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Research Article

Translational Process of Enactive, Iconic, Symbolic Representations in Understanding the Concept of Fractions

Topanus Tulak[1*], Abdul Rahman[2], Asdar Ahmad[3]
[1]State University of Makassar, Indonesia
[2]State University of Makassar, Indonesia
[3]State University of Makassar, Indonesia

*Corresponding Author
Topanus Tulak
(topan@ukitoraja.ac.id)

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Abstract: Fraction concept translation studies have been conducted extensively, but there is variability in their application especially in the context of concept understanding by students. In understanding the concept of fractions, students apply representations through enactive, iconic, or symbolic methods. This study aims to describe and analyze the translation process from enactive to iconic representations, as well as from iconic to symbolic in understanding the concept of fractions by students. This research was conducted in North Toraja with the research subject being a third-grade elementary school student. Data were collected through task-based interview sheets, and analyzed using data condensation, data presentation, and conclusion drawing and verification methods. The results showed that third grade elementary school students with a concrete operational level of thinking were able to understand the concept of simple fractions through a translation process from enactive to iconic representations, as well as from iconic to symbolic. This process involves thinking activities through the stages of unpacking the source, preliminary coordination, constructing the target, and determining equivalence.

Keyword: Translation process, enactive representation, iconic representation, symbolic representation, understanding, fraction concept

INTRODUCTION

Representation is the ability to express or interpret ideas in different forms (Suningsih & Istiani, 2021; Utomo & Syarifah, 2021). The form of interpretation or disclosure of student thinking can be in the form of words, tables, writing, drawings, concrete objects, graphs, mathematical symbols, and others. Representation is not only a product, but also a process. Understanding of mathematical objects is related to the existence of internal representations in the representation network and their interrelationships, so as to form meaningful and communicable external representations. The variety of representations that are often used in representing mathematics include: (1) Visual presentations such as tables, graphs, and images; (2) Mathematical statements or symbols; and (3) Written text written in one's own language both formal and informal (Mustangin, 2015; Santia, 2015).

Mathematical literacy in mathematics education is expected of students at all levels of education. Mathematical representation skills are needed by students to understand mathematical concepts and to communicate mathematical ideas (Kaharuddin et al., 2020; Mahendra et al., 2019; Mubarak et al., 2020; Rahman et al., 2017). This opinion was reinforced by Yuniarti (2013), who said that mathematical representation is needed in understanding concepts and solving mathematical problems (Yuniarti, 2013).

Current studies on representational translation tend to focus on the types of errors students make (Molina et al., 2017; Tulak et al., 2022, 2023) and the types of representational translations for specific concepts (Adu-Gyamfi et al., 2019). In the learning process, there have been quite a number of studies that try to provide conditions and situations that allow students to develop mathematical representation skills. However, it has not shown how a detailed process description of the success of mathematical representation is formed, what are the types of difficulties, factors that cause failure or success in mathematical representation skills. Therefore, translation between representations is one of the interesting aspects to be studied further.

The process of representation translation can occur in the process of thinking to understand an idea or concept. This translation is necessary because of the need to accommodate the structure of information in order to obtain mental balance (equilibrium). Translations or shifts in the representation of ideas can lead to maturity of thinking or increased levels of thinking. One of the cognitive theories about the level of thinking is the theory of meaningfull learning by Bruner (Bruner, 1966; Lawton et al., 2012) which connects or relates information to concepts in the cognitive structure with enactive, iconic, symbolic levels (Mcleod, 2019; Tulak & Mangalik, 2019). Bruner's levels of thinking are in line with Piaget's theory of intellectual development, namely:

(1) sensorimotor, (2) preoperational, (3) concrete operations, (4) formal operations. Both levels of thinking are influenced by the cognitive age of the child. The more mature the cognitive age of the child, the more abstract and symbolic the ability to think. In the development of thinking, children will experience enactive, iconic and symbolic phases and in the process children will experience translations in representing ideas/concepts that are thought or solved. The characteristics of each thinking translation experienced by children are interesting information in cognitive psychology theory to underlie the need to design knowledge transfer strategies in learning.

One of the concepts in math that must be understood is fractions. Fractions play a central role in learning math (Siegler et al., 2013). The concept of fractional numbers is not a simple concept but has its own uniqueness that is different from natural numbers and whole numbers (Clarke et al., 2008; Tulak et al., 2022). In addition, the complexity of the characteristics and concepts of fractions requires stages of understanding that make it incomprehensible in a relatively short time (Yusof & Malone, 2003). One of the solutions offered to minimize student errors in understanding the concept of fractions is to start with concrete objects and then be guided to understand something abstract.

