



# Exploring students' mathematical computational thinking ability in solving pythagorean theorem problems

Faizah Nurwita<sup>1\*</sup>, Yaya Sukjaya Kusumah<sup>1</sup>, Nanang Priatna<sup>1</sup>

<sup>1</sup> Department of Mathematics Education, Indonesia University of Education.

✉ [nurwitaFaizah@gmail.com](mailto:nurwitaFaizah@gmail.com)

## Article Information

Submitted June 11, 2022

Revised Nov 10, 2022

Accepted Nov 17, 2022

## Keywords

ICT;

Mathematical Computational

Thinking;

Problem-Solving;

The Pythagorean Theorem.

## Abstract

This study explores students' mathematical computational thinking ability in solving the Pythagorean Theorem problem. This research method used a qualitative approach with a phenomenological design. The subjects involved in this study were 12 junior high school students. Six students in grade 7 had not studied the Pythagorean Theorem, and six students in grade 8 were studying the Pythagorean Theorem. This study's results indicate several problems with students' mathematical computational thinking skills in mathematics learning. The first problem is seen from the aspect of abstraction. Students are given problems with the help of digital-based teaching aids. Then the researcher provides procedures containing questions so students can digest the information and follow their intuition to find a solution strategy. Still, students have not decided what information should be stored or ignored. The second problem is seen from the aspect of decomposition. Students have not been able to decompose complex problems into simpler and more manageable ones. Student responses are also still not according to the researchers' predictions. However, with the scaffolding technique, researchers can direct students' intuition or thought processes to focus more on the problem being asked. The third problem is seen from the aspect of generalization. Students have not been able to generalize the problem and have not been able to conclude from the steps that have been taken. These three problems indicate that students cannot recognize and identify patterns well, thereby reducing the efficiency of the mathematical problem-solving process.

## INTRODUCTION

A person's ability to think begins with uncertainty or doubt, so it encourages the process of scientific investigation. At the beginning of the 20th century, Lipman (2015) described the ability to think as a goal of learning and teaching in the classroom. The teacher involves students in thinking by determining hypotheses, then testing these hypotheses in learning practice (Kallia et al., 2021). This thinking ability has been the focus of research and development in schools for many years, especially to improve the quality of education and prepare students to become lifelong learners by developing their intellectual and cognitive abilities (Fisher, 1999; Wing, 2017). The ability to think can be achieved because there is a problem. The problem in learning mathematics is a challenging question that cannot be solved by routine procedures usually carried out, and the process requires deep thinking (Insorio & Librada, 2020).

Several previous research results show that the thinking ability of Junior High School students in solving mathematical problems is still low, especially in the fields of geometry

and algebra (Nuryanti et al., 2018; Septiana et al., 2019). One of the low factors is that students are not used to being actively involved in learning (Nuryanti et al., 2018). They have difficulty determining the information needed (important) and identifying ideas or establishing methods to solve mathematical problems. This is also stated in the 2018 *Program for International Student Assessment* (PISA) scores in Indonesia that the results of mathematics scores still occupy a low level, which has decreased from the previous year (Marchelin et al., 2022). Even though the orientation of the PISA 2022 assessment is on students' computational thinking skills in solving problems (Zahid, 2020), according to Kallia et al. (2021), mathematical thinking and computational thinking must be synergistic with each other. Osman et al. (2018) also stated that every child's computational thinking skills are important. Every child can not only read, write, and count but also needs computational thinking skills because it is important to improve analytical skills and academic achievement and integrate academics into everyday life (Csizmadia et al., 2019; Sykora, 2021).

Computational thinking skills will be a human mental orientation to design new problem-solving strategies and test new solutions in the virtual and real worlds (Pulimood et al., 2016; Wing, 2017). Computational thinking has resulted in innovation and imagination because it facilitates efforts to solve urgent problems (such as prevention or cure of disease, eradication of world hunger) and expands a human's understanding of himself as a biological system and human relations with the world around him (Kallia et al., 2021). In the field of education, computational thinking skills are widely used in learning because they synthesize critical and creative thinking to be able to formulate problems and develop solutions in all disciplines, such as humanities, mathematics, and science (Karakozov & Ryzhova, 2019; Sykora & Caroline, 2021). Companies such as Google and Microsoft support this idea, and several programs have emerged to integrate computational thinking skills into various learning curricula (Costa et al., 2017).

Since 2012, the UK has incorporated computational thinking skills into its curriculum through learning informatics. Then, European Union countries began to discuss integrating computational thinking into their educational curricula from 2016 to 2017 (Bocconi et al., 2016). Indonesia has begun integrating computational thinking skills through learning informatics, as issued by Permendikbud Number 37 of 2018 (Permendikbud, 2018). This integration is supported by the orientation of the PISA 2022 assessment, which is different from the previous year's PISA.

