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An analysis of mathematical representation ability middle school students on concept congruence on learning style

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Mathematical representation ability; Concept congruence; Learning style.

Abstrack
The ability of mathematical representation helps students solve mathematical problems in forms that are easy to understand and more concrete, so that they can maximize their potential for achievement in learning mathematics. The purpose of this study was to describe the mathematical representation abilities of junior high school students on the concept of congruence in terms of learning styles. The subjects of this study were 35 grade VIII junior high school students using a random sampling technique. Data collection was carried out using mathematical representation ability tests, learning style questionnaires, and interviews. After that, it was analyzed using triangulation techniques to determine the validity of the data. The results showed that on average, students have very good visual representation abilities with auditory, visual, and kinesthetic learning styles because all students can solve questions correctly according to the indicators. Students who have the ability to represent good expressions or equations have a visual learning style. Whereas students with word representation abilities cannot be said to be good because of the existing subjects, there are no students with any learning style who can solve word representation ability questions correctly. Based on this, it can be concluded that the low representation ability of students is not influenced by their learning styles, both visual, auditory, and kinesthetic, especially in the concept of congruence.

INTRODUCTION

A myriad of elements coalesce to shape the success trajectory in learning. These constituents encompass students, educators, instructional methodologies, the learning environment, external surroundings, and parental involvement, all of which collectively influence the learning process's outcome (Buchari, 2018; Nurfadhillah et al., 2021; Saihu, 2022). Acquiring mastery over learning materials significantly bolsters students' performance, particularly when underpinned by fundamental problem-solving skills. An essential foundational skill in mathematical learning is mathematical representation (Handayani & Juanda, 2018; Nurbayan & Basuki, 2022).

Employing mathematical representation skills enhances students' comprehension and problem-solving capabilities, making the learning process more efficient. Furthermore, it plays a pivotal role in daily life, for instance, in decoding graphical information, tables, and diagrams, that are prevalent in diverse fields like science and technology (Arianti, 2021; Dehani, 2019). Mathematical representation can be demonstrated visually (e.g., graphs, tables, sketches), through expressions or equations (e.g., mathematical models), or in verbal form (Supandi et al., 2018; Waluya, 2020). This aptitude empowers individuals to express and manifest mathematical thoughts lucidly and systematically, aiding students in forming clear mental imagery of the concepts (Muhamad, 2017).

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Skills in mathematical representation can facilitate students in constructing concepts and articulating mathematical ideas, thus fostering their development (Muhamad, 2017; Noer & Gunowibowo, 2018). The topic of congruence is an integral component in building mathematical concepts (Hidayanti et al., 2016; Marthani & Ratu, 2022). It serves as a catalyst in strengthening spatial abilities, enhancing visualization skills, and mastering concepts (Kariadinata, 2010). Additionally, grasping the concept of similarity aids students in resolving various measurement and comparison-related problems (Cahyaningsih, 2018). Therefore, a sound understanding of congruence is vital in learning mathematics, which further lays a foundation for grasping more complex concepts and resolving daily life problems, while also improving students' representation skills.

However, students' proficiency in mathematical representation remains deficient due to their struggles in converting mathematical ideas into models, a challenge that pervades not just in Indonesia but even in developed nations like South Korea (Handayani & Yanti, 2017; Kim et al., 2017; Sabrina & Effendi, 2022; Syabaniah & Nuraeni, 2023). To address questions related to mathematical representation, students require a robust skill set in this domain (Komala & Suryadi, 2018; Waluya & Asikin, 2021). Hence, educators must consider factors impacting students' mathematical representation skills to tailor the learning experience according to their needs.

Student awareness of their preferred learning style can minimize this gap. A comprehension of students' learning preferences can significantly influence their mathematical representation abilities (Danaryanti & Noviani, 2015). Learning style pertains to an individual's predilection for processing and assimilating information to understand and retain learning materials (Lestari & Djuhan, 2021). When students learn in alignment with their preferred style, their engagement and motivation in the learning process elevate (Nuralan et al., 2022).