In the view of (Bruner, 1966), (enactive, iconic, and symbolic) are related to a person's mental development, and each higher representation development is influenced by other representations. For example, to arrive at an understanding of the concept of fractions for elementary school students, it can be obtained through several related experiences, for example starting with manipulating concrete objects such as oranges, apples, tarts as a form of enactive representation. Then the activity is remembered and produces and enriches through images (such as pictures of oranges, pictures of apples, pictures of square, rectangular, triangular and circular flat shapes) or static perceptions in the child's mind known as iconic representations.

Through this research, it is expected that in understanding the concept of fractions, students start with real objects then they are guided to obtain something abstract, namely the concept of fractions. The use of inappropriate representatives or representations can result in students not being able to understand a concept. In addition, the transition between these representations can also cause students to lose the meaning of the concept itself. The process of moving from the iconic to the symbolic level needs attention in the formation of mathematical concepts. If not careful, this process will become meaningless because symbols have abstract properties and are empty of meaning (Andayani & Amir, 2019; Mandasari, 2018). According to the principle of notation, the achievement of a concept and the use of mathematical symbols must be gradual, from cognitively simple for students to understand then slowly increase to more complex. Bruner (2006), emphasizes that each student experiences and recognizes real events or objects around his environment, then finds by himself to represent these events or objects in his mind. This is often known as a mental model of the events experienced or objects observed and recognized by students (Bruner, 2006).

METHOD

This research is descriptive qualitative research. Descriptive serves to get an overview of a research topic that will be studied further in order to get scientific clarity (Morissan, 2012). This is in line with Yusuf's opinion (2022), that descriptive research is a study by tracing, especially in stabilizing the concepts used in a broader scope of research with a greater conceptual reach. The subject of this research was a third grade student from State Elementary School 2 Rantepao, North Toraja. Subject selection using purposive sampling. This technique is often used in qualitative research to select certain groups of individuals or units that are believed to provide appropriate and useful information (Bisht, 2024). In this case, the subjects were selected based on the considerations or characteristics of the research as well as through interviews with homeroom teachers based on math ability and interpersonal communication skills. The research instrument used was a task-based interview sheet. The data analysis process follows the flow of the Miles & Huberman (1984) interactive model, which includes data condensation, data presentation, and conclusion drawing and verification (Miles et al., 2014). Furthermore, data validity checks through triangulation aim to ensure the truth and consistency of the data (Moleong, 2021). The triangulation used is time triangulation. The use of time triangulation aims to ensure the validity and trustworthiness of the data collected, making the information obtained more complete and reliable.

RESULT AND DICUSSION

This research is qualitative research that aims to describe and analyze the process of enactive, iconic, symbolic representation translation in understanding the concept of fractions. This research involved a third-grade student. This research is in the form of task-based interviews by providing various tools and materials such as bread, fruit (apples and tomatoes), knives, paper, stationery, rulers and colored pencils. In this study, there were two types of questions, namely preliminary questions and translational questions. In-depth interviews were conducted to clarify the subject's expressions and things that were not apparent (for example, when the subject was silent or confused) when the subject did the think aloud. Data collection in the form of transcribed interviews to help researchers in analyzing the process of translating enactive, iconic, symbolic representations in understanding the concept of fractions.

The third-grade student who was the subject in this study, in the interview results revealed that the subject could observe the objects on the table well and mention them one by one appropriately. Based on experience at school, the subject stated that these tools and materials can be used to describe fractions using paper and pens. From this interview, it is known that the subject can identify the problem by mentioning the objects on the table based on the subject's own experience. This process is known as the unpacking the source stage.

When the subject identified that the objects could be used to represent fractions, the researcher continued with a task-based interview to explore the subject's understanding in connecting the information that had been identified with the concept of fractions that had been understood. During the task-based interview, the subject was also able to manipulate objects by using tomatoes to divide into fractions of 1/2, 1/3, 2/3, and 1/4 as instructed. Furthermore, the subject can depict the tomato fruit into a picture using paper and pen, by drawing and shading. This process of connecting information to manipulate concrete objects (tomatoes) to build iconic representations is referred to as the preliminary coordination stage.