Computational thinking ability is integrated not only as a computer programmer but also as a thought process. Some experts state that this ability can be integrated and stimulated through mathematics subjects at school because it stimulates students' thinking skills by presenting mathematical problems that will become the process of constructing students' knowledge (Cahdriyana & Richardo, 2020; Maharani et al., 2019). Based on the study of Grover and Pea (2013), stimulating students' computational thinking skills can improve their number sense and arithmetic abilities. This increase in cognitive abilities can be trained by learning that sharpens students' spatial reasoning (Yasar et al., 2017). Therefore, this computational thinking ability will be considered important as a core factor because it can predict other cognitive abilities.

The integration of computational thinking into mathematics learning is not an easy process. It requires learning designs that use authentic practices, as Dewey wrote that schools

and classrooms could replicate students' real-life scenarios (Williams, 2017). Students are involved in social activities and problem-solving in a community (Williams, 2017). The abstract parts of math need to be put in a real-world context so that math can be understood well and learning has meaning. Based on the study of Osman et al. (2018), students cannot solve problems well, and students with low abilities state to researchers to teach problem-solving techniques until students understand. The study shows that it is essential for teachers to use various strategies and approaches while teaching using a problem-solving approach. The study of Hattikudur et al. (2016) also states that student learning outcomes are outstanding when they learn to use procedures, plan solutions, and find solutions so that students have meaningful mathematics learning. According to Tiwari et al. (2021), visualization techniques can be a tool to develop intuition to start solving problems or a natural way to identify problems and concepts. Therefore, this study used a problem-solving approach, the teacher taught visualization techniques using digital-based teaching aids, and learning activities involved students. This way of learning helps students build their knowledge and train their mathematical computational thinking skills to solve problems.

Based on the description, it can be concluded that mathematical computational thinking is an ability that students must master because it helps them structure mathematical problem-solving and improve other cognitive skills. Researchers also found research gaps during literature studies. Several literature studies examined the theory of computational thinking ability, but little literature still investigates how students mathematical computational thinking when learning mathematics. Maharani et al. (2019) investigate undergraduate students' computational thinking skills. A study by Barcelos et al. (2018) presents a Systematic Literature Review on reported evidence of learning mathematics in computational thinking skill development activities. The results show that only one article examines computational thinking skills at the secondary school level. Therefore, the focus of this study is to explore computational thinking as a thinking process in solving mathematical problems so that it becomes a solution and preparation for facing educational challenges in the 21st century and student responses regarding the use of media based on ICT in learning mathematics. The aim is to explore students' mathematical computational thinking ability in solving the Pythagorean Theorem problem. To achieve this purpose, three research questions are discussed in this study: (1) how is students' mathematical computational thinking ability in solving Pythagorean theorem problems? (2) how do teachers teach with a problem-based approach? and (3) how do students respond to media use in learning mathematics?

## METHODS

This research method used a qualitative method with a phenomenological design. Researchers investigated phenomena that occur with research subjects in certain situations. The situation was in the form of mathematics learning and teaching activities. The researcher acted as an instrument, and a teacher who taught the Pythagorean Theorem material using a problem-based learning approach assisted by digital teaching aids in the form of *PowerPoint*. The subjects involved in this study were 12 junior high school students, six grade 7 students who had not studied the Pythagorean Theorem, and six grade 8 students who had studied the Pythagorean Theorem.

The data collection technique was carried out using a documentation study assisted by the *Zoom* recording platform feature. The research procedure was carried out in five stages, namely: (1) identifying the problem; (2) determining the research focus; (3) developing Learning Implementation Plans and digital teaching aids in the form of *PowerPoint* as teaching materials; (4) determining student criteria; and (5) carrying out teaching and learning for 2×45 minutes (two meetings) using the *Zoom* platform. Researchers taught with a visualization technique assisted by digital-based teaching aids in the form of *PowerPoint* and scaffolding techniques to develop students' intuition in solving mathematical problems and encourage students to learn independently. Researchers also taught with a problem-based approach because the learning process must begin with presenting problems that contain challenges for students to think about. The problem can be related to discovering concepts, procedures, problem-solving strategies, or rules in mathematics.

The researcher began the lesson by presenting the problem because it has the potential to explore students' computational thinking. Researchers asked some follow-up questions in teaching to investigate students' intuition and solution procedures, whether students can formulate their solution procedures in computational thinking, justify their procedures, and relate or infer from a form or pattern. The researcher coded the students' utterances and their oral solutions. Data analysis techniques were carried out through the following steps: (1) collecting data by recording main events or things according to the research focus, namely the achievement of students' mathematical computational thinking skills in learning mathematics and student responses related to the use of media; (2) organizing data systematically based on categories and classifications; (3) analyzing and presenting data in a descriptive form; (4) interpreting the data; and (5) drawing conclusions and recommendations for further research (Miles et al., 2018).

