Primary: Jurnal Pendidikan Guru Sekolah Dasar
journal homepage: https://primary.ejournal.unri.ac.id/
contents lists available at SINTA and DOAJ

Vol. 14 No. 4 (2025): August
http://dx.doi.org/10.33578/jpfkip.v14i4.p475-484

Effectiveness of interactive learning in teaching fraction concepts to elementary school teacher education students at UKI Toraja

Topanus Tulak [1*], Rubianus [1], Harmelia Tulak [1], Desi Natalia [1]

[1] Universitas Kristen Indonesia Toraja, Makale, Indonesia, 91844

Article info

Keywords:
Conceptual understanding, elementary teacher education students, fraction concepts, interactive learning, qualitative approach

Abstract

This study explores 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 analysed 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.

* Corresponding Author.
E-mail address: topan@ukitoraja.ac.id (Topanus Tulak)
DOI: http://dx.doi.org/10.33578/jpfkip.v14i4.p475-484
Received 29 May 2025; Received in revised form 03 July 2025; Accepted 26 July 2025
Available online 31 August 2025
e-ISSN 2598-5949 | p-ISSN 2303-1514

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 emphasise 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, and the utilisation 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 is 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; Park et al., 2023)Therefore, learning to concretise abstract concepts, such as fractions, is needed 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 fractions is crucial. They are not only required to master the material academically but also 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 can 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 visualisation, 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 positively improves math learning outcomes. Students who learn through this approach improve 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 modelling, 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 cooperative activity helps students build a broader understanding of the concept of fractions through the different perspectives of their classmates.

This research becomes very relevant when considering the vital role of Elementary School Teacher Education students as prospective teachers and the complexity of fraction

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

materials. 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 experiences 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 UKI Toraja Elementary School Teacher Education students' understanding of fractions? and (2) how do students respond to interactive learning methods in learning fraction concepts? The research objectives 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) analyse the level of student understanding of fraction concepts before and after applying 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 emphasises exploring students' learning experiences, changes in conceptual understanding, and engagement in the interactive learning process.

This study's subjects 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 being attending at least two semesters of introductory mathematics courses, being active in interactive learning, and being willing to be respondents in 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 performed for four 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, which are: 1) enactive representation: the ability to use concrete objects; 2) iconic representation: the ability to describe visually; and 3) symbolic representation: the ability to use formal mathematical notation.

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

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: Analyse the results of observations, tests, and interviews to draw a conclusion

The data analysis technique consists of:

a. Quantitative data from the tests were analysed using descriptive analysis (mean, standard deviation) and the normalised gain test (N-Gain) to measure the improvement of learning outcomes.
b. Qualitative data from observations and interviews were analysed using a thematic analysis approach (Braun & Clarke, 2019), including: 1) data transcription; 2) initial coding; 3) theme identification; and 3) interpretation of findings.

Triangulation techniques were used between observation, test and interview data to increase credibility.

