}$. They identified that $\frac{1}{4}$ and $\frac{3}{4}$ could be compared immediately because they shared the same denominator. Meanwhile, fractions such as $\frac{1}{2}$ and $\frac{3}{2}$ required equalized denominators before comparison. The students then determined the LCM of the denominators 2 and 4, which resulted in a common denominator of 4. Afterward, they converted each fraction into its equivalent form $\frac{1}{2}$ into $\frac{2}{4}$ and $\frac{3}{2}$ into $\frac{6}{4}$, while $\frac{1}{4}$ and $\frac{3}{4}$ remained unchanged. With the denominators now uniform, the students arranged the fractions in order as $\frac{1}{4} < \frac{2}{4} < \frac{3}{4} < \frac{6}{4}$. This explanation illustrates that the students were able to select appropriate strategies and describe each step coherently, demonstrating a solid understanding of how to order fractions with both identical and differing denominators.

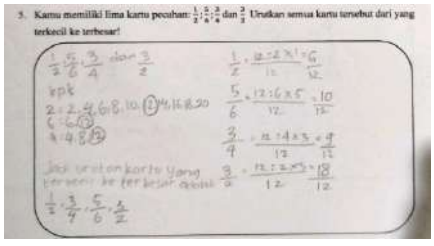

Figure 12. Students' Work on Ordering Fractions with the Same and Different Denominators

In this activity, the students completed another mixed set of problems involving the fractions $\frac{1}{2}$; $\frac{5}{6}$; $\frac{3}{4}$ and $\frac{3}{2}$. They first identified the LCM of the denominators 2, 6, 4, and 2, and found that 12 could serve as the common denominator. The students then converted each fraction into an equivalent fraction with denominator 12, resulting in $\frac{6}{12}$; $\frac{10}{12}$; $\frac{9}{12}$ and $\frac{18}{12}$. After completing the conversion, they ordered the fractions by comparing their numerators.

This final result demonstrates that the students were able to combine both strategies for ordering fractions, those with the same denominator and those with different denominators, effectively and in alignment with the predictions outlined in the HLT.

Tabel 2. Students' Achievement

Number of Students	
Passed (Satisfactory)	Failed (Unsatisfactory)
18	1

Based on Table 2, it can be seen that out of 19 students, 18 achieved satisfactory learning results because their scores were above the class average, while only one student obtained an unsatisfactory result. These findings indicate that the HLT was effective in improving students' learning outcomes on the topic of ordering fractions at UPT SD Negeri 185 Gresik.

This result is consistent with the findings of Abrika & Mariana (2023), who explain that an HLT functions as a guide for teachers to predict students' developing understanding and to interpret their responses throughout the learning process. In fraction instruction, the HLT also helps structure a more directed learning trajectory and anticipate potential learning obstacles, as highlighted by Primasari et al. (Primasari et al., 2021).

The results of implementing Activities A–E show that students' understanding progressed in accordance with the predicted learning trajectory that had been designed. These activities guided students from recognizing the basic concept of fractions to being able to order fractions with both like and unlike denominators. This developmental pattern aligns with Hanipah et al. (2025) who

emphasize that an HLT should include predictions of students' thinking strategies as well as activities that support gradual conceptual transitions.

Concrete representations, such as area models, also made a substantial contribution to students' initial understanding. Visuals such as cakes or pizzas helped students grasp the relationship between parts and wholes before being introduced to equivalent fractions and the ordering of fractions. These findings support those of Febriani & Susanti (2023) who note that concrete and semi-concrete representations serve as effective preliminary steps in building foundational fraction understanding.

When students reached the activity involving common denominators through the LCM, they demonstrated the ability to connect concrete representations with more abstract mathematical forms. Students were able to convert fractions into equivalent fractions and then order them based on their numerators. This result is consistent with studies by Lantakay et al. (2023) and Nurafifah et al. (2021), which report that HLT is effective in enhancing students' ability to apply mathematical strategies independently and flexibly.

In Activity E, students began to demonstrate the ability to select appropriate strategies based on the types of fractions they encountered. They were able to compare fractions with like denominators directly, as well as apply the strategy of finding a common denominator when the denominators differed. This ability indicates that the designed learning trajectory functioned as predicted in the HLT.

Theoretically, the findings of this study are consistent with the work of Hajriyanto et al. (2024) who assert that an HLT can minimize epistemological, didactical, and ontogenic obstacles through systematically structured activities. Thus, this study further strengthens the position of HLT as a relevant and effective approach in mathematics instruction, while also providing new empirical evidence for the development of HLT in teaching the ordering of

fractions in fourth-grade elementary classrooms.

D. Conclusion

The implementation of the Hypothetical Learning Trajectory (HLT) in teaching the ordering of fractions in fourth grade demonstrates strong results in supporting students' progression from initial understanding toward more mature conceptual and procedural mastery. The structured sequence of activities effectively guided students in comprehending the relationship between numerators and denominators, recognizing equivalent fractions, and applying appropriate methods to order fractions in various forms of problems. Consequently, HLT proved to be effective in fostering learning that is more systematic, independent, and flexible.

The implications of this study provide direction for teachers in designing fraction instruction through a gradual series of coherent activities, beginning with concrete experiences and progressing toward symbolic representations. This approach helps students build conceptual understanding while simultaneously developing the ability to apply problem-solving strategies for ordering fractions. HLT-based learning may also serve as a model to enhance students' engagement, accuracy, and mathematical communication skills.

For curriculum development, the findings underscore the importance of structuring fraction content progressively by emphasizing visual representations, the use of least common multiples for finding common denominators, and opportunities for diagnostic processes and reflection. A curriculum that adopts the principles of HLT has the potential to create stronger and more meaningful learning experiences for elementary students.

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