After successfully connecting the information with the understood concept, the subject then transferred the information from the source representation (enactive) to the target representation (iconic) through task-based interviews. During this process, the subject succeeded in constructing tomatoes divided into fractions of 1/2, 1/3, 2/3, and 1/4 into the picture. Although the subject had difficulty in explaining the fraction 2/3, the subject revealed that apart from using a square, this fraction could also be illustrated using a circle. This process in transferring information from enactive to iconic is called the constructing the target stage.

After going through these three stages in the translation process, the researcher conducted an additional interview to ensure the target representation produced was appropriate. In the follow-up interview, the subject re-examined the tomatoes that were divided and the rectangular drawing he made, to ensure that the division was in accordance with the correct form and properties of fractions. This process of checking the suitability between enactive and iconic representations is referred to as the determining equivalence stage.

Based on the description of the data that has been explained from the results of the research conducted, it is known that the subject is able to carry out the process of translating enactive representations to iconic representations as shown in diagram 1 below:

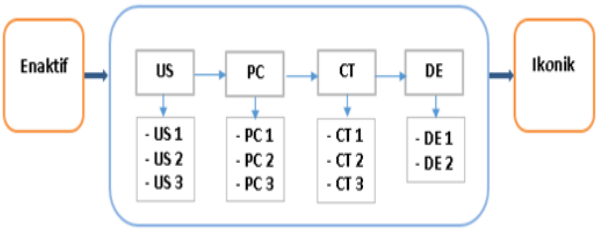

Table 1 Description of subject data exposure in the process of translating enactive representation to iconic representation

Code	Description	Code	Description
US	**Unpacking the Source Stage**	**CT**	**Constructing the Target Stage**
US 1	Observes the objects prepared on the table and mentions one by one correctly	CT 1	Able to construct a tomato fruit in the form of a fraction into a square drawing by shading the part that shows the fraction
US 2	Knowing that the tools and materials can be used to explain a fraction	CT 2	Revealed that apart from using a box shape to represent fractions, one can also use a circle shape
US 3	Conveyed that previously they had learned fractions from the teacher through drawings using paper and pens by drawing the shape of fractions	CT 3	Concluded that a fraction is a part of a whole
PC	**Preliminary Coordination Stage**	**DE**	**Determining Equivalence Stage**
PC 1	Conveying that apart from using paper and pens to represent fractions, you can also use tomatoes or sliced bread	DE 1	Paying attention to the whole process again by trying to divide the tomatoes equally and the drawing made
PC 2	Splitting tomato to demonstrate fractions	DE 2	Ensure that the target representation in the form of a drawing is appropriate
PC 3	Showed that the tomato halves can be brought into the shape of shaded squares that represent fractions		

Because the subject was able to translate from enactive representation to iconic representation on simple fractions, so the research continued to see the translation process from iconic representation to symbolic representation. This study used task-based interviews to

identify problems in understanding the concept of fractions.

From the interview, the subject observed the objects on the table well and mentioned them accurately based on experience, including teaching about fractions through pictures by the teacher. The subject also revealed that fractions can be depicted in the form of a square or circle, according to the learning experience at school. The process of identifying this problem is referred to as the unpacking the source stage.

Since the subject could reveal that the objects on the table could be used to show fractions, the researcher continued the task-based interview to explore the subject's understanding in connecting the identified information with the concept of fraction properties that had been understood.

During the interview, the subject also revealed that in addition to using rectangular images, fractions can also be represented in circular images. The subject can coordinate the information from the picture with the concept of the nature of fractions that has been understood, focusing on the concept of part of the whole. This process, to construct a symbolic representation of the information that has been identified, is referred to as the preliminary coordination stage.

After that, the researcher conducted another interview to understand how the subject transferred information from iconic representation to symbolic representation in simple fractions. From the interview results, it was revealed that the subject could construct simple fraction images such as 1/2, 1/3, 2/3, and 1/4 into fraction symbols 1/2, 1/3, 2/3, and 1/4. The subject can also explain the concept of fraction a/b as part of a whole consisting of a part taken from b equal parts. In this task-based interview, the process of transferring information from iconic representation to symbolic representation on simple fractions is referred to as the constructing the target stage.

After going through the three stages of translation, the researcher conducted additional interviews to ensure that the symbolic representation produced by the subject was correct. From the results of the additional interview, the subject re-checked the suitability of the iconic representation to the symbolic representation by ensuring equal division in the drawing and marking according to the fraction symbol. Although the size of the picture is not the same because it does not use measuring instruments, the subject still understands the concept of part of the whole. This checking process is referred to as the determining equivalence stage in the translation of iconic representation to symbolic representation.

