Students’ Translation Ability of Mathematical Representations (Symbolic and Visual) Based on Their Learning Styles

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Students’ Translation Ability of Mathematical Representations (Symbolic and Visual) Based on Their Learning Styles

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Abstract. This qualitative study aims to describe students’ ability of translation between mathematical representations (visual and symbolic) of visual, auditory or kinesthetic learners. The students’ translation ability between mathematical representations was seen from the process undertaken during the translation, namely: unpacking the source, preliminary coordination, constructing the target, and determining equivalence. The participants of this study were three junior high school students with different learning styles, having the similar mathematical ability. The participants were given a translation ability test between mathematical representations and followed by semi-structured interviews. Then, the data were analysed by step of data condensation, data display and conclusion. The results of this study showed that at the unpacking the source stage, they are able to unpack the representations of a given resource by identifying the information contained in the source representations. At the preliminary coordination stage, they can prepare a formula or strategy as a first step to determine the target representations. In the constructing the target, they can transfer information obtained from the source representations to form a target representations. At the determining equivalence, they consider the target representations made by the representations of the given source.

1. Introduction
Representation is one of the mathematical skills that should be mastered by students in learning mathematics [1] due to it is very important for students and related to communication skills and problem solving closely [1-5]. Representation is defined as any configuration of characters, images, concrete objects etc., that can symbolise or “represent” something else [6-8]. In psychology representation can be viewed as the process of modeling concrete things in the real word into abstract concepts or symbols [9]. Many experts divide the form of mathematical representation into several types such as graphs, images, diagrams, words, manipulative and symbol forms [9-12].

In the learning process, students not only used one representation but also required to use multi-representations [13,14], because the ability of students in using various forms of mathematical representation can affect mathematical abilities [15], students can understand broader mathematical concepts and solve mathematical problems in various forms of representation [14,16].

Besides being able to use various representations, students are also required to change the form of representation [17, 18]. The ability of students to change the form of mathematical representation can be known by doing the translation. Translational ability between representations is very important in mathematics learning [19], because with translation skills students can express mathematical ideas [19] and also students have access to a broader set of strategies in problem solving [20, 21].
Translation between mathematical representations is the process of changing a given mathematical representation (source representation) into another requested mathematical representation (target representation) [17, 20-22]. Translation and the translation process are psychological forms (mental processes), intellectual and cognitive processes that are transformed into source mathematical representations into target representational forms [22]. The translation of the mathematical representation is done through four stages: unpacking the source, preliminary coordination, constructing target, and determining equivalence [21].

Many researchers have examined translation between representations, but are limited to only a few representations. There was a study of the translation between verbal representations and symbols [20], translational representations between verbal representations and graphs [18], translational representations between visual and verbal representations [17]. The findings of some previous studies showed that each number of students made mistakes in transcribing between representations [17, 18, 20]. This study will make the students’ translation of symbolic and visual representations of the material of straight-line equations.

Previous research has been proven that students who have different learning styles (visual, auditory and kinesthetic) will choose mathematical representations that suit their needs in solving mathematical problems [23] and students have different learning styles have different translation skills and representations skills in learning [8]. This study focuses on students who have visual, auditory, and kinesthetic learning styles.

2. Methods

This research was a descriptive research with a qualitative approach that aimed to describe the ability of students in visual, auditory, and kinesthetic learning styles in translating between mathematical representations. Subjects in this study consisted of 3 subjects taken from 42 students in one school of Surabaya. The three selected subjects had different learning styles: visual, auditory and kinesthetic. The data used in this study were collected on March 2018. The instruments used in the study consisted of learning style test, math ability test, and translation ability test between mathematical representations, as much as two matter taken from equation of straight-line equation. The learning style questionnaire and mathematics ability test was used to determine the subjects in the research, while the translation ability test was used to identify ability of students in doing translation between representations. The translation ability test between mathematical representation is shown in Table 1.

| Table 1. Translation ability test between mathematical representations. |
|-------------------------------------------------|
| Translations from Symbol to Visual Test | Translations from Visual to Symbol Test |
| Sketch the graph of the line equation follow | Determine the equation of the graph follow. |
| $2x + y = 4$. | |