Students exhibit varying learning styles. For instance, those with visual or graphic preferences grasp mathematical concepts more efficiently through pictures, graphs, or diagrams (Asela et al., 2020). They excel at using visual representations to depict mathematical problems, apply models, or demonstrate relationships between concepts. Students with auditory or verbal learning styles show greater receptivity to information delivered orally or through words (Setiawan & Waspodo, 2015). They excel in verbalizing mathematical concepts, discussing them in groups, or presenting verbal solutions. Students with a kinesthetic learning style learn best through physical experiences and actions (Rambe & Yarni, 2019; Wassahua, 2016). They actively participate in practical activities like manipulating physical objects, using instructional media, or participating in mathematical simulations.

Previous studies examining mathematical representation abilities and learning styles have found that different styles impact students' visual, verbal, and symbolic representation skills in problem-solving (Azzahra & Sopiany, 2023; Natonis et al., 2022). Other research explores if mathematical representation skills and learning styles can enhance contextual mathematical problem-solving skills (Setyawati et al., 2022) and mathematical communication (Suyandi et al., 2022). Moreover, studies demonstrate that mathematical representation skills and learning styles can boost understanding of circle topics (Sanjaya et al., 2018), lines and series (Ramadhana et al., 2022), quadratic functions (Sinaga & Hartoyo, 2015), and algebraic arithmetic operations (Klara et al., 2021). However, no prior research analyzes junior high school students' mathematical representation skills on the topic of congruence in relation to

learning styles, backed by data triangulation techniques for validating the findings. Therefore, this study aims to analyze the proficiency of junior high school students in mathematical representation, particularly concerning the concept of congruence, in terms of learning styles.

METHODS

This research employs a descriptive-qualitative methodology with an embedded case study approach (Doyle et al., 2020). This strategy enables a more nuanced examination of the conditions under study, generating data in both written and oral formats from the observed subjects (Ulfatin, 2022).

Participants

The study comprised 35 students from a junior high school located in Bandar Lampung. The cohort was selected using a random sampling technique, an approach that allows for unbiased participant selection, disregarding individual capabilities (Firmansyah, 2022).

Instrumen

The research data were procured using written tests and questionnaires. The tests were designed to assess the mathematical representation abilities in tackling geometric problems, while questionnaires were utilized to gather information pertaining to students' learning styles. The procedure of the instrumentation is graphically presented in Figure 1.

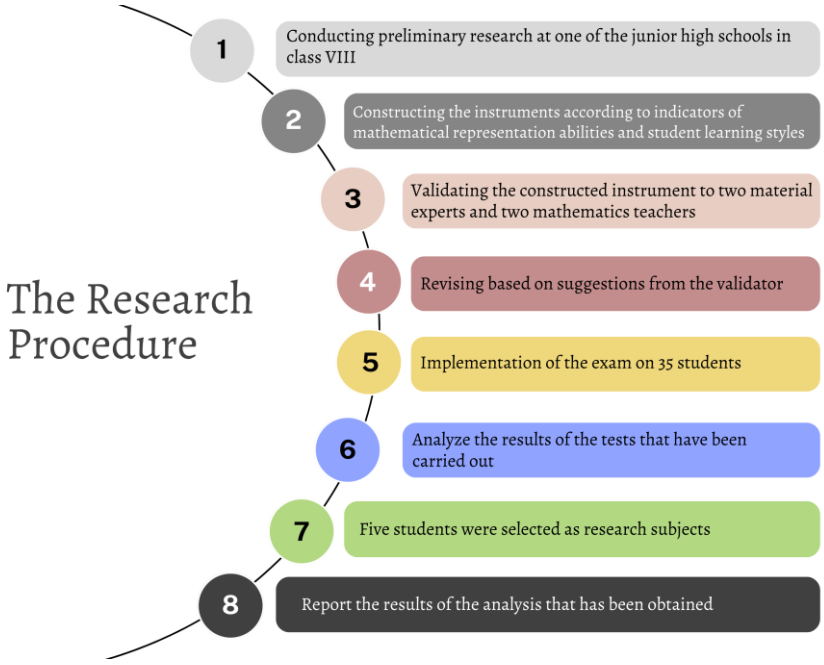

Figure 1. The Research Procedure

Data Collection

In this study, a triangulation technique is employed. This approach facilitates the validation of findings and curtails the potential biases that might arise from disparate techniques (Arini, 2017). Specifically, tests of mathematical representation abilities and interviews with research subjects are used. The procedure for the data triangulation technique is illustrated in Figure 2.