Based on the description of the data that has been described, the process of translating iconic representations to symbolic representations carried out by the subject is shown in diagram 2 below:

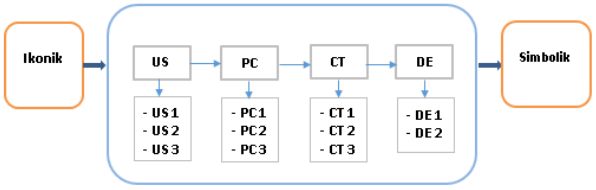

Table 2 Description of subject data exposure in the process of translating iconic representation to symbolic representation

Code	Description	Code	Description
US	**Unpacking the Source Stage**	**CT**	**Constructing the Target Stage**
US 1	Observes the objects prepared on the table and mentions one by one correctly	CT 1	Construct a picture of simple fractions into fraction symbols
US 2	Conveying that previously they had learned fractions from the teacher through picture media	CT 2	Understand the concept of a/b fractions where a is a shaded part of a whole consisting of b equal parts
US 3	Conveying that fractions can be shown by drawing the shape of the fraction into a square or circle based on the experience gained from the teacher at school	CT 3	Concluded that a fraction is a part of a whole
PC	**Preliminary Coordination Stage**	**DE**	**Determining Equivalence Stage**
PC 1	Revealed that besides using a square image in describing a fraction, one can also use a circle image	DE 1	Rechecking the suitability by trying to divide equally in the shape of the picture and shading the part according to the symbol/symbol of the fraction number
PC 2	Understand the concept of fraction as part of a whole	DE 2	Ensure that the target representation in symbol form is appropriate
PC 3	Coordinate information in the form of drawings with concepts that are already		

	understood by focusing on the concept of part of the whole		

Based on the description of the data that has been described, the process of translating enactive, iconic, symbolic representations in understanding the concept of fractions in the subject can be depicted in diagram 3 below:

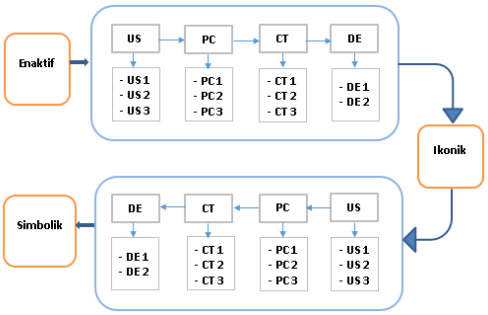

Diagram 3 Simplification of the translational process of enactive, iconic, symbolic representations in understanding the concept of fractions of the subject

Translational Process of Enactive Representation to Iconic Representation

The enactive to iconic representation translation process carried out by third grade students in this study went through four stages of translation, namely unpacking the source, preliminary coordination stage, constructing the target stage and determining equivalence stage. At the unpacking the source stage, students analyze the information in the source representation by observing the objects available on the table and mentioning them one by one correctly. During the interview process, students were able to compare the problems faced with the problems solved previously where students revealed that the tools and materials available on the table can be used to explain a fraction based on previous experiences that have been learned and taught by teachers at school. This shows that at the unpacking the source stage, students need an understanding of the problem situation in the form of objects, data, rules, sentences and phrases to interpret the problem.

After going through the unpacking the source stage followed by the preliminary coordination stage, this stage is done after students identify problems to understand the concept of fractions. At this stage students reveal that concrete objects such as tomatoes and bread available on the table can be used to show a fraction. Students are able to manipulate objects, namely tomatoes, in understanding the concept of fractions, where students are able to demonstrate by splitting tomatoes and showing the parts according to the fraction form. This is in line with Bruner's level of thinking and the theory of intellectual development by Piaget, namely the level of thinking is influenced by the cognitive age of the child where children aged 7 to 11 years at this stage can understand concepts concretely. However, in this study it was found that grade III students still have difficulty in dividing concrete objects into equal fractions, this can be seen from the shape of the tomato which is divided into several parts that do not look the same shape of each part. In this case there is an adaptation phase where students realize that what they are doing is in accordance with the concept of dividing equally even though technically students are not able to do it but students assume that it is equal.

In this study, it was also found that third grade students did not recognize mixed fractions and only arrived at simple fractions. During the triangulation of fractions, students were able to understand the part of the whole of each fraction practiced through tomatoes by cutting the tomatoes according to the number of parts that show the fraction according to the triangulation tested. At this stage, students' thought process develops from ideas to relationships between representations.