The ability of the students in conducting the translation analysed in this research was the ability of the students in performing the translation between representation through four stages of translation of mathematics, i.e., unpacking the source, preliminary coordination, constructing target, and determining equivalence [14]. The research adapted from these four stages. The indicators were created based on Indonesia’s student culture. The translational indicator between the mathematical representations was described in Table 2.
| Stages of Translation | Indicator |
|-----------------------|-----------|
| Unpacking The Source  | Identifying the form of visual representation/symbol representation, and mentioning the existing information in the form of visual representation or symbol representation and visual representation/symbol representation symbol to be searched. |
| Preliminary Coordination | Determining the strategy/plan for the initial formation of target representations based on existing information on visual representation or symbol representation. |
| Constructing the Target | Transferring information that exists in the visual representation/symbol representation into the initial strategy/plan of formation (Formulation). Form a visual representation or symbol requested in the question. |
| Determining Equivalency | Looking again at the conformity between the visual representation/symbol representation formed by the visual representation or symbol representation in the question. |

Adapted from [17]

3. Results

3.1. Translations from Symbol Representations to Visual Representations

3.1.1. Visual Learner

The translation ability of visuals learner from symbol representations to visual representations shows in Figure 1.

![Figure 1. Translation from Symbol Representations to Visual Representations by Visual Learner](image1)

In the unpacking the source stage the visual learner student could unpack the symbol representation by identifying and mentioning the existing information on the symbol representation of the equation $2x + y = 4$. In the preliminary coordination stage the students replaced the variables $x$ and $y$ variables with 0. In the stage student was able to transfer information into the plan of visual representation formation by substituting $x = 0$ and $y = 0$ into the line equation so that students obtain the coordinate points from the graph $(0, 4)$ and $(2, 0)$, then the students draw a line equation graph. At determining equivalency stage the student adjusted the visual representation with the symbol doing the truth check by recreating the line equation of the graph formed.

3.1.2. Kinesthetic Learner

The translation ability of kinesthetic learner from symbol representations to kinesthetic representations shows in Figure 2.

![Figure 2. Translation from Symbol Representations to Visual Representations by Kinesthetic Learner](image2)
The translations performed by kinesthetic learner was the same as visual learner students. In the unpacking stage the kinesthetic learner unpacked the symbol representation by identifying and mentioning the existing information symbol representation of the line equation $2x + y = 4$. In the preliminary coordination stage the student replaced the variables $x$ and $y$ variables with 0. In the stage student was able to transfer information into the plan of visual representation formation by substituting $x = 0$ and $y = 0$ into the line equation so that student obtained the coordinate points from the graph $(0, 4)$ and $(2,0)$, then the student drawn a line equation graph. At this stage the student adjusted the visual representation with the symbol doing the truth check by recreating the line equation of the graph formed.

3.1.3. Auditory Learner
The translation ability of auditory learner from symbol representations to auditory representations shows in Figure 3.

![Figure 3. Translations from Symbol Representations to Visual Representations by Auditory Learner](image)

Based on Figure 1-3 in the unpacking the source stage, preliminary coordination, and constructing the target of auditory learner perform the same process with visual and kinesthetic learning styles, but which differentiate among the three students at the determining equivalence stage. In the determining equivalence stage the auditory-style students re-check the coordinate points obtained as revealed by the students in the following interview:

ISP  Why do you believe in your answer?
SA  Because this equation through 2 coordinates, so I believe that two coordinate are correct.
ISP  How do you re-examine your answer?
SA  I checked these two coordinate points correctly or not and I also checked the graphs that I made were appropriate or not.

3.2. Translations from Visual Representations to Symbol Representations
3.2.1. Visuals Learner
The translation ability of Visuals Learner from visual representations to symbol representations shows in Figure 4.

![Figure 4. Translations from Visual Representations to Symbol Representations by Visuals Learner](image)

In the unpacking the source stage, student identified the line graph that became the source representation to know and understand the information contained in the graph. So student could name information that is known from the graph. At the preliminary coordination stage, the student used the
formula \( \frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1} \) to determine the equation of the given line. In the stage of constructing the target student transferred the information they have that is two point coordinates through which the line into the formula used to determine the equation of the given line. The third subject entered the known coordinate e.g., point (0, 3) and point (-5,0) into the formula \( \frac{y - y_2}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1} \) by substituting \( x_1 = 0, x_2 = -5, y_1 = 3 \) and \( y_2 = 0 \) to obtain the \(-5y + 3x = -15\) equation which is the symbolic representation of the given line graph. At the determining equivalence stage, the student learned visually to recreate the graph from the graph equation \(-5y + 15 + 3x = 0\) formed.