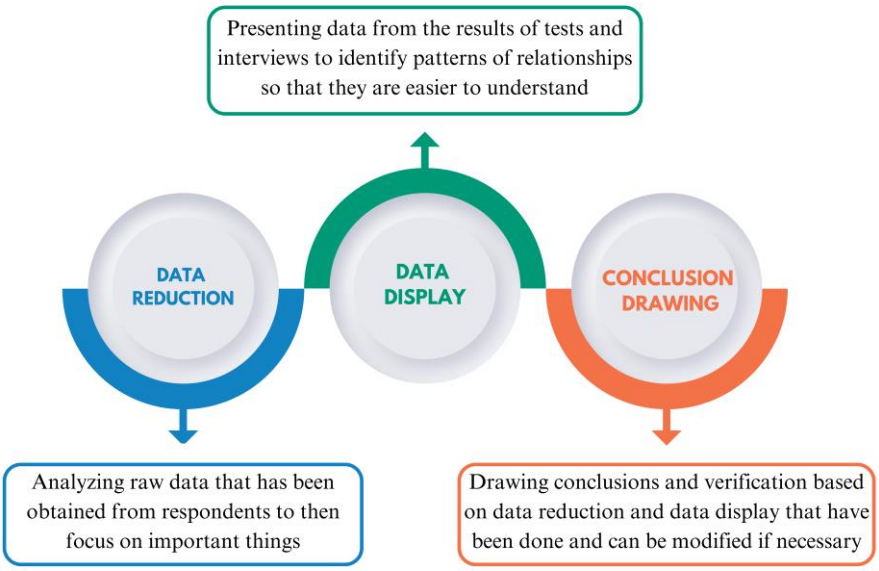

Figure 2. Procedure Teknik Triangulasi

RESULT AND DISCUSSION

The mathematical representation abilities gauged in this study include visual representation, representation of mathematical expressions, and representation of words or written text. Meanwhile, the learning styles assessed are visual, auditory, and kinesthetic.

Visual Representation Ability

Visual representation ability is assessed based on the students' responses to specific questions, with indicators revolving around the use of visual representations to solve problems. Figure 3 portrays the questions and characterizes students' responses on visual representation abilities.

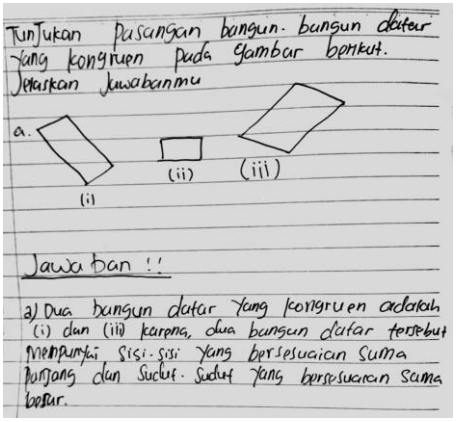

Figure 3. Student answers on visual representation ability

For question number 1, depicted in Figure 3, all students successfully analyzed the image correctly. From their responses, it's apparent that students could adequately dissect the presented images. This interpretation aligns with the students' responses post-interview with five selected subjects. The interviews revealed that students could scrutinize the image as they comprehended the meaning and forms of congruence concerning side lengths and angles.

The results from the learning style questionnaire reveal that students with visual, kinesthetic, and auditory learning styles provided accurate answers devoid of errors. Based on test results, questionnaires, and interviews, it's deduced that students are proficient in interpreting the purpose of the questions and comprehending the meaning and forms of congruence. This indicates that the average visual representation ability concerning this question is commendable.

Equations Representation Ability

The ability to represent mathematical expressions or equations is evaluated based on students' responses when tackling specific questions. These questions use expression or equation representations as indicators to solve problems. Figure 4 illustrates the questions and outlines students' responses regarding expression and representation skills.