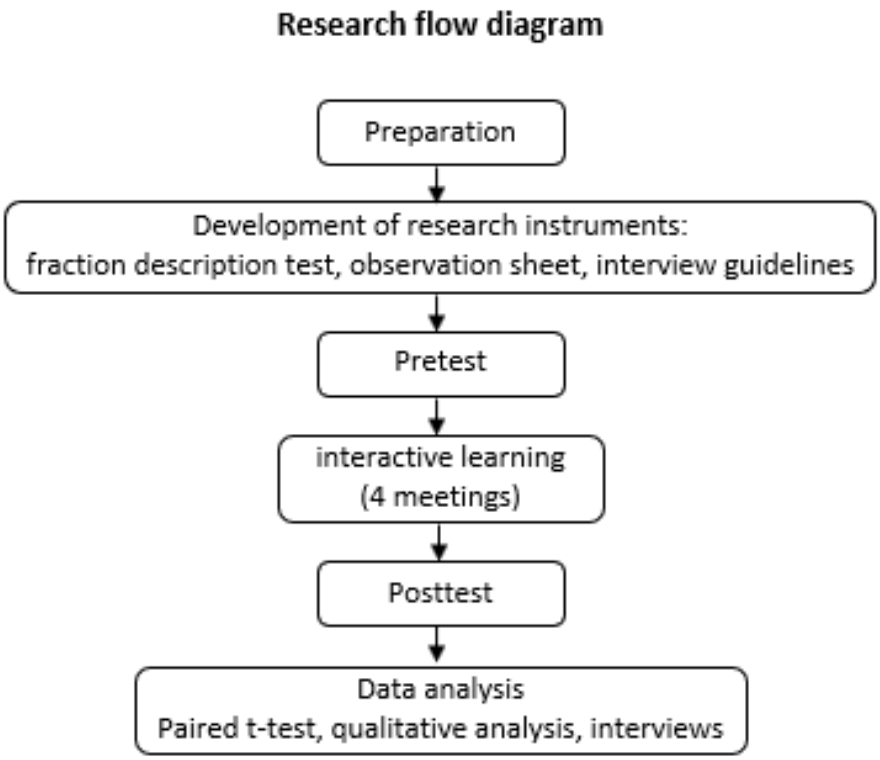

Figure 1. Research flow diagram

3. Results

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

3.1 Learning format test results (Pre-test and post-test)

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 analysed using the N-Gain test with the following results:

Table 1. Graph of improvement of pre-test to post-test 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 can meaningfully improve students' understanding. This is especially true when students actively use concrete and visual representations.

3.2 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. Below 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	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

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

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

3.3 In-depth interview results

Based on the thematic analysis of the interviews, three main themes emerged:

1) initial difficulties in understanding fractions: Most 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) helped them link abstract concepts with real-life experiences.

   "If it were 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)

3.4 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 knowledge after implementing 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 more profound 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

The present 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 quantitative and qualitative impact on students' knowledge.

Quantitative data analysis showed a significant increase in scores from pre-test to post-test, 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 fractions after students follow interactive learning. This increase shows that the interactive learning approach positively contributes 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,

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

et al., 2024). This confirms that multiple representation-based learning strategies effectively accelerate the process of making meaning of mathematical concepts.

Qualitative data 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: (a) iconic representation: Able to draw fractions in visual forms such as pie charts, fraction bars, and number lines; and (b) symbolic pepresentation: Using math symbols such as 3/4 and performing addition and subtraction operations of fractions with different denominators.

Students reported that using digital simulations and fraction games significantly improved their understanding of the material, due to their active involvement in dividing and combining fractions. This is in line with the findings by Bush (2021), which showed that software-based interventions with digital manipulatives can support deep conceptual understanding of fractions. Additionally, Lajoie (2021) emphasised that using 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, can potentially improve mathematical modelling skills, which are relevant in fraction manipulation. Thus, integrating digital simulations and educational games increases student motivation and engagement and strengthens conceptual knowledge construction through meaningful enactive and iconic representations.

Interactive learning affects cognitive understanding as well as 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. As Vygotsky's theory emphasises, this engagement in collaborative activities reinforces the social construction of mathematical meaning; 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 gradual transition from concrete experience to mathematical symbols is very suitable for the characteristics of Elementary School Teacher Education students, who still need real expertise to understand abstractions. This research proves that this theory-based approach can accelerate the change from concrete to symbolic representations, become an effective bridge in the abstract thinking process, and provide a logical and progressive learning structure (Smith & Alvares, 2024; Zhang & Xie, 2022).

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

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

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).