## RESULTS AND DISCUSSION

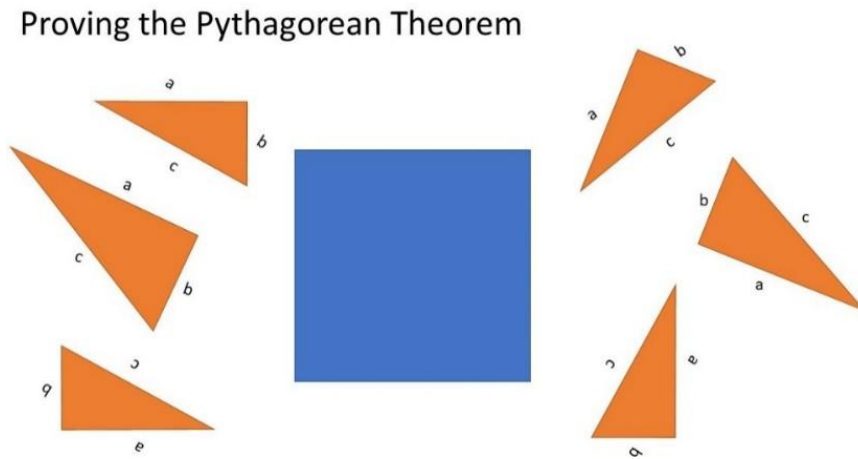
The results of this study discussed two main themes: (1) students' computational thinking ability in mathematics learning. This theme presented how students answer and solve problems and how teachers teach with a problem-based approach; 2) Student responses when using learning media based on ICT, this theme presented students' responses regarding the use of media during the learning process, whether they understand the presentation of the material, and whether the presentation of the material helps them understand the concept of mathematical thinking better.

### Students' Computational Thinking Ability in Mathematics Learning

This study lasted two meetings to explore students' mathematical computational thinking ability in learning mathematics. Students construct mathematical knowledge, and researchers are responsible for teaching mathematics lessons appropriately, namely constructivist perspectives, visualization techniques, and problem-solving approaches. In the first meeting, students studied the Pythagorean theorem and checked its truth with the help of digital teaching aids using *PowerPoint*. The proof of the Pythagorean theorem is closely related to the surface area of squares and triangles. Pythagoras revealed that in a right-angled triangle, the square of the hypotenuse side equals the sum of squares of the other two sides. To check the truth, students carry out learning activities with the following steps:

### Step 1: Students Observe and Gather Information

The researcher prepared a digital-based Pythagorean teaching aid, namely *PowerPoint*. *PowerPoint* consists of one square plane and six right triangle planes. Students are asked to choose and arrange the four right triangles to cover the surface of the square and digital props, according to Figure 1.



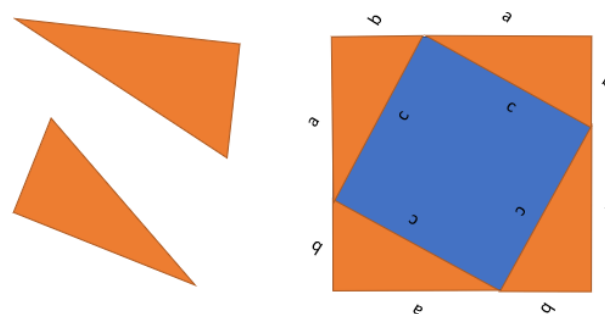
**Figure 1.** Digital-based props for finding the Pythagorean theorem (1)

When the students got the four right triangles planes to fit together and cover the surface of the square, the researcher asked:

*"Are all the planes of the triangle able to exactly cover the surface of the square, and what new shape is formed?"*

All students agreed that they could correctly cover the surface of the square, according to Figure 2.

### Proving the Pythagorean Theorem



**Figure 2.** Digital-based props for finding the Pythagorean theorem (2)

However, some students answered that the flat shapes formed were rhombus, parallelogram, or square. Researchers show the shape of real objects around students by entering keywords for objects in the search engine so that students can identify the properties of flat shapes. Then, the researcher investigated further and asked the students:

*"What is the proper flat shape from the options of a rhombus, a parallelogram, or a square?"*

All students agreed to answer that the shape formed is a square. Students construct their knowledge. As teachers and facilitators, researchers provide procedures, so students find the differences in the flat shapes of diamonds, parallelograms, and squares. This process is called "debugging ability." Students can identify, delete, and correct errors so that students find the right answer.

### Step 2: Students Understand the Problem and Create a Strategy

In this step, students are given the following problems:

*"Suppose the surface area of the outer rectangular frame is  $r$ , the surface area of the triangle is  $s$ , and the surface area of the inner rectangle is  $t$ . What is the relationship between the area of the outer square frame, the surface area of the triangle, and the area of the inner rectangle? Tell!"*

Some students answered:

*"Isn't the surface area of the outer square  $side \times side$ ?"*

The student's answer is correct but shows that students' abstraction skills need to be trained so that known problems can be appropriately considered and students can relate the surface area of the outer square in  $r = side \times side$ . Then, some students forgot the surface area of a triangle, so the researcher recalled the surface area of a flat shape. Then, the researcher investigated how students could relate the surface area of the outer square, triangle, and inner square. Students managed to answer that the relationship:

***The surface area of the outer square four times the surface area of the triangle + the surface area of the inner square***

$$r = 4s + t$$

This process is called "abstraction ability," which refers to how students focus on important information and ignore information or details that do not help them solve problems.

