Comic Based on Creative Problem Solving to Enhance Mathematical Representation for Visual Learning Style

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Abstract. Students with a visual learning style usually use that contain with a lot of figures, as well as stories that contain lots of color. This study aims to develop a valid and practical mathematics comic based on creative problem solving and its effect in mathematical representation of students with visual learning styles. The subjects were 14 students who were categorized visual learning styles from 36 students in grade 7th at Junior High School Palembang. This is developmental research and its procedures consisting of three stages, namely preliminary study, prototyping and formative study. The preliminary stage consists of the analysis and design stages. Prototyping, consist of paper based and computer-based design, while the formative evaluation consists of evaluation and revision. The instruments used to collect data consisted of validation, observations, tests and interview. In general, the data analysis used descriptive qualitative technique. Based on the results, the comics based creative problem solving has been categorized as valid and practical and has a enough effect on students' mathematical representation abilities. By using comics in learning, students can imagine real situations and then represent them in the form of figures, tables, number lines, making it easier for students to write them as a form of mathematical expression.

Keywords: Creative Problem Solving, Comic, Learning Style, Representation, Visual.

Introduction

Reasoning, logic, creative thinking, problem solving abilities can be developed with mathematics, so the goal of mathematics in school is to equip students to solve problems with their mathematical abilities. Furthermore, based on learning outcomes in the independent curriculum, it is found that one of the objectives of mathematics learning aims to help students be able to communicate ideas with symbols, tables, diagrams, or other media to clarify situations or problems, as well as presenting a situation in symbols or mathematical models (communication and representation). So mathematical mathematical representation skills are important for students [1].

Representation is a form of interpretation of students' thinking about a problem, which is used as a tool to find a solution to the problem. Someone needs representation in the form of figures, graphs, diagrams, or other forms of representation to be able to communicate mathematical ideas [2]. Mathematical representation as language mathematical communicating activities describing phenomenon, mathematical ideas, solving mathematical problems by written and oral representation of words, symbols, and graphics as a carrier [3].

However, students' representation abilities are still low [4]. The lack is caused of students' courage in presenting the answers they obtain. Apart from that, students are still lacking in producing mathematical representations in the form of images and are not yet able to convert them into mathematical symbols. Students also still make mistakes in converting problems into mathematical models. However, there are some students who use verbal representations to convey their mathematical ideas. The lack of development of students' representational abilities because students are not given the opportunity to present their own representations but must follow what has been exemplified by their teacher [5].

The problem of student representation also occurs in the topic of integers [6]. Students have difficulty understanding and solving problems related to integer material. For example, example the students have difficulty visualizing concepts related to positive and negative numbers, including addition, subtraction, multiplication, and division. This has a big impact on understanding and solving problems in integer topic [7].

The low representation ability of students is also influenced by learning that is too teacher-centered and learning materials that do not suit student characteristic [8]. Students rarely write answers in the form of figures or words and often make mistakes in writing mathematical expression [9]. Previous research shows that students with a visual learning style tend to read quickly and rush to solve questions, so they have a high error rate in finding answers as seen in the error percentage reaching above 70% [10]. This shows that low representation abilities are also influenced by students' learning styles. One of the factors that can influence students' mathematical representation abilities is learning style [11].

Learning style is a reference to a person's dominant preferred way of learning. If someone understands their learning style, then that person will be able to learn well and the learning results they obtain will be good [12]. So, that if students know the characteristics of their learning style themselves, it will be easier to motivate themselves in learning [13].

Based on several factors above, it can be concluded that in implementing learning, teachers should choose innovation and adapt it to student characteristics, one of which is by using comics. Comics are learning materials that suit the characteristics of students with a visual learning style [14]. Where students with a visual learning style prefer something that contains lots of figures, in the form of colored figures presented in the form of a story line about integer material. Comic teaching material can make students have good representation skills. As can be seen from the comic which is related to indicators of mathematical representation, namely visual, verbal, and mathematical expressions [15].

From comics that contain lots of colorful figures, they can be linked to mathematical representation indicators, namely visual indicators [16]. From the existing figures, students will be able to visualize the forms of symbols in the form of images.