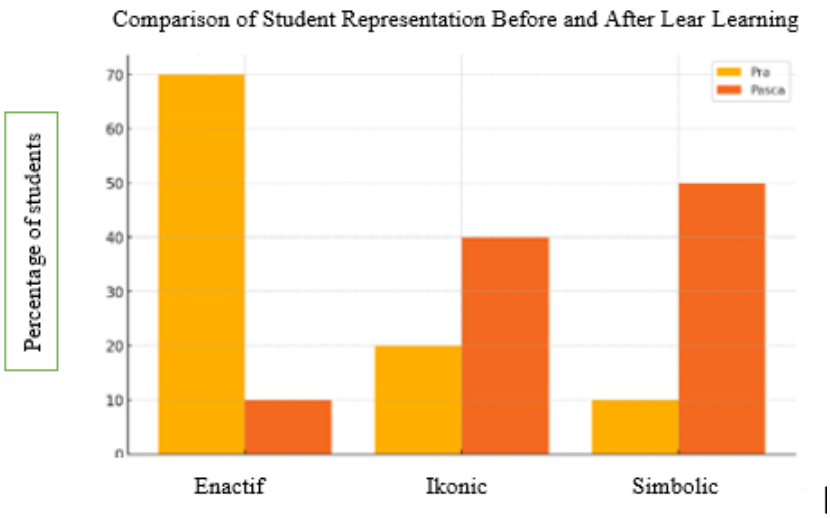

Figure 2: Visual graph of student representation comparison

5. Conclusion and Implications

Based on the research results, it can be concluded that interactive learning based on Bruner's theory of representations, enactive, iconic, and symbolic, effectively enhances students' conceptual understanding of fractions among students of the Elementary School Teacher Education Program at UKI Toraja. This effectiveness is evidenced by increased 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 transitioning 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 could make meaningful connections between hands-on activities and formal mathematical concepts. Interactive learning comprehensively stimulated cognitive, social, and affective engagement.

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 visualisations, 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 implementing interactive learning

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

approaches as an effective strategy for teaching abstract mathematical concepts, such as fractions, particularly in the context of teacher education. Therefore, lecturers in PGSD programs should consider integrating more interactive strategies in their instruction, especially in foundational mathematics courses.

References

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, *11*(4), 589–597. https://doi.org/10.1080/2159676X.2019.1628806

Bruce, C. D., Flynn, T., Yearley, S., & Hawes, Z. (2023). Leveraging Number Lines and Unit Fractions to Built Student Understanding: Insights from a Mixed Methods Study. *Canadian Journal of Science, Mathematics and Technology Education*, *23*(2), 322–339. https://doi.org/10.1007/s42330-023-00278-x

Bruner, J. S. (1966). *Toward a Theory of Instruction*. Harvard University Press.

Bush, J. B. (2021). Software-based intervention with digital manipulatives to support student conceptual understandings of fractions. *BJET: British Journal of Educational Technology*, *52*(6), 2299–2318. https://doi.org/10.1111/bjet.13139

Flores, R., Inan, F. A., Han, S., & Koontz, E. (2018). Comparison of algorithmic and multiple-representation integrated instruction for teaching fractions, decimals, and percent. *Investigations in Mathematics Learning*, *11*(4), 1–14. https://doi.org/10.1080/19477503.2018.1461050

Hanggara, Y., Sa'dijah, C., & Qohar, Abd. (2023). Theory and practice of constructive approaches in mathematics learning. *JCP (Jurnal Cahaya Pendidikan)*, *9*(1), 27–34. https://doi.org/10.33373/chypend.v9i1.5127

Kaharuddin, A., Tulak, T., Magfirah, I., & Ode, R. (2021). Mengapa Kita Membutuhkan Teknologi Dalam Pendidikan? *Jurnal Keguruan Dan Ilmu Pendidikan*, *10*(1), 57–61. https://doi.org/10.47178/jkip.v10i1.1279

Mahmudi, M. R., Davidi, E. I. N., & Tulak, T. (2024). Tren Penggunaan Teknologi dalam Pembelajaran Numerasi Di Sekolah Dasar: Analisis Bibliometrik. *Elementary Journal: Jurnal Pendidikan Guru Sekolah Dasar*, *7*(2), 148–160. https://doi.org/10.47178/hjncz940

Mangalik, A., & Tulak, T. (2019). Penggunaan Alat Peraga Bangun Ruang Untuk Meningkatkan Hasil Belajar Matematika Siswa. *Elementary Journal: Jurnal Pendidikan Guru Sekolah Dasar*, *2*(2), 24–36. https://doi.org/10.47178/elementary.v2i2.857