### Step 3: Create a Strategy

The researcher directs students to develop plans or procedures for the solution of the previous problem, namely finding the Pythagorean Theorem:

*"If the lengths of the sides of the triangle are  $a$  and  $b$ , and the length of the hypotenuse is  $c$  (as shown in figure 2), then determine the surface area of the outer square ( $r$ ), the surface area of the triangle ( $s$ ), and the surface area of the inner square ( $t$ )!"*

Students can create a strategy well because they already recognize the pattern of the problem to be solved, and the teacher only follows the intuition of the student's plan. Students can find  $r = (a + b)^2$ ,  $s = \frac{a+b}{2}$ , and  $t = c^2$ . This process is called "generalization ability." Students can apply what they have learned to new problems and develop quick, good solutions based on what they have learned.



#### Step 4: Implementing the Plan

In this step, the researcher asked the students to carry out the previous solution plan  $r = 4s + t$  to  $(a + b)^2 = 4 \times \frac{a+b}{2} + c^2$ . However, students have not yet studied the Quadratic Multiplication of Two Variables material, so the researcher explains how to multiply quadratic equations in algebra. In this step, learning activities are centered on the researcher by writing equations, asking for the next steps, and following students' answers or intuitions so that  $a^2 + b^2 = c^2$  is obtained (as shown in figure 3).

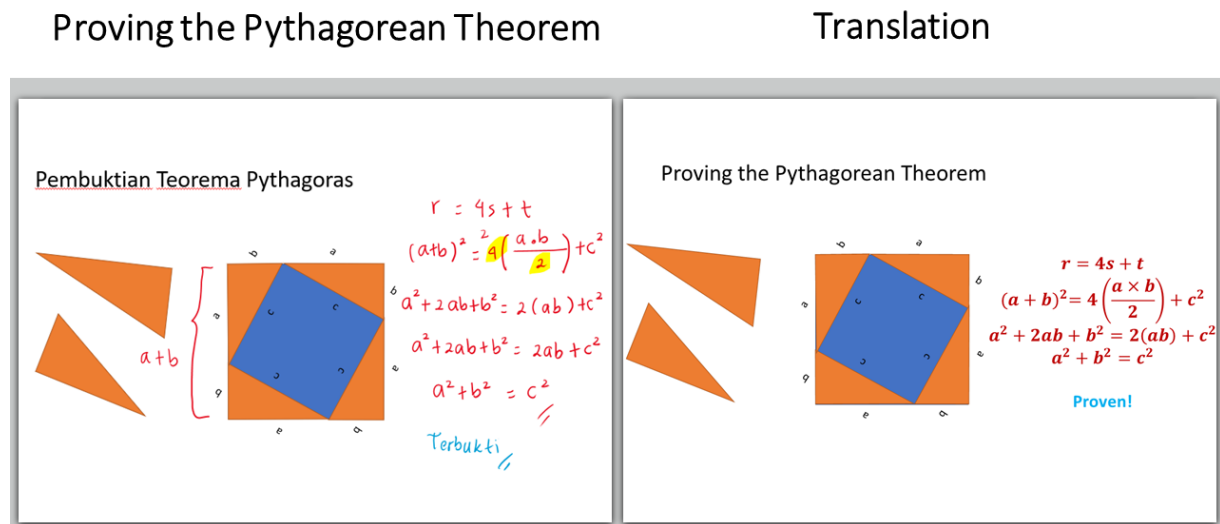


Figure 3. Digital-based props for finding the Pythagorean theorem (3)

After finding  $a^2 + b^2 = c^2$ , the researcher asked students to explain the relationship between  $a$ ,  $b$ , and  $c$  with triangles:

*"c is the hypotenuse, miss."*

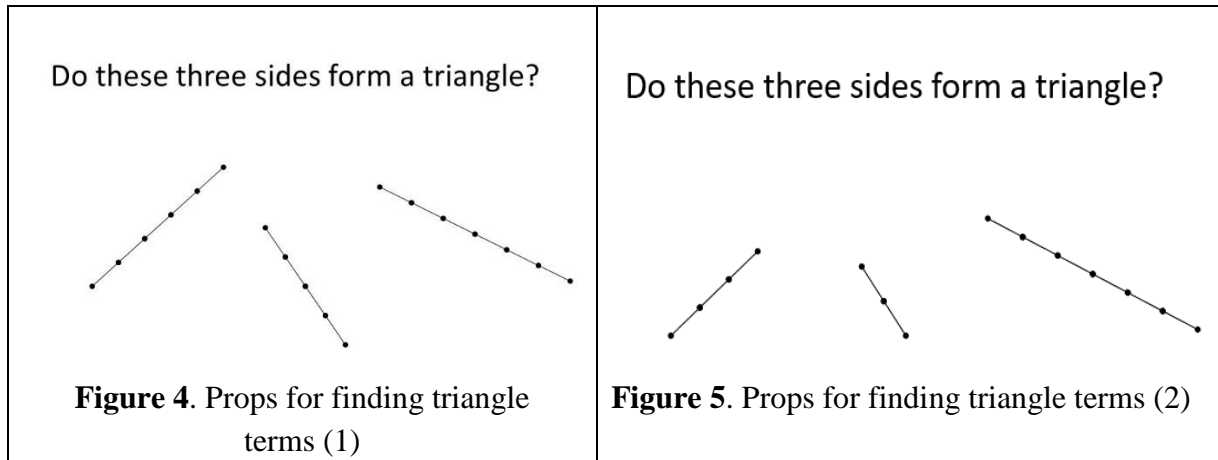
*"So, if you want to calculate the length of side c, add the lengths of sides a and b. Meanwhile, to calculate the length of a side other than c, the length of side c is subtracted from the length of the other side miss."*