Meanwhile, comic teaching materials combined with creative problem solving enable students to represent mathematics verbally in a comic storyline in the form of words so that students can understand the verbal meaning. Through these comics, it is hoped that students will be able to restate problems in the form of words [17].

The comic also presents math problems whose solutions are packaged in story form. Through this question, it is hoped that students will be able to represent in verbal form and mathematical expressions. Based on the description above, researchers are interested in developing and producing teaching materials in the form of mathematical comics that are valid and practical and influence mathematical representation abilities.

2   Method

2.1   Subjects

The subjects were 14 students who were categorized visual learning styles from 36 students in grade 7th at Junior High School at SMPN 10 Palembang in the odd semester of the 2023/2024 academic year.

2.2   Research procedure

The research uses development research methods. The procedure in this research generally consists of two stages, namely preliminary study, and formative study. At the preliminary stage the study consists of analysis and design stages, while at the formative stage the evaluation consists of evaluation and revision. At the analysis stage, an analysis of the current curriculum is carried out, namely the Independent Curriculum.

Apart from that, at the analysis stage, abilities, skills, and mathematical ideas are also identified which are suitable to be taught to students with a visual learning style. The next stage is design. At this stage there are two design stages, namely: concept design with a story that will be linked to the material, then designing the comic directly on Canva.

The formative evaluation stage begins with validating comic learning Materials. The results of input from validators are used as material for revising the comic learning Materials. After it was revised, it was then tested on groups of students to see the weaknesses of comic learning Materials when used by students, especially students with a visual learning style. Weaknesses found during one-to one, small group and field tests will become as material for evaluation and revision.

2.3   Data collection

Research instruments used consisted of observation, validation, questionnaires, and interviews. Observation is used to obtain data about how students use it, the obstacles

they face, and the possible responses students give. Validation is used to obtain input from the validator whether the comic being developed is categorized as valid in terms of content, construct, and language. The questionnaire used is a learning style questionnaire. This questionnaire is given to students before learning. The interview guide used in this research is semi-structured. Interviews were used to explore students' perceptions of comics.

2.4   Data analysis technique

In general, the data analysis technique used is descriptive qualitative. All findings described according to the phenomena that occur in the field. Validation data is presented in the form of tables, diagrams and then discussed quantitatively and qualitatively. Student learning style data is analyzed by counting the number of dominant choices. This dominant choice shows the student's learning style. First, the interview data is made in transcript form. Next, the transcript results are simplified by providing coding and described qualitatively.

3   Result and Discussion

3.1   Analysis Results

The first stage is analysis of the current curriculum and students' characteristics. Based on the results of curriculum analysis, it was found that mathematics learning outcomes in Phase D consisted of several elements, namely: numbers, algebra, measurement, geometry, as well as data and opportunity analysis. Based on these learning outcomes, integers were chosen as the main material and have potential if research is carried out on students with a visual learning style.

Besides that, students with a visual learning style generally understand something by looking at figures, diagrams, also demonstrations and enjoy learning new things with what they see. So, the comic as students learning material for visual learning style must present all the mathematical abilities, skills, and ideas with optimizing the use of figures, stories and other interesting images.

3.2   Design Results

The next stage is design. This stage also consists of two design stages, namely: concept design in the form of creating a story board and then comic design using Canva. This stage aims to obtain an overview of the story ideas that will be presented in the comic, as well as the suitability of the comic content with the learning objectives to be achieved. The design of this teaching material starts with characterization to developing story ideas. From the design results, it was found that the comic being developed consisted of two adventures, namely an adventure at sea to instill the concept of adding and

subtracting integers, while an adventure in the forest was to instill the concept of multiplication and division of integers. The following are the results of the paper-based concept design.

Comics assessment focuses on three characteristics, namely: content, construct, and language. From the content aspect, comic assessments are reviewed from their suitability to the curriculum, learning objectives to be achieved, adequacy of facts, concepts and principles, suitability to student learning styles and the Creative Problem Solving (CPS) learning model.