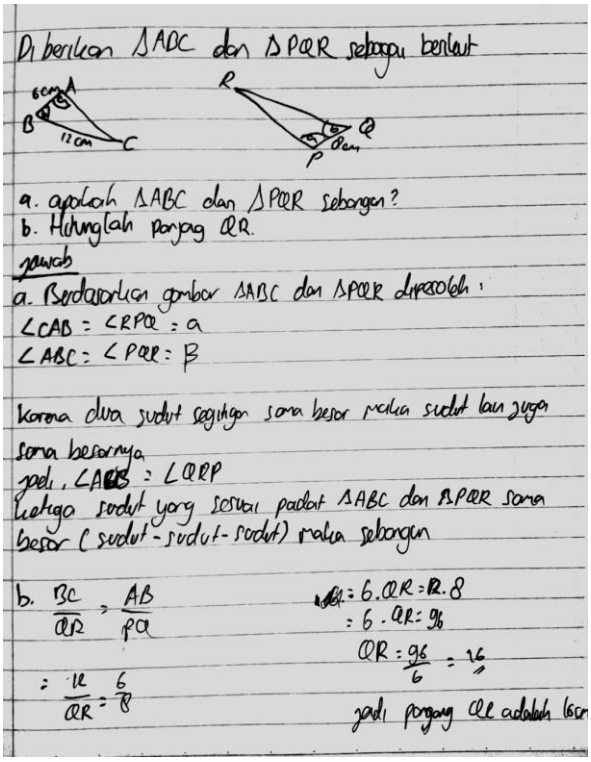

Figure 4. Student answers on equations representation ability

In response to question number 2, as shown in Figure 2, a majority of students accurately answered the questions. A minority made errors. Evidently, students could recognize the given questions, devise a plan to solve the problem, and apply the correct concept regarding the side lengths utilized in the equations within the image. Therefore, a handful of students provided accurate responses to these items. Nevertheless, some students struggled to solve the problem correctly. This is attributable to the students' inability to differentiate the side lengths applicable in the concept of congruence. Based on interviews, students could solve problems proficiently as they identified images and grasped the concept of congruence, thus they were able to derive equations and express them in the form of a mathematical model. However, interviews with students who failed to answer the questions correctly revealed that they were confused in formulating the problem mathematically, resulting in incorrect equations.

From the learning style questionnaire, it's apparent that students with a visual learning style predominantly provided accurate answers without errors. Students with kinesthetic and auditory learning styles could provide correct answers, but their reasoning was often inaccurate. Based on test results, questionnaires, and interviews, it's concluded that students could interpret the purpose of the questions, but they struggled to apply the concept of congruence correctly. This indicates that the average ability to represent expressions or equations regarding this question is satisfactory.

Words Representation Ability

The capability to represent words is evaluated through the presentation of students' responses when addressing given questions, with indicators employing word representations to solve problems. Figure 5 exhibits the questions and characterization of students' responses regarding word representation ability.

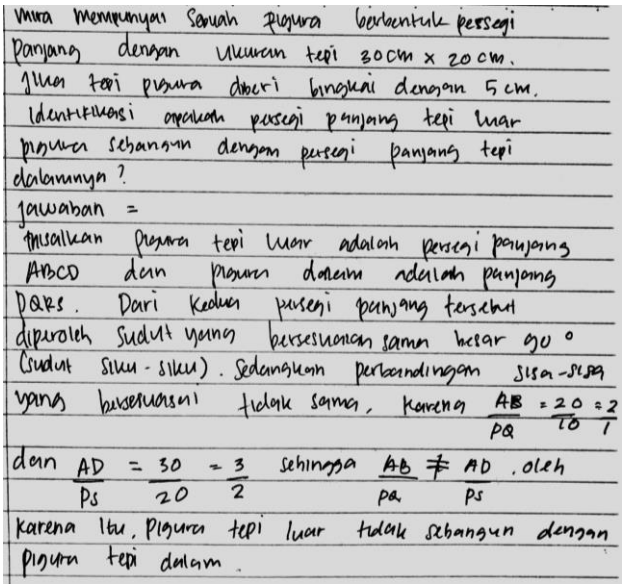

Figure 5. Student answers on words representation ability.

In the context of question number 3, as depicted in Figure 5, all five students stumbled in providing correct answers. Students were unable to visually depict the sentences contained in the questions, hence the received answers were not in line with the previously learned concept of similarity. It would be beneficial for students to initially visualize the problem in the form of an image for a correct analysis, in accordance with their understanding of the problem. Students seem to struggle in interpreting words and identifying the crux of the problem. Based on interview findings, students do possess knowledge of the necessary concepts, yet they misinterpret them, leading to incorrect problem-solving.