Finally, in checking the truth of the Pythagorean Theorem, some students forget the meaning of the square of the side lengths of a right triangle. Several times the researcher gave an example of applying the Pythagorean Theorem. Students answered the solution **with**  $a + b = c$ , where  $c$  is the longest side of a right triangle.

In this learning activity, the researchers saw the students' mathematical computational thinking ability from algorithmic thinking and decomposition. In "algorithmic thinking," namely students mention the steps to get the right solution to solve the problem or the rules that must be followed to solve the problem. In "Decomposition," students can identify problems to be simpler so they are easy to understand.

After studying the Pythagorean theorem, the students were trained in their thinking process at the second meeting by giving the problems in Figure 4 and Figure 5. Students were asked to form a triangle with three known side lengths. If a triangle is formed, students need to determine whether it is a right triangle. In addition, students need to find the terms of an

acute or obtuse triangle using the inequalities of the Pythagorean theorem. To form a triangle, students are given digital-based props such as Figure 4 and Figure 5.



This digital prop used *PowerPoint*. Students can drag, drop, and rotate all three side lengths. Students can be creative in forming triangles on their respective devices. When students form a triangle (according to picture 5), students have difficulty and ask questions:

*"Miss, I'm confused about how to form a triangle because the length of the side is too long. Can it form a triangle?"*

In this learning process, students are trained in their analytical and critical thinking skills to analyze the differences between Figure 4 and Figure 5 and how the three side lengths of the two images are related. The goal is for students to be able to explain the relationship between the lengths of the other side of the triangle and find the terms of the triangle students said:

*"The length of the other side is too long (as in picture 6), miss."*

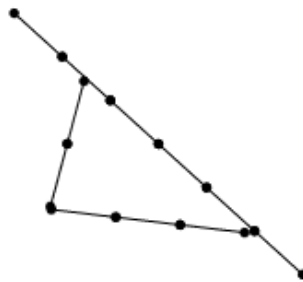
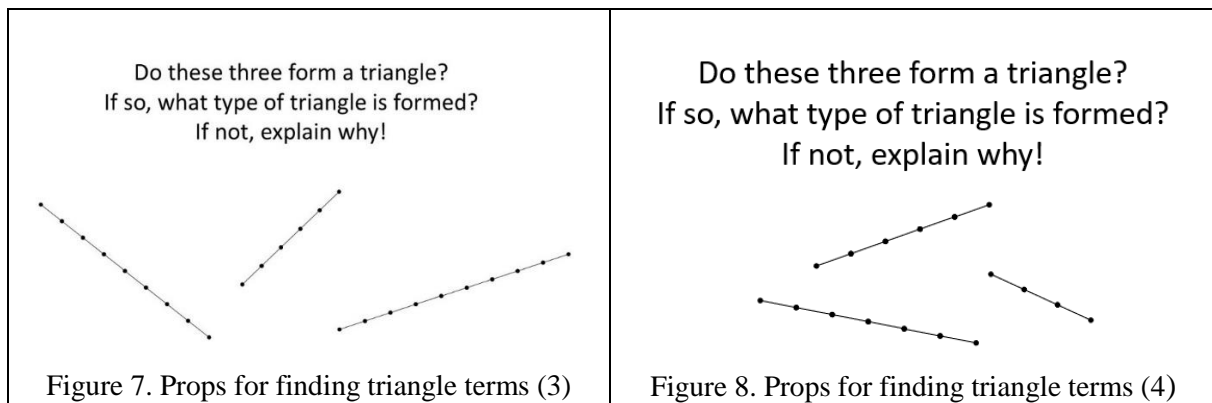


Figure 6. Students answer to determine the type of triangle (1)

Students already know the different shapes/patterns of the two problems. However, students do not yet know the meaning or relationship of shapes/patterns that allow students to know how to model the mathematical syntax. The researcher constructs students' knowledge that a triangle requirement must be met based on the length of its side, namely  $a + b > c$  ( $c$  is the longest side). Figure 4 shows that the three side lengths can form a triangle because it meets the triangle requirements, namely  $4 + 5 > 6$ . Figure 5 shows that the three side lengths cannot form a triangle because they do not meet the triangle requirements, namely  $2 + 3 < 6$ .