From the construct aspect, comic assessment is reviewed from the aspects of completeness of components, suitability to student characteristics, attractiveness of illustrations and storyline, as well as consistency in the choice of color, letters, and location. From the linguistic aspect, the comic assessment is reviewed from its conformity with PUEBI, the choice of sentences that are communicative, effective, unambiguous, and in accordance with students' level of thinking and norms in education. Following are Illustration of comics.

Table 1. Illustration of comics

Images	Explanation
	The pictur e on the side is part of the story Adventures at Sea. Through this adventure, students are led to understand the concept of the operation of adding integers.
	The figure on the side is part of the story Adventures in the Forest. Through this adventure, students are led to understand the concept of multiplication of whole numbers.

3.3   Validation Results

The formative evaluation stage begins with validating the comics. There are five validators in this research, namely: SA, Ln, AN, and HY. They are consisting of teachers and lecturers. Based on the validation results, it can be concluded that the comics developed are categorized as good in terms of content, construct, and language aspects. Following are the validation results.
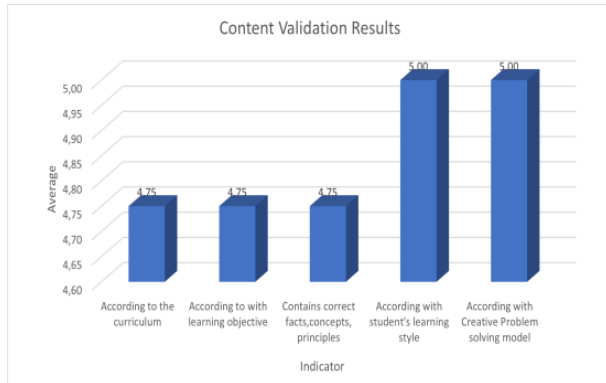

Fig. 1. Content Validation

Fig. 1. Content Validation Results The results of content validation show that the comics developed are valid. From the Fig. 1. above, if viewed from the aspect of suitability to learning styles and learning models, it is found that comics are suitable for students with a visual learning style and the storyline is in accordance with the CPS model. If viewed from the curriculum aspect, at the front of the comic it is necessary to add learning outcomes.
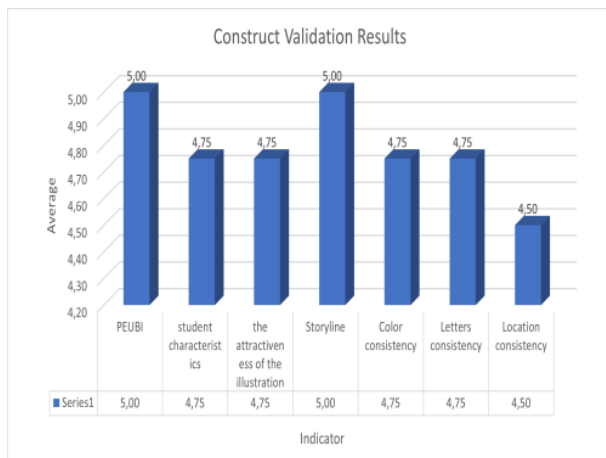
Fig. 2. Construct Validation

From Fig. 2, the comics were categorized as good. However, many aspects of the construct still need to be revised, especially the consistency aspect. From the language aspect, it was also found that the comics developed were categorized as good, but still needed a little revision, especially in the aspect of consistency.
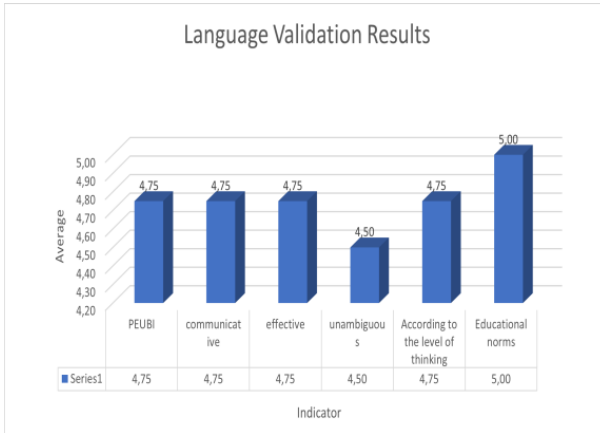

Fig. 3. Language Validation Results

Even though the validation results have been categorized as good, there are still several comments and suggestions given by the validator to improve the comic. Below are comments and suggestions from validators.

