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Effectiveness of Interactive Learning in Teaching Fraction Concepts to Elementary School Teacher Education Students at UKI Toraja

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Article info

Interactive Learning, Fraction Concepts, Elementary Teacher Education Students, Qualitative Approach, Conceptual Understanding

Abstract

This study aims to explore the effectiveness of interactive learning in teaching fraction concepts to students of the Elementary School Teacher Education Program at UKI Toraja. A qualitative approach using a case study method was employed to gain an in-depth understanding of students' experiences during the learning process. Data were collected through observations, interviews, and document analysis, and analyzed using Miles and Huberman's interactive model. The findings reveal that interactive approaches promote active student engagement, enhance conceptual understanding, and help address common misconceptions in fractions. These results highlight the importance of contextual, collaborative, and experience-based learning strategies in elementary mathematics education. The study offers implications for designing more meaningful instruction for prospective teachers and contributes to curriculum development based on students' learning needs.

Pembelajaran Interaktif, Konsep Pecahan, Mahasiswa PGSD, Pendekatan Kualitatif, Pemahaman Konseptual

Abstrak

Penelitian ini bertujuan untuk mengeksplorasi efektivitas pembelajaran interaktif dalam mengajarkan konsep pecahan kepada mahasiswa Program Studi Pendidikan Guru Sekolah Dasar (PGSD) UKI Toraja. Pendekatan kualitatif dengan metode studi kasus digunakan untuk memahami secara mendalam pengalaman mahasiswa selama proses pembelajaran. Data dikumpulkan melalui observasi, wawancara, dan analisis dokumen, kemudian dianalisis menggunakan model interaktif Miles dan Huberman. Hasil penelitian menunjukkan bahwa pendekatan interaktif mendorong keterlibatan aktif mahasiswa, meningkatkan pemahaman konseptual, serta membantu mengatasi miskonsepsi umum dalam materi pecahan. Temuan ini menegaskan pentingnya strategi pembelajaran yang kontekstual, kolaboratif, dan berbasis pengalaman dalam pendidikan matematika dasar. Penelitian ini memberikan implikasi terhadap perancangan pembelajaran yang lebih bermakna bagi calon guru, sekaligus memberikan kontribusi terhadap pengembangan kurikulum berbasis kebutuhan belajar mahasiswa.

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1. Introduction

Interactive learning is an approach that has increasingly gained a place in the modern educational landscape, along with the demands of the 21st century that emphasize the importance of active involvement of learners in the learning process(Mahmudi et al., 2024; Pratama et al., 2023). This approach not only encourages students to be recipients of information, but also to be active actors who are critically and reflectively engaged in understanding the material, building knowledge, and developing higher-order thinking skills (Sampelolo et al., 2024; T. Tulak et al., 2021). In interactive learning, two-way communication between educators and learners is key (T. Tulak, Rubianus, et al., 2024). This interaction can be facilitated through various strategies such as group discussions, simulations, educational games, to the utilization of digital technology that allows exploration of concepts in a more concrete and fun way (Kaharuddin et al., 2021).

In the context of mathematics education, interactive learning has enormous potential to improve students' conceptual understanding (Hanggara et al., 2023; Zhang et al., 2020). One of the materials that are often considered difficult by students is the concept of fractions (Ölmez & Izsák, 2020; T. Tulak et al., 2022). Fractions are part of rational numbers that require abstract thinking, visual representation, and good procedural skills (Flores et al., 2018; T. Tulak, Rahman, et al., 2024). Students' difficulty in understanding this concept can be caused by a weak foundation of prior knowledge and limitations in connecting mathematical symbols with concrete meanings in everyday life (Bush, 2021; Pa et al., 2023). Therefore, learning that is able to concretize abstract concepts such as fractions is needed in the learning process in the classroom, especially for students of the Elementary School Teacher Education Study Program who will become educators at the primary level.

For students of Elementary School Teacher Education at Universitas Kristen Indonesia Toraja, a deep understanding of the concept of fractions is very important. They are not only required to master the material academically, but also to be able to transform the concept into a form of learning that is interesting and easily understood by elementary school students. Interactive learning comes as a promising alternative solution because it is able to touch the cognitive, affective, and psychomotor aspects of students simultaneously (Bruce et al., 2023; Wilkie & Roche, 2022). By integrating learning media such as concrete props, digital visualization, and holographic animation, interactive learning facilitates the process of knowledge construction through enactive, iconic, and symbolic representations as proposed by Jerome Bruner (Bruner, 1966).