In the next learning activity, the teacher recalls the definitions of acute and obtuse angles and introduces the types of acute and obtuse triangles. Then, students are given problems according to Figure 7 and Figure 8. Students are not only asked to form triangles, but students need to determine the type of triangle based on the length of the sides. The goal is for students to be able to explain the relationship between the lengths of the other side of the triangle and find the terms of an acute triangle and an obtuse triangle. To form a triangle, students are given digital-based props, namely *PowerPoint*, as shown in Figure 7 and Figure 8.



Students said:

*"Figure 7 forms an acute triangle, and Figure 8 forms an obtuse triangle."*

Students already know the different forms or patterns of the two problems. Still, students' analytical skills are the same as in previous learning activities. Students do not yet know the meaning or relationship of shapes/patterns that allow students to know how to model the mathematical syntax. The researcher recalls the Pythagorean Theorem and asks students to square the length of the longest side of a right triangle and look for the relationship  $<$  or  $>$  from the sum of the squares of the lengths of the other sides so that students can construct their knowledge. Student says:

*" $5^2 + 8^2 > 9^2 \leftrightarrow 25 + 64 > 81 \leftrightarrow 89 > 81$ , picture 6 is an acute triangle bu. Meanwhile,  $3^2 + 5^2 < 6^2 \leftrightarrow 9 + 25 < 36 \leftrightarrow 34 < 36$ , which in Figure 7 is an obtuse triangle."*

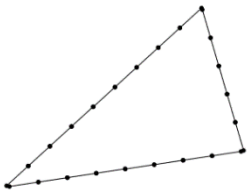
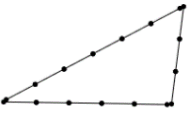
The researcher asked again about the relationship between the shapes/patterns of the two pictures so that students could conclude in their mathematical formulas. However, the researcher's prediction did not match the students' saying that the terms for an acute triangle must be met based on the length of its side, namely  $a^2 + b^2 > c^2$ , and the terms for an obtuse triangle, namely  $a^2 + b^2 > c^2$  ( $c$  is the longest side). Student says:

*"I don't understand, miss."*

At the end of this activity, the researcher concludes with a mathematical formula. The new students understand the meaning and differences in the pattern/shape of the two triangle images. Student says:

*"Oh, I just realized that the terms of an acute and obtuse triangle are missing."*

Figure 9 shows the results of creating acute triangles, and Figure 10 shows the results of creating obtuse triangles by students.

<p>Do these three form a triangle? If so, what type of triangle is formed? If not, explain why!</p>  <p><b>Figure 9.</b> Students answer to determine the type of triangle (2)</p>	<p>Do these three form a triangle? If so, what type of triangle is formed? If not, explain why!</p>  <p><b>Figure 10.</b> Students answer to determine the type of triangle (3)</p>
---	---

As a result of this learning activity, researchers saw how students' mathematical computational thinking abilities developed. During the learning process, students do not yet have good "Pattern Recognition" skills, namely the ability to solve problems by finding similarities or differences in repeated components, which will help students make conclusions and predictions.

### Student Responses when Using Learning Media Based on ICT

During the learning process, researchers used ICT-based learning media, namely *PowerPoint*. The researcher asked the students after the lesson was finished. The goal is to explore how they think about the use of media during the learning process, whether they understand the presentation of the material, and whether the presentation of the material helps them understand the concept of mathematical thinking better. Five students stated that media use during the learning process helped them train in mathematical computational thinking well.

*"I came to know how to find a formula because, learning so far, only formulas can be obtained instantaneously, but I don't know what kind of proof the formula is. Presentation of material in PowerPoint is interesting because I can explore as much as I like, so I am free to be creative in forming triangles with the three lengths of sides provided."*

*"Usually, the teacher teaches how to do the questions, or I search for questions on google, then if I need further explanation, I watch videos on YouTube. So, learning like this sticks to my brain more."*

*"Yes, I understand by proving the Pythagorean Theorem formula and practicing my way of thinking. The use of technology can be maximized if it is developed according to the purpose. The presentation of this material has been maximized."*

*"The media that has been used is easy to understand clearly."*

*"It's interesting because there is a visual that proves the Pythagorean formula and triangle."*

Based on student statements that the use of media during the learning process needs serious attention, considering this media as one of the learning resources. The use of media

must improve their thinking and construct knowledge so that students are accustomed to solving a problem. The ability to solve problems that are part of the ability to think mathematically and is an ability that will continue to be used in the long term. If teachers and students are less than optimal in utilizing the media as a source of learning, it will impact students' low mathematical knowledge and competence. They are not able to compete professionally and globally. Therefore, the use of media must be to the characteristics of students, and at the same time, can improve their mathematical thinking.

Based on the learning case described above, several important things must be underlined regarding students' mathematical computational thinking abilities. First is the abstraction aspect. Students are given a problem with an illustration model in the form of structured images in *PowerPoint*. Researchers try to provide procedures with questions so that students can digest the information and follow their intuition to find solving strategies. However, students have not decided what information should be stored or ignored.