The third stage that is passed in the process of translating enactive representation to iconic representation is the stage of constructing the target. In this stage students still have difficulty in dividing the box into equal parts. This can be seen from the shape of the box drawn which shows that a fraction is not equal because students do not use a ruler to draw but only estimate that the box they made is equal. In this case there is also an adaptation phase where students realize that what they are doing is in accordance with the concept of dividing equally even though technically students are not able to do it but students assume that it is equal.

The last stage is the determining equivalence stage. This stage rechecks the suitability of the enactive representation to the iconic representation to ensure the resulting target representation is correct. At this stage students rechecked all the activities they did in the process of translating enactive representations to iconic representations and made sure that everything they did was correct according to what was learned and taught by the teacher at school. This shows that this stage is dominated by the verbal description of the solution. This verbal situation is a stimulus for students to believe that the entire solution process is correct.

Translational Process of Iconic Representation to Symbolic Representation

The process of translating iconic representations to symbolic representations carried out by third grade students in this study also goes through four stages of translation, namely the unpacking the source stage, the preliminary coordination stage, the constructing the target stage and the determining equivalence stage. At the unpacking the source stage, students again observe the objects available on the table and mention them one by one the objects available on the table. During the interview process, the student was able to compare the

problem faced with the problem solved previously where the student conveyed the way the teacher explained about fractions using pictures in the form of a square, rectangle or circle shaded according to the shape of the fraction. This shows that at the unpacking the source stage, students need an understanding of the problem situation in the form of objects, data, rules, sentences and phrases to interpret the problem.

After going through the unpacking the source stage, it continued to the preliminary coordination stage, this stage was carried out after students identified the problem to understand the concept of fractions. At this stage students explain that in showing a fraction students prefer to use a square or rectangle because it is easier to divide equally than if using a circle. Students are able to explain that a square or rectangle that is divided into two equal parts each has a value of one-half so that if it is brought into the form of a picture then one part between the two parts is shaded which shows the value of one-half. At the time of triangulation, students were able to understand the part of the whole of each fraction described by shading the number of parts showing the fraction according to the triangulation tested. This is in line with (Khairunnisak et al., 2012) that students' prior knowledge greatly affects their learning process. Based on the research data, it is known that students connect the information/information that has been explored with concepts that are already understood and prepare information that might be used to construct the target representation. At this stage, students' thinking process develops from ideas to relationships between representations.

The third stage that is passed in the process of translating iconic representations to symbolic representations is the stage of constructing the target. In this stage students are able to construct solutions through symbolic representations but only in simple fractions with small numerators such as one to two only, for numerators of more than two it is still difficult for grade III students to understand because the thinking patterns of children of this age are still at the concrete thinking stage so it is still difficult to represent symbolically. This is in line with Bruner's level of thinking and the theory of intellectual development by Piaget, namely the level of thinking is influenced by the cognitive age of the child where children aged 7 to 11 years at this stage can understand concepts concretely.

The last stage is the determining equivalence stage. This stage rechecks the suitability of the iconic representation to the symbolic representation to ensure that the resulting target representation is correct. At this stage students recheck all the activities they do starting from the unpacking the source stage to the constructing the target stage and ensure that everything they do is correct according to what the teacher has learned and taught at school. This verbal situation is a stimulus for students to believe that the entire solution process is correct.

When viewed from the representations produced by students at each stage of the translation process, it tends to involve coordination between representations to continue the solution process. This complements the findings (Jazim & Rahmawati, 2020) that the process of translating representations in solving mathematical problems occurs indirectly, namely through two translation processes, namely verbal translation to graphics (images) then to symbols. This representation translation process is generally carried out through four stages, namely unpacking the source, preliminary coordination stage, constructing the target stage and determining equivalence stage. This has implications for the approach to learning mathematics. When introducing concepts, it is assumed that students' understanding is still low, so they need concrete things to reduce the level of abstractness of mathematical concepts (Geller et al., 2017). This is in line with Baroody's opinion, that mathematics learning can be improved if changes are made not only in the curriculum, but also in the way mathematics is taught to students (Baroody, 2004).

CONCLUSION

Based on the results and analysis, the conclusion of this study is that third grade elementary school students in the concrete operation thinking phase can understand the concept of simple fractions by translating enactive representations to iconic representations, and from iconic representations to symbolic representations. This happens through thinking activities that include unpacking the source stage, preliminary coordination stage, constructing the target stage, and determining equivalence stage.

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