When analyzed through the learning style questionnaire, students with visual, auditory, and kinesthetic learning styles could not provide answers in line with the intended objectives of the questions. Based on the test results, questionnaires, and interviews, it can be inferred that some students struggle to correctly comprehend the objectives of the questions, thereby resulting in errors. This implies that the average ability to represent words in the question is subpar. Word representation ability is not directly related to students' learning styles. While learning styles refer to individual preferences in acquiring and processing information, word

representation ability is linked to a person's capability to associate and connect words with pre-existing understanding and knowledge.

This study demonstrates that representational ability does not directly influence students' learning styles. Different learning styles exhibit varied tendencies in mastering mathematical representation abilities. For instance, students with visual learning styles tend to exhibit strong visual representation abilities (Azzahra & Sopiany, 2023; Marifah et al., 2020). Yet, several studies do not reveal a positive or significant correlation between mathematical representation abilities and students' learning styles (Junita, 2016; Sanjaya et al., 2018). This suggests that mathematical representation abilities and learning styles are not mutually exclusive, but can be interconnected in the progression of students' mathematical abilities.

Even though excellent representation skills can aid students in comprehending, recalling, and applying words and concepts, they do not directly dictate student learning style preferences. For example, a student favoring a visual learning style may prefer to utilize images or diagrams in their learning process, but their word representation ability does not directly influence this preference.

From the question analysis results, it is evident that understanding the concept of congruence remains a challenging aspect for students in mathematics education, particularly when solving word problems involving congruence. Hence, learning that underscores the comprehension of the basic concepts of congruence and resolving students' mathematical issues needs to be prioritized in mathematics instruction in schools.

Numerous studies align with the results of this research, showing that students with activist learning style types possess competent symbolic representation abilities, while verbal and visual representation skills are satisfactory (Rahmayani et al., 2023). However, other studies have demonstrated that the mathematical representation skills of students with a visual learning style are better at utilizing graphic or image representations, expression equations, arithmetic symbol representations (Setyawati et al., 2022), and triangle symbols (Rahmayani et al., 2023). Research revealing the results of understanding the concept of similarity also shows that student learning outcomes related to the concept of similarity increase through realistic mathematics learning and guided inquiry models. This suggests that the comprehension of the concept of similarity can be enhanced through mathematical learning models or strategies.

Therefore, research on students' mathematical representation abilities on the concept of congruence in terms of their learning styles still needs to be pursued to provide a better understanding of how students' learning styles can affect their mathematical representation abilities, especially regarding the concept of congruence. In the context of congruence learning, it is essential to enhance teachers' abilities to provide learning methodologies that align with student learning styles, for instance, by considering students' visual, auditory, or kinesthetic abilities. This could be achieved by contemplating various teaching methods and strategies that cater to the distinct characteristics of students.

Additionally, the application of an effective learning model can improve students' mathematical representation abilities in understanding the concept of congruence. Observations and assessments of students' mathematical representation abilities need to be carried out systematically and regularly to ascertain the extent of students' understanding of the concept of congruence and the areas that require improvement.

CONCLUSIONS

Based on the analyzed research results from tests of mathematical representation abilities, learning style questionnaires, and interviews with five subjects, it can be concluded that students on average possess commendable visual representation abilities across auditory, visual, and kinesthetic learning styles, as all students can solve problems exactly in accordance with the indicators. Students exhibiting proficient abilities to represent expressions or equations are typically those with a visual learning style. However, students with word representation abilities are not considered proficient, as none of the subjects, regardless of learning style, were able to correctly solve questions related to word representation ability.

From these findings, it can be concluded that the poor representational ability of students is not influenced by their learning styles, whether visual, auditory, or kinesthetic, particularly in the context of the concept of congruence. The ability to represent mathematical concepts visually and verbally is a critical skill for learning mathematics, especially on topics related to the concept of congruence. Teachers should emphasize the importance of mathematical representation, develop students' ability to represent mathematical concepts in various ways, consider the usage of certain models and teaching materials, and pay attention to students' mathematical development. Future research can involve other psychological factors that affect the ability of mathematical representation to convey the concept of congruence in students with various learning styles, such as self-efficacy or learning motivation.

AUTHOR CONTRIBUTIONS STATEMENT

Based on his contribution to this research. KI as the main researcher, prepared the overall research, developed research instruments, and composed the articles. CC contributed as a documentarian during the research and as an editor when composing the articles.

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