Table 2. Comments and Suggestions from validators

Validator	Comments & Suggestions
SA (Lecturer)	1. Consistency in the use of backgrounds in dialogue sections 2. Improve the editorial language, make it simpler so it is easy to understand
Ln (Lecturer)	1. Remove the Canva text from the watermark. 2. Consistency of the background in the dialogue, change it to white. 3. Change the learning. Objectives
AN (Teacher)	1. Good story idea 2. It can be used for research. 3. The language used must be more communicative. 4. The background does not contrast with the writing, so the content is difficult to read
HY (Teacher)	1. Interesting for students 2. The story is too long. 3. Select sentences according to student characteristics

The comments and suggestions provided by the validator are used to revise the comics. After it was revised, then the comics tested on 3 people with a visual learning style to see the weaknesses of comics. From the results of observations, it was found that students at the end of the activity, students were interviewed and asked to provide their

comments regarding the comics they had read and worked on. The following are students' comments during the trial.

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Table 3. Students' Comments

Students	Findings
JD	1. This is the first time I have seen a comic with mathematics lessons. 2. This comic doesn't make me afraid of mathematics, which is usually always presented in the form of mathematical numbers or just story problems without figures
CO	1. the math comics provided kept me from getting bored. 2. With this comic, apart from learning mathematics, I also really enjoy imagining the jumps of dolphins.
DES	1. At first I thought this comic would be like a boring story, but it turns out it's different, especially since it has a fun adventure story

3.4 Small Group

Next, in this stage, the comic also tested on small groups of students to see the practicality of comics. The following are some of the students' comments during the trial, including: (1) students liked the story and concept of the comic material provided; (2) the existence of a story with a created plot so that students do not feel bored; (3) the large number of figures presented in comic makes students more interested; (4) more figures, more fun and more excitement because the story is easier to understand.
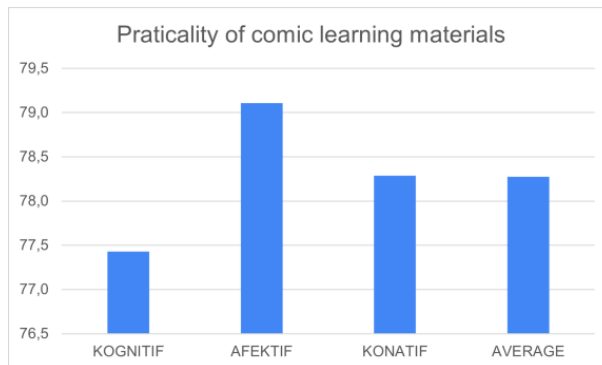

Fig. 4. Practicality of comic learning materials

This stage ends with giving a questionnaire to see the practicality of the comics that have been given during the lesson. The practicality questionnaire consists of 15 questions containing cognitive, affective, and conative aspects. Based on the practicality questionnaire, it was found that the comics was categorized as good. The practicality of the comics being developed can be seen in Fig. 4.

3.5   Field Test Results

This stage begins with learning using comics. In comic 1, students are guided to be able to solve problems regarding addition and subtraction operations on integers. Meanwhile, in the comic 2, students are guided to be able to solve problems in the operations of multiplication and addition of integers. Learning activities are carried out in accordance with the Creative Problem Solving (CPS) model.

The stages of problem clarification can be seen from activity 1. Students are guided to clarify the problem from Anan and Adit's story about dolphin jumps. From the story of the dolphin jump, students describe the jump using a number line based on the information students receive from of the story, the results of students' answers at this stage can be seen from Fig. 5.

Fig. 5 Student Answers in ClarificationActivities

The next stage is expressing the results and evaluation. At this stage students can solve the problem bycalculating the height of the dolphin's jumpfrom the sea to above the water surface. The answer can be seen in Fig. 6.