3.2.2. Kinesthetic Learner

The translation ability of kinesthetic learner from visual representations to symbol representations shows in Figure 5.

![Figure 5](image)

The translations of kinesthetic learner was the same as the translations of visual learner. In the unpacking the source stage, student identified the line graph that became the source representation to know and understand the information contained in the graph. So student could name information that is known from the graph. At the preliminary coordination stage, the student used the formula \( \frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1} \) to determine the equation of the given line. In the stage of constructing the target student transferred the information that is two point coordinates through which the line into the formula used to determine the equation of the given line. The third subject entered the known coordinate points e.g., point (0, 3) and point (-5,0) into the formula \( \frac{y - y_2}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1} \) by substituting \( x_1 = 0, x_2 = -5, y_1 = 3 \) and \( y_2 = 0 \) to obtain the \(3y - 5x = -15\) equation which is the symbolic representation of the given line graph. At the determining equivalence stage, the visual learner to recreate the graph from the grnd equation \(3y - 5x = -15\) formed.

3.2.3. Student in Auditory Learning Styles

The translation ability of auditory Learning Styles student from visual representations to symbol representations shows in Figure 6.

![Figure 6](image)

Based on Figure 4-6 in the unpacking the scourge stage, preliminary coordination, and constructing the target of Auditory Learner performed the same process with visual and kinesthetic learner, but which differentiate among the three students at the determining equivalence stage. At the determining
equivalence stage the auditory learner re-entered the known coordinate points (−5,0) and (0.3) into the −5y + 3x = −15 equation.

4. Discussion
Based on the result, in general, the three students were able to translate between visual representations into symbols and symbols to visuals. To form a target representation the three students dismantled the source representation by identifying and mentioning the initial information contained in the representation of the source provided. It was consistent with research that reveals that the initial step to form a target representation of students had to dismantle the source representation by identifying to know the initial information needed to form a charger representation [21]. Furthermore, the three subjects made the initial formulation to form a target representation at the preliminary coordination stage. The three subjects were able to form the target representation requested based on the initial formulation made previously. In translating between visual representations to symbols the three subjects formed different representations such as students learning visual learning style making -5y + 15+ 3x = 0, students with kinesthetic learning style made 3y-5x = -15, while students with auditory learning style made -5y + 3x = -15, while in translating symbols into visuals the three students formed the same graph. Similarities and different forms of representation made by students based on their understanding of mathematical concepts that had been known before. It was based on the theory which states that students who had different learning styles will choose the form of representation according to their understanding and needs [9, 23].

Next, the students did the final step in translating between representations, namely determining equivalence. At this stage we could see the difference in the translation process carried out through the translation stages. In translating visual representations to symbols, the visual and kinesthetic learners re-created the representation of the visual representation of the form, while the auditory-style students only checked the two coordinate points generated, because the line could only be make two coordinate points, the student was able to perform the last stage in pass translation. In the translation of symbol representation into visuals, the auditory learners re-entered the known coordinate points (-5.0) and (0.3) into the line equation. Whereas students studied visual and kinetic recreating the graph from the line equation formed. This stage showed that the third students were able to translate representations well. It was based on previous research which showed that students with good math skills will translate well [9, 20, 21].

The results of this research indicated that the translation ability between student representations influenced by an understanding of the mathematical concepts that have been studied. The better the students' mathematical abilities, the better the translation between representations [9, 20, 21].

5. Conclusion
Based on the result of the study, we concluded that the students’ of visual, kinesthetic and auditory styles are able to make translation between mathematical representation (visual and symbolic) through the translation process (1) Unpacking the sources; (2) Preliminary coordination; (3) Constructing the target; (4) Determining equivalence. At the unpacking the source stage, they are able to unpack the representations of a given resource by identifying the information contained in the source representations. At the preliminary coordination stage, they can prepare a formula or strategy as a first step to determine the target representations. In the constructing the target, they can transfer information obtained from the source representations to form a target representations. At the determining equivalence, they consider the target representations made by the representations of the given source.

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