Ölmez, I. B., & Izsák, A. (2020). Characterizing reasoning about fraction arithmetic of middle grades teachers in three latent classes. *Mathematical Thinking and Learning*, 1–29. https://doi.org/10.1080/10986065.2020.1780368

Park, J., Bryant, D. P., & Shin, M. (2023). Effects of a Synchronous Online Fraction Intervention Using Virtual Manipulatives for Students With Learning Disabilities. *Journal of Special Education Technology*, *39*(2), 234–246. https://doi.org/10.1177/01626434231195313

Pratama, Muh. P., Sampelolo, R., & Tulak, T. (2023). Mengembangkan Pembelajaran Interaktif dengan Canva Untuk Pendidikan Di SMP. *Resona: Jurnal Ilmiah Pengabdian Masyarakat*, *7*(2), 290–297. https://doi.org/10.35906/resona.v7i2.1843

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]

Samantray, A., Behera, R. R., & Acharya, A. K. (2024). Effectiveness of ICT-integrated pedagogy on pre-service teachers' teaching competence in mathematics. *Curriculum, Instruction, and Pedagogy*, *9*, 1–12. https://doi.org/10.3389/feduc.2024.1401188

Sampelolo, R., Abdullah, M., Tulak, T., Palayukan, H., Langi, E. L., Tulak, H., Pakiding, A., Pratama, Muh. P., Tangkearung, S. S., & Duma, S. Y. (2024). *Buku Pembelajaran Aktif: Teori dan Aplikasi*. UKI Toraja Press.

Smith, A. R., & Alvares, M. (2024). Sequencing enactive, iconic, and symbolic representation stages: A meta-analysis. *Review of Educational Research*, *94*(2), 2023–2234.

Tulak, H., Tulak, T., & Kiki. (2023). Penerapan Teori Bruner Untuk Meningkatkan Hasil Belajar Peserta Didik. *Prosiding Universitas Kristen Indonesia Toraja*, *3*, 142–148. https://doi.org/10.47178/prosidingukit.v3i2.2276

Tulak, T., Rahman, A., & Ahmad, A. (2024). Translational Process of Enactive, Iconic, Symbolic Representastion in Understanding the Concept of Fractions. *Himalayan Journal of Education and Literature*, *5*(3), 1–8. https://doi.org/10.47310/hjel.2024.v0i503.006

Tulak, T., Rubianus, & Maramba', S. (2024). Optimizing Mathematics Learning Outcomes Using Artificial Intelligence Technology. *MaPan: Jurnal Matematika Dan Pembelajaran*, *12*(1), 160–170. https://doi.org/10.24252/mapan.2024v12n1a11

Tulak, T., Rubianus, Rianto, W., Stevania, V., & Cindy. (2022). Analysis of Misconception of Elementary School Teacher Study Program UKI Toraja Lectures about Fraction. *Edumaspul: Jurnal Pendidikan*, *6*(2), 1550–1556. https://doi.org/10.33487/edumaspul.v6i2.4139

Tulak, T., Tangkearung, S. S., Hendrik, & Selin, R. (2021). Analisis Kemampuan Berpikir Tingkat Tinggi Siswa pada Mata Pelajaran Matematika. *Prosiding Universitas Kristen Indonesia Toraja*, *1*, 97–106.

Wilkie, K. J., & Roche, A. (2022). Primary teachers' preferred fractions models and manipulatives for solving fractions tasks and for teching. *Journal of Mathematics Teacher Education*, *26*, 703–733. https://doi.org/10.1007/s10857-022-09542-7

Zhang, L., Shang, J., Pelton, T., & Pelton, L. F. (2020). Supporting primary students' learning of fraction conceptual knowledge through digital games. *JCAL: Journal of Computer Assisted Learning*, *36*(4), 540–548. https://doi.org/10.1111/jcal.12422

Zhang, L., & Xie, J. (2022). Digital manipulatives accelerate concrete-to-symbolic transitions in fraction learning. *Journal of Educational Technology & Society*, *25*(3), 112–125.

[e-**ISSN** 2598-5949 | p-**ISSN** 2303-1514]