Based on the Fig. 6, it can be seen that students actually have a variety of answers or various ways to answer questions, seen from students who initiallyexplain numbers using a number line, thenthe students express opinions from "because it is down or from the initial depth, namely below, then the student gives a value of -8, then the dolphin jumps up, meaning the bigger the value or the higher it is, the bigger the value or the positive value, then students write positive 8". From this, students then write

answers by writing 10 - (-8) =18. Based on student answers, students can answer questions from the activities and stories in the comic.

Fig. 6. Student answers in ExpressionResult and evaluation activity

Implementation Stage, at this stage students are directed to implement ideas that have been previously answered in the form of other questions, or questions given by Anan and Adit's grandfather obtained in the previous stage. At this stage it can be seen from the students' answers, students are able to implement or apply the stages previously. The following are students' answers at the implementation stage. In this activity students are about ordering integers from largest to smallest. The following are student activities.
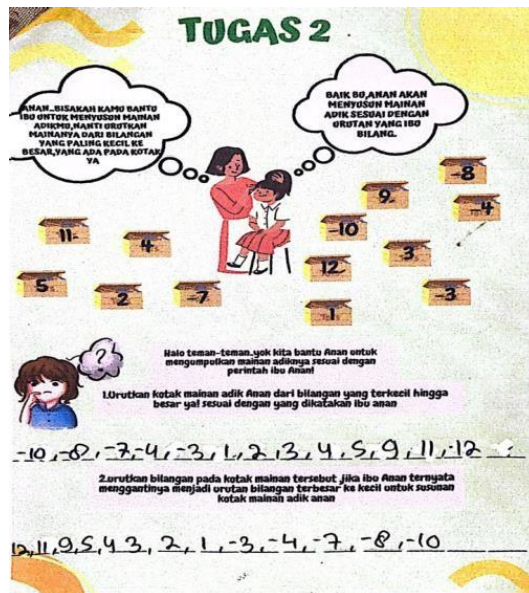
Fig. 7. Student answers in Implementation activity

After the learning activities are completed, students are asked to complete the test to see the effect of comics on students' representational abilities that are seen from three aspects, namely: Visual, Verbal, Mathematical expression.

In general, and based on the test results, it was concluded that the use of comics in mathematics learning had a good impact on the mathematical representation abilities of students with a visual learning style. The students' mathematical representation abilities are depicted in the following diagram.

Table 4. Students' MathematicalRepresentation

Interval	Percentages	Category
81- 100	35,7%	Excellent
61-80	7,14%	Good
41-60	50%	Enough
21-40	0%	Less
0-20	0%	Poor
Average		Enough

Based on the test results, it was found that the use of comics had a quite good impact on representational abilities. This isin line with the creative problem-solving learning model which really supports students' mathematical disposition [18].

3.6   Solution in Problem Number 1

From the results of the students' answers it was obtained, the students can draw directions or points according to those in the question. Creative problem-solving learning model which really supports students' mathematical disposition The student can depict the initial position by drawing the situation based on problem. When asked, students prefer to illustrate problems in the form of figures to make it easier [19]. Based on the figure can make student understand the meaning of the problem and alternative solutions, and to make it easier to create mathematical expressions [20].
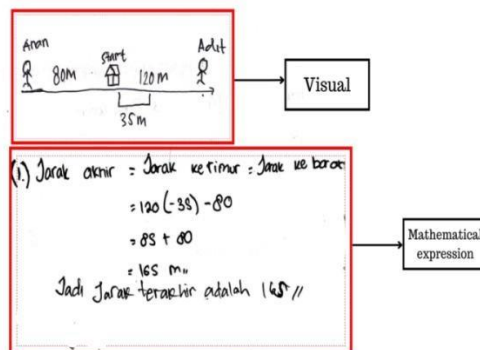

Fig. 8. Students 1 in Answer the FirstProblem

Other students can describe the distance from the question using cardinal directions as an analogy or visual depictionof the question. The student imagines the position of the Anan and Adit in the cardinaldirections. The student imagines the situation based on the question [21]. In this reaserch student can imaginethat Adit walking to east while Anan walking to west. So, to make it easier in solving the problems, the students put dotsfor the positions of Anan and Adit.
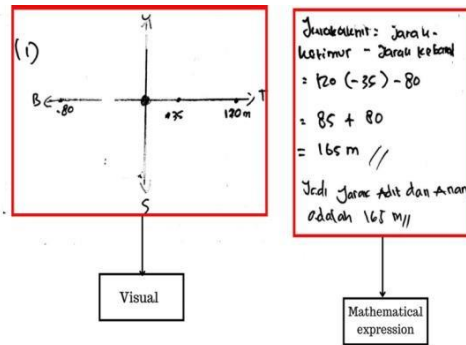