The second is the decomposition aspect. Student responses are still not by the researchers' predictions, but the scaffolding technique used by researchers can direct students' intuition or thinking processes to be more focused on the problem being asked. The illustration model turned out to be quite effective in helping students' thinking processes so that they could identify problems in a simpler way and were easy to understand. In the illustration model at the first meeting, the researcher presented a problem based on digital teaching aids to find the truth of the Pythagorean Theorem. The process was strengthened at the second meeting. The researcher presented a problem based on digital teaching aids to find the terms of a triangle, an acute triangle, and an obtuse triangle. This process is carried out with the hope that it will directly foster students' mathematical reasoning. This reasoning can be the proper foundation for students' mathematical computational thinking processes in solving mathematical problems.

The third is the generalization aspect. Students have not been able to generalize the problem into new problems, and they have not been able to draw general conclusions. The reasoning includes student observations regarding the steps to solve the given problem so that students find the presented patterns or rules. In the view of inferential intuition experts, intuition can be interpreted as reasoning guided by interactions with the environment (Panbanlame et al., 2014). Although this reasoning is more intuitive or informal, in particular learning activities, its existence is necessary for the mathematical computational thinking process.

The learning activities above also provide an overview of learning activities with a problem-solving approach. The teacher presents the problem and allows students to initiate individual learning activities. The interactivity the teacher develops is based on students' needs in achieving their potential level of development when they solve problems. This is done by encouraging students to think critically and asking teachers or other students who can or already understand more about the problems at hand. It is realized that each student has a different potential, so during the learning process, the teacher always identifies the potential and difficulties students may face. In the next process, this can be used to improve students' mathematical computational thinking skills.

This finding has important implications for integrating and improving computational mathematical thinking skills. Computational thinking is becoming a fundamental skill for the

21st century and responding to an increasingly computerized discipline due to extensive professional practice (Kamal, 2016). In PISA 2022, aspects of computational thinking will be measured as part of the mathematical assessment (OECD, 2018; Zahid, 2020). In this short-term goal, the researcher hopes Indonesia will get a higher score in PISA 2022, which would mean a higher ranking. This increase can be obtained by working hard to equip Indonesian students with abilities measured in PISA 2022, especially mathematical computational thinking.

Meanwhile, the long-term interests of students are to be ready to become the nation's next generation that competes professionally and globally. Students who think computationally in all academic subjects can be seen from how they implement the material they have learned in class into real life (outside class). Based on the research results by Echeverria et al. (2019), student achievement increases because students feel delighted when learning to analyze flat shapes. Students are trained in mathematical computational thinking skills, planning, developing, and implementing solutions. Grover (2013) also stated that computational thinking could improve the quality of mathematics learning. Then Morreale et al. (2012) discuss the impact of computational thinking workshops on secondary school teachers. The results suggest that teachers should understand the perception of computational thinking and identify the best tools and resources most likely to implement computational thinking in core curriculum standards (Morreale et al., 2012; Psycharis & Kallia, 2017). Therefore, students' mathematical computational thinking skills need to be trained and integrated into learning mathematics and pay attention to appropriate learning media to support students' thinking processes.

## CONCLUSIONS

In this study, researchers found several problems related to students' computational thinking skills in learning mathematics. The first problem is seen from the aspect of abstraction. Students are given problems with the help of digital-based teaching aids. Then the researcher provides procedures containing questions so students can digest the information and follow their intuition to find a solution strategy. However, students have not decided what information should be stored or ignored.

The second problem is seen from the aspect of decomposition. Student responses are still not following the researchers' predictions. However, through the scaffolding technique, researchers can direct students' intuition or thinking processes to be more focused following the problem being asked.

The third problem is seen from the aspect of generalization. Students have not been able to generalize the problem into new problems, and they have not been able to draw general conclusions. The reasoning includes student observations related to the steps to solve the given problem so that students find similarities or differences in repeated patterns (Pattern Recognition) or the rules presented.

Researchers found problems and that digital-based teaching aids were quite effective in helping students' thinking processes, so students could explore solutions to problems and more easily understand mathematical concepts, theorems, and propositions. This process is carried out with the hope that it will foster students' mathematical reasoning directly. This

reasoning can be the proper foundation for the achievement of students' mathematical computational thinking skills.

Based on the findings in this study, there are several limitations, namely the exploration of students' mathematical computational thinking skills during mathematics learning and students' responses to the use of learning media based on ICT. To achieve a deeper analysis, the next research needs further investigation regarding students' mathematical computational thinking skills, which are generated based on students' answers from giving test instruments and collecting data on how well students' mathematical computational thinking works in a globalized professional world. The results of this study can be used as a guide for curriculum developers to develop a math curriculum with various problem approaches so that students can improve their ability to mathematical computational thinking and for mathematics teachers to plan to learn with real-life problem approaches with students.

## AUTHOR CONTRIBUTIONS STATEMENT

FN and NP is the coordinator and the author of articles in this research activity. YSK as the data collection and processing of instrument data.