Previous research has shown that interactive learning contributes positively to improving math learning outcomes. Students who learn through this approach show improvements in concept understanding, confidence and motivation to learn (H. Tulak et al., 2023; T. Tulak, Rubianus, et al., 2024). This is reinforced by studies that underline the importance of active engagement in the learning process, especially when the material taught is complex and requires deep understanding, such as fractions (Bush, 2021). In interactive learning, students are given the opportunity to explore various representations of fractions through manipulation of concrete objects, visual modeling, and problem-solving discussions involving group work.

Furthermore, interactive learning not only impacts cognitive aspects, but also encourages the development of social and collaborative skills (Mangalik & Tulak, 2019; Sampelolo et al., 2024). In this

learning process, students learn to listen, discuss and give feedback to each other, which is very important in the context of collaborative education and lifelong learning. This collaborative activity helps students build a broader understanding of the concept of fractions through the different perspectives of their classmates.

By considering the important role of Elementary School Teacher Education students as prospective teachers and the complexity of fraction materials, this research becomes very relevant. It is expected that through interactive learning, students will not only understand the concept of fractions in depth, but also be able to design and implement innovative and fun learning for students in the future. This is in line with the mission of the UKI Toraja Elementary Teacher Education Study Program to produce professional, creative, and competent elementary school teachers in Eastern Indonesia in 2025.

Based on this background, the problem formulations to be studied in this research are: (1) Is interactive learning effective in improving the understanding of UKI Toraja Elementary School Teacher Education students on the concept of fractions? (2) How do students respond to interactive learning methods in learning fraction concepts? The objectives of this study are to: (1) Measure the effectiveness of interactive learning in improving the understanding of fraction concepts in UKI Toraja Elementary School Teacher Education students, and (2) Analyze the level of student understanding of fraction concepts before and after the application of interactive learning methods.

2. Method

This research used a descriptive qualitative approach with a case study design. This approach was chosen because the main objective of the study was to deeply understand the effectiveness of interactive learning in teaching fraction concepts to UKI Toraja Elementary School Teacher Education students, especially in the context of mathematical representation based on Bruner's theory (enactive, iconic, symbolic) (Bruner, 1966; T. Tulak, Rahman, et al., 2024). This study emphasizes the exploration of students' learning experiences, changes in conceptual understanding, and engagement in the interactive learning process.

The subjects in this study were 10 fourth semester Elementary School Teacher Education students at Universitas Kristen Indonesia Toraja who had taken the Basic Mathematics course. The subjects were selected by purposive sampling with the criteria: having attended at least 2 semesters of basic mathematics courses, active in interactive learning, and willing to be respondents of in-depth interviews. This research was conducted in the UKI Toraja Elementary School Teacher Education lecture environment for 4 weeks in March 2025. Teaching and learning activities were conducted for 4 meetings, each lasting 100 minutes. Interactive media such as simulation videos, digital manipulatives, and fraction games were used to build concept understanding.

Data was collected through: 1) Participatory observation, to observe student learning interaction in interactive sessions, 2) Diagnostic tests (pre and post learning) to identify the understanding of fraction concepts, 3) In-depth interviews, conducted to explore students' internal representations (enactive, iconic, symbolic), and 4) Documentation, in the form of learning video recordings, student worksheets, and reflection notes.

The research instrument was prepared based on Bruner's mathematical representation indicators:

- Enactive representation: the ability to use concrete objects,
- Iconic representation: the ability to describe visually,
- Symbolic representation: the ability to use formal mathematical notation.

The research procedure includes several implementation flows:

a. Preparation Stage: Preparation of interactive learning devices, validation of instruments by experts.

b. Implementation Stage:

Meeting 1: Introduction to the concept of fractions through concrete activities.

Meeting 2: Visual representation through interactive media.

Meeting 3: Symbolization and practice of fraction problems.

Meeting 4: Reflection, evaluation and final test.

c. Evaluation and Analysis Stage: Analyze the results of observations, tests, and interviews to draw conclusions.

The data analysis technique consists of:

a. Quantitative data from the tests were analyzed using descriptive analysis (mean, standard deviation) and normalized gain test (N-Gain) to measure the improvement of learning outcomes.

b. Qualitative data from observations and interviews were analyzed using a thematic analysis approach (Braun & Clarke, 2019), including:

- Data transcription
- Initial coding
- Theme identification
- Interpretation of findings.

To increase credibility, triangulation techniques were used between observation, test and interview data.