Fig. 9. Student 2 in Answer the FirstProblem

Apart from that, there are also studentswho use the number line to solve problems about integer operations. Blank number lines are useful for recording arithmetic operations carried out by students and visualize the ideas they have so thatstudents become flexible in seeing and Operate numbers well, including addition and subtraction [22-23]. The student describes its visual formusing a number line with each scale being 10 and the initial position at zero (0) then towards the east starting from +10 or the right and towards the west starting from - 10 to the left. Based on the Fig., thestudent also can make solution the mathematical expression. The student writes down "the final distance = distance to the east - distance to the west = 120 (- 35)-80 = 85 + 80 = 165".
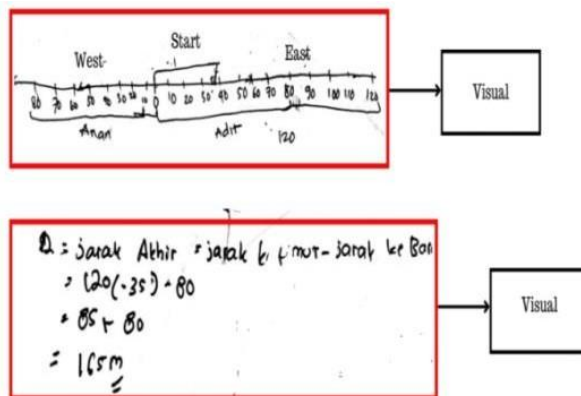

Fig. 10. Student 3 in Answer the FirstProblem

3.7   Solution in Problem Number 2

Based on the result of question number2, Students use different representations influenced by different mathematical abilities [24]. That comics also influence visual representation. It can be seen with a table in accordance withthe question command.
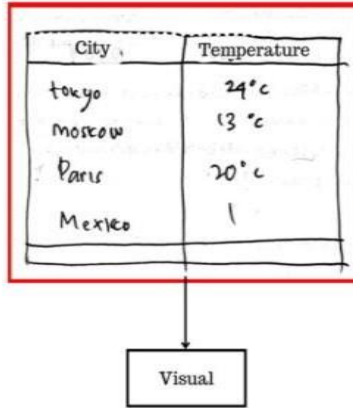

Fig. 11. Student 1 in Answer the SecondProblem

Other students use visual and verbal representations to answer question number 2. First, the student tracks temperature changes until he finds the citythat has the largest temperature change.
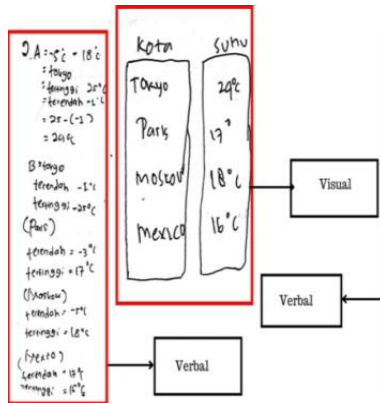
Fig. 12. Student 2 in Answer the SecondProblem

The other student makes a table about the highest and lowest temperatures, but he can't arrange the information to find solutions. He only adds all the numbers as the solutions. Based on interviews the student said that he understood the meaning of the question, but he doesn't know what to do next.
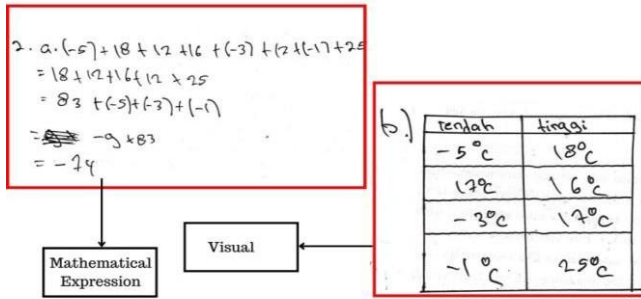
Fig. 13. Student 1 in Answer the Second Problem