## REFERENCES

- Barcelos, T. S., Munoz, R., Villarroel, R., Merino, E., & Silveira, I. F. (2018). [Mathematics learning through computational thinking activities: A systematic literature review](#). *Journal of Universal Computer Science*, 24(7), 815–845.
- Bocconi, S., Chiocciariello, A., Dettori, G., Ferrari, A., Engelhardt, K., Kampylis, P., & Punie, Y. (2016). [Developing computational thinking: Approaches and orientations in K-12 education](#). *Proceedings EdMedia 2016, June*, 1–7.
- Cahdriyana, R. A., & Richardo, R. (2020). [Berpikir komputasi dalam pembelajaran matematika](#). *LITERASI (Jurnal Ilmu Pendidikan)*, 11(1), 50.
- Ching, Y. H., Hsu, Y. C., & Baldwin, S. (2018). [Developing computational thinking with educational technologies for young learners](#). *TechTrends*, 62(6), 563–573.
- Costa, E. J. F., Campos, L. M. R. S., & Guerrero, D. D. S. (2017). [Computational thinking in mathematics education: A joint approach to encourage problem-solving ability](#). *Proceedings - Frontiers in Education Conference, FIE, 2017-Octob(June)*, 1–8.
- Csizmadia, A., Standl, B., & Waite, J. (2019). [Integrating the constructionist learning theory with computational thinking classroom activities](#). *Informatics in Education*, 18(1), 41–67.
- Echeverria, L., Cobos, R., & Morales, M. (2019). [Improving the students computational thinking skills with collaborative learning techniques](#). *Revista Iberoamericana de Tecnologias Del Aprendizaje*, 14(4), 196–206.
- Fisher, R. (1999). [Thinking skills to thinking schools: Ways to develop children's thinking and learning](#). *Early Child Development and Care*, 153(1), 51–63.
- Gadanidis, G., Cendros, R., Floyd, L., & Namukasa, I. (2017). [Computational thinking in mathematics teacher education](#). *Contemporary Issues in Technology and Teacher Education*. 17(4), 458–477.

- Grover, S., & Pea, R. (2013). [computational thinking in k-12: a review of the state of the field](#). *Educational Researcher*, 42(1), 38–43.
- Hattikudur, S., Sidney, P. G., & Alibali, M. W. (2016). [Does comparing informal and formal procedures promote mathematics learning? the benefits of bridging depend on attitudes toward mathematics](#). *The Journal of Problem Solving*, 9(1).
- Insorio, A. O., & Librada, A. R. P. (2020). [Enhancing mathematical critical thinking and problem-solving skills through emergentics® as a grouping mechanism](#). *Contemporary Mathematics and Science Education*, 2(1), ep21002.
- Kallia, M., van Borkulo, S. P., Drijvers, P., Barendsen, E., & Tolboom, J. (2021). [Characterizing computational thinking in mathematics education: A literature-informed Delphi study](#). *Research in Mathematics Education*, 23(2), 159–187.
- Kamal, P. (2016). [Fostering critical thinking practices at primary science classrooms in Nepal](#). *Research in Pedagogy*, 6(2), 1–7.
- Karakozov, S. D., & Ryzhova, N. I. (2019). [Information and education systems in the context of digitalization of education](#). *Journal of Siberian Federal University - Humanities and Social Sciences*, 12(9), 1635–1647.
- Lipman, P. (2015). [Capitalizing on crisis: Venture philanthropy’s colonial project to remake urban education](#). *Critical Studies in Education*, 56(2), 241–258.
- Maharani, S., Nusantara, T., As’ari, A. R., & Qohar, A. (2019). [How the students computational thinking ability on algebraic?](#). *International Journal of Scientific and Technology Research*, 8(9), 419–423.
- Marchelin, L. E., Hamidah, D., & Resti, N. C. [Efektivitas metode scaffolding dalam meningkatkan kemampuan berpikir komputasi siswa smp pada materi perbandingan](#). *Jurnal Pengembangan Pembelajaran Matematika (JPPM)*, 4(1), 16–29.
- Matthew, L. (2012). *Thinking in education* (2nd editio). Cambridge University Press.
- Miles, M. B., Huberman, A. M., & Saldana, J. (2018). *Qualitative data analysis a methods sourcebook* (4th ed.). SAGE Publications.
- Morreale, P., Goski, C., Jimenez, L., & Stewart-Gardiner, C. (2012). [Measuring the impact of computational thinking workshops on high school teachers](#). *Journal of Computing Sciences in Colleges*, 27(6), 151–157.
- Nuryanti, L., Zubaidah, S., & Diantoro, M. (2018). [Analisis kemampuan berpikir kritis siswa SMP](#). *Jurnal Pendidikan*, 3(2), 155–158.
- OECD. (2018). [PISA 2021 mathematics framework \(DRAFT\)](#). *Angewandte Chemie International Edition*, 6(11), 951–952., 5–24.
- Osman, S., Che Yang, C. N. A., Abu, M. S., Ismail, N., Jambari, H., & Kumar