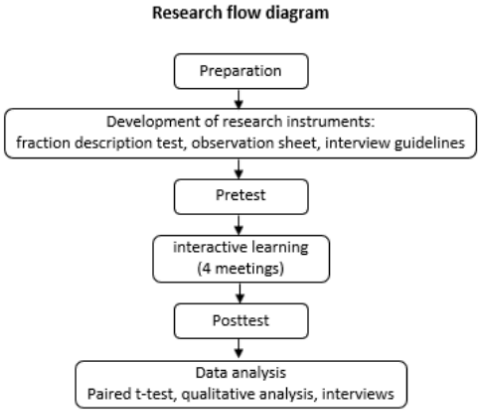


Figure 1: Research flow diagram

3. Results

This research produces two main types of data, namely quantitative data obtained from students' formative test results and qualitative data from observations and in-depth interviews. These results were analyzed to assess the effectiveness of interactive learning on students' understanding of fraction concepts based on enactive, iconic, and symbolic representations.

A. Learning Format Test Results (Pretest and posttest)

Tests given before and after interactive learning showed a significant increase in scores. The students' pretest average score was 52.3, while the posttest average increased to 81.6. This increase was analyzed using the N-Gain test with the following results:

Table 1. Graph of Improvement of Pretest to Posttest Score

Subject	Pretest	Posttest	N-Gain	Category
M1	48	80	0.62	Medium
M2	60	84	0.60	Medium
M3	44	78	0.61	Medium
M4	55	88	0.73	High
M5	50	75	0.56	Medium
M6	46	85	0.72	High
M7	57	89	0.74	High
M8	51	82	0.66	Medium
M9	54	83	0.65	Medium
M10	50	80	0.60	Medium
Average	51,5	81,4	0,65	Medium

This significant increase in scores indicates that the interactive approach is able to improve students' understanding in a meaningful way. This is especially true when students are actively involved in the use of concrete and visual representations.

B. Interactive Learning Observation Results

During the four learning sessions, students showed increased engagement, initiative to ask questions, and the ability to link concrete objects to mathematical symbols. The following is a summary of the observation results:

Table 2. Graph of Observation Results

Observation Indicators	Session 1	Session 2	Session 3	Session 4
Student Engagement (score 1–5)	3	4	4	5
Use of Enactive Representation	4	5	4	4
Use of Iconic Representation	2	4	5	5
Ability to Transition to Symbolic Representation	1	3	4	5

Important notes from the observations show that in the early sessions, students still relied on concrete objects (enactive), but after the third session began to move to symbolic representations smoothly.

C. In-depth Interview Results

From the thematic analysis of the interviews, three main themes emerged:

1) Initial Difficulties in Understanding Fractions: The majority of students stated that before interactive learning, they found it difficult to understand the meaning of fractions as parts of a whole.
2) Effect of Concrete and Visual Media: Students felt that manipulatives (fraction cards, block games) were very helpful in linking abstract concepts with real-life experiences.
   "If it was just numbers, I was confused... but when I used pictures and direct objects, I understood why 1/2 is bigger than 1/4." (M2)
3) Representation Transition: There is a shift from reliance on tools to independent symbolic understanding.
   "At first I always needed a picture. But after the third session, I could immediately calculate 2/3 + 1/6 using the usual method." (M7)

D. Key Findings

Interactive learning has been proven effective in improving students' conceptual understanding of fractions. This is demonstrated by an average N-Gain score of 0.65, which falls into the moderate category, indicating a meaningful improvement in understanding after the implementation of this learning strategy. Additionally, enactive and iconic representations have been shown to play a crucial role as cognitive bridges that facilitate students' transition toward a deeper mastery of symbolic representations. This finding is supported by interview results indicating that students were satisfied with the learning process they experienced and reported increased confidence in solving fraction problems independently.

4. Discussion

This study aims to evaluate the effectiveness of interactive learning based on Bruner's representation theory in improving the understanding of fraction concepts in PGSD UKI Toraja students. The results showed that this approach had a significant impact, both quantitatively and qualitatively, on students' understanding.

Quantitative data analysis showed a significant increase in scores from pretest to posttest, with an average N-Gain value of 0.63, which falls into the moderate to high category. This indicates a meaningful increase in understanding of the concept of fractions after students follow interactive learning. This increase shows that the interactive learning approach makes a positive contribution to student learning outcomes, especially in understanding abstract concepts such as fractions. This finding is in line with the results of previous research (Flores et al., 2018; T. Tulak, Rahman, et al., 2024) which confirms that multiple representation-based learning strategies are effective in accelerating the process of making meaning of mathematical concepts.

Qualitative data obtained from observations and interviews, strengthened the quantitative findings by showing a change in students' conceptual representations. Before learning, most students could only understand fractions through enactive representation (using concrete objects such as folded paper, pieces of cake, etc.). After participating in interactive learning in four structured meetings, students showed more complex abilities, namely:

- Iconic Representation: Able to draw fractions in visual forms such as pie charts, fraction bars, and number lines.
- Symbolic Representation: Using math symbols such as 3/4 and performing addition and subtraction operations of fractions with different denominators.