3.8   Solution in Problem Number 3

Based on result of question number 3, that comics also have effect on mathematical expression representation. The results of the representation ability test are viewed from the level of student ability that the student has high ability meets the indicators of symbolic representation ability with a high value, in addition high ability students also tend to use symbolic representation [25]. This student has an interesting answer and a strategy that is easier for him, namely making his calculation operations using downward sorting such as addition from previous learning and writing them in the form of mathematical expressions. Other students also use verbal and mathematical expressions, as well as the correct answer.
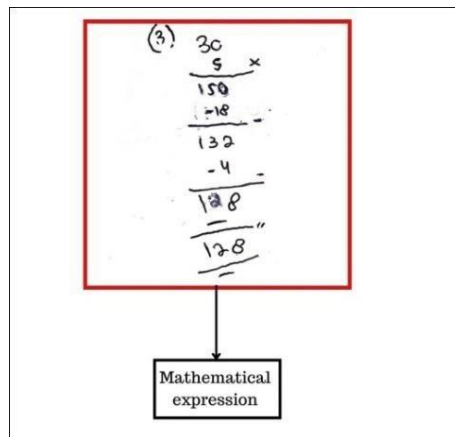

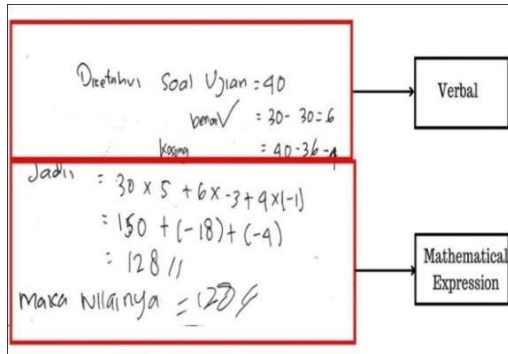**Fig. 14.** Student 1 in Answer the Third Problem

Fig. 15. Student 2 in Answer the Third Problem

Apart of that, the other student does not display the verbal indicator. It can be seen from the answers that only calculate and draw visuals. When asked, the student said that it was too complicated or took too long to explain the situation in verbal form with words.

4   Conclusion

Based on the results obtained, it shows that comics based creative problem solving has been categorized as valid and practical and has enough effect on students' mathematical representation abilities by using comics in learning, students can imagine real situations and then represent them in the form of figures, tables, number lines, making it easier for students to write them as a form of mathematical expression.

References

1. Fitri, A., Herman, T., Sa'ud, U. S., Suparman, T., DS, Y. N.: Analysis of the Implementation of the Independent Curriculum in Mathematics Subjects in Elementary Schools. In: 4th Borobudur International Symposium on Humanities and Social Science 2022 (BIS-HSS 2022). pp. 906-915. Atlantis Press, (2023).
2. Umbara, U., Munir, M., Susilana, R., Puadi, E. F. W.: Increase Representation in Mathematics Classes: Effects of Computer Assisted Instruction Development with Hippo Animator. International Electronic Journal of Mathematics Education **15**(2), (2019).
3. Zhe, L.: Survey of Primary Students' Mathematical Representation Status and Study on the Teaching Model of Mathematical Representation. Journal of Mathematics Education **5**(1), 63-76 (2012).

4. Hengki, H., Ratna, R.: The Use of Communicative Language Teaching (Clt) Approach Through English Village for Improving a Transactional Language Function of Speaking Skill. AL-ULUM: Jurnal Ilmu Sosial dan Humaniora **5**(2), (2019).

5. Zulfakri, Z., Ikhsan, M., Yusrizal, Y.: Improving the Ability of Representation and Problem Solving Through Concrete Representational Abstract (CRA) Approach in Mathematical Learning. International Journal for Educational and Vocational Studies **1**(3), 244–248 (2019).

6. Fuadiah, N. F., Suryadi, D., Turmudi.: Teaching and learning activities in classroom and their impact on student misunderstanding: A case study on negative integers. International Journal of Instruction **12**(1), 407–424 (2019).