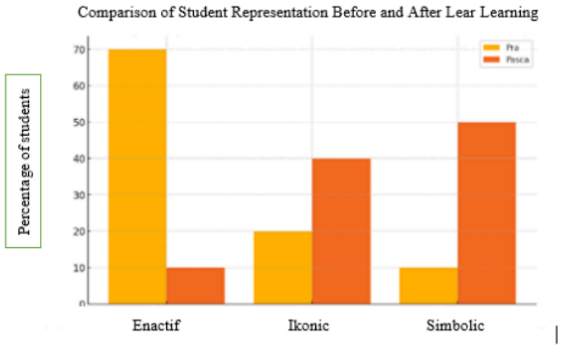
Students reported that the use of digital simulations and fraction games significantly improved their understanding of the material, due to their active involvement in the process of dividing and combining fractions. This is in line with the findings of (Bush, 2021), which showed that software-based interventions with digital manipulatives can support deep conceptual understanding of fractions. Additionally, Lajoie (2021) emphasized that the use of interactive multimedia simulations aligns with the principles of multimedia learning, promoting the dual cognitive engagement (visual and verbal) necessary for meaningful understanding. Furthermore, a recent study by Siller et al. (2025) shows that digital tools like GeoGebra, which provide interactive simulations, have the potential to improve mathematical modeling skills, which are relevant in the context of fraction manipulation. Thus, the integration of digital simulations and educational games not only increases student motivation and engagement but also strengthens conceptual knowledge construction through meaningful enactive and iconic representations.

Interactive learning not only affects cognitive understanding, but also affective and social aspects. Observations showed that students: actively discussed in small groups, exchanged ideas about the most appropriate representation, and were able to reflect on their learning at the end of each session. This

engagement in collaborative activities reinforces the social construction of mathematical meaning, as emphasized in Vygotsky's theory, that social interaction is very important in cognitive development.

The interactive learning in this study was designed based on Bruner's three-stage theory of representation: enactive, iconic and symbolic (Bruner, 1966). The process of transitioning from concrete experience to mathematical symbols gradually is very suitable for the characteristics of Elementary School Teacher Education students who still need real experience to understand abstractions. This research proves that this theory-based approach: is able to accelerate the change from concrete to symbolic representations, becomes an effective bridge in the abstract thinking process, and provides a logical and progressive learning structure (Smith & Alvares, 2024; Zhang & Xie, 2022).

Figure 2: Visual Graph of Student Representation Comparison



This finding confirms that the interactive learning approach not only improves learning outcome scores, but also changes the way students gradually build meaning towards the concept of fractions. Students do not just memorize procedures, but understand concepts through active engagement, use of media, and exploration of mathematical representations.

Thus, interactive learning provides space for students to construct knowledge independently and collaboratively, while supporting the achievement of better pedagogical competence in the future as prospective elementary school teachers (Samantray et al., 2024).

5. Conclusion and Implications

Based on the results of the research conducted, it can be concluded that interactive learning based on Bruner's theory of representations enactive, iconic, and symbolic is effective in enhancing students' conceptual understanding of fractions among students of the Elementary School Teacher Education Program at UKI Toraja. This effectiveness is evidenced by the increase in learning outcome scores from pre-test to post-test, with an average N-Gain of 0.63, which falls into the medium-high category. These findings indicate that students experienced significant cognitive development, particularly in their ability to transition gradually from concrete representations to abstract mathematical symbols. In addition to the quantitative data, qualitative findings from observations and interviews support this conclusion. Students exhibited a notable shift in representation, moving from enactive experiences toward symbolic comprehension, and were able to make meaningful connections between hands-on activities and formal mathematical concepts. Interactive learning was found to stimulate cognitive, social, and affective engagement comprehensively.

Moreover, students responded positively to the use of interactive learning strategies. Interview results revealed that they found it easier to grasp the concept of fractions through a combination of simulation activities, concrete manipulatives, digital visualizations, and collaborative discussions. They reported that this approach made learning more enjoyable, meaningful, and relevant to their future roles as elementary school teachers. Students also appreciated the coherent sequencing of learning stages from concrete to symbolic which allowed them to build their understanding progressively, avoiding abrupt exposure to abstract content. Overall, this study provides empirical support for the implementation of interactive learning approaches as an effective strategy for teaching abstract mathematical concepts, such as fractions, particularly in the context of teacher education. It is therefore recommended that lecturers in PGSD programs consider integrating more interactive strategies in their instruction, especially in foundational mathematics courses.

Credit authorship contribution statement

First Author: Conceptualization, Formal analysis. **Second Authors**: Resources, Methodology. **Third Authors**: Project Administration, Formal analysis, Data curation. **Last Author**: Resources , Formal analysis, Data curation.

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