7. Nur, A. S., Kartono, K., Zaenuri, Z., Rochmad, R.: The learning trajectory construction of elementary school students in solving integer word problems. Participatory Educational Research **9**(1), 404-424 (2022).

8. Mascolo, M.: Beyond student centered and teacher-centered pedagogy: Teaching and learning as guided participation. Pedagogy and the Human Sciences **1**(1), 3–27 (2009).

9. Hebert, M. A., Powell, S. R.: Examining fourth-grade mathematics writing: features of organization, mathematics vocabulary, mathematical and representations. Reading and Writing **29**(7), 1511 1537 (2016).

10. Brown, P. C., Roediger III, H. L., McDaniel, M. A.: Make it stick: The science of successful learning. Harvard University Press, (2014).

11. Masduki, M., Savitri, D., Khotimah, R. P.: Students' Visual Reasoning Ability in Solving Quadratic Function in Terms of Learning Style. JTAM (Jurnal Teori Dan Aplikasi Matematika) **7**(3), 576 (2023).

12. Kolb, A. Y., Kolb, D. A.: Learning styles and learning spaces: Enhancing experiential learning in higher education. Academy of Management Learning and Education **4**(2), 193 212 (2005).

13. Indah Sari, L. N., Sibuea, A. M., Tanjung, S.: The Effect of Learning Models and Learning Styles on Social Science Learning Outcomes of Arrahman Percut Students. Budapest International Research and Critics in Linguistics and Education (BirLE) Journal **3**(4), 2076–2083 (2020).

14. Badeo, J. M. O., Ong Kian Koc, B. C. U.: Use of Comic-based Learning Module in Physics in Enhancing Students' Achievement Motivation. International Science and Education **32** (2), 131–136 (2021).

15. Kusuma, J. W., Jefri, U., Hidayat, A., Hamidah, H.: Application of Treffinger Learning Model to Improve Creative Reasoning and Mathematical Problem-Solving Skills as Well as Student Learning Interests. JTAM (Jurnal Teori Dan Aplikasi Matematika) **4**(2), 204 (2020).

16. Rusydiana, U., Widodo, W., Suprapto, N.: The Development of Picture Story Book to Improve the Science Literacy Skills of Grade 4 Elementary School Student. Studies in Philosophy of Science and Education **4**(1), 22 34 (2023).

17. Stafford, T.: Teaching visual literacy in the primary classroom: comic books, film, television, and picture narratives. Routledge, (2010).

18. Kusumadewi, R. F., Neolaka, A., Yasin, M.: Improving the ability of understanding mathematical concepts through digital-based comics for elementary school students. Al Ibtida: Jurnal Pendidikan Guru MI **7**(2), 280-294 (2020).

19. Mainali, B.: Representation in teaching and learning mathematics. International Journal of Education in Mathematics, Science and Technology **9**(1), 1–21 (2021).

20. Lesh, R., Doerr, H. M.: Foundations of a models and modeling perspective on mathematics teaching, learning, and problem solving. In: Beyond constructivism, pp. 3-33. Routledge, (2003).

21. Dwijayani, N. M.: Development of circle learning media to improve student learning out-comes. Journal of Physics: Conference Series **1321**(2), 022099 (2019).
22. Heirdsfield, A. M., Cooper, T. J.: Flexibility and inflexibility in accurate mental addition and subtraction: Two case studies. The Journal of Mathematical Behavior **21**(1), 57-74 (2002).
23. Teppo, A., van den Heuvel-Panhuizen, M.: Visual representations as objects of analysis: The number line as an example. ZDM - International Journal on Mathematics Education **46**(1), 45 58 (2014).
24. Krawec, J. L.: Problem Representation and Mathematical Problem Solving of Students of Varying Math Ability. Journal of Learning Disabilities **47**(2), 103 115 (2014).
25. Konidaris, G., Kaelbling, L. P., Lozano Perez, T.: From skills to symbols: Learning symbolic representations for abstract high-level planning. Journal of Artificial Intelligence Research **61**, 215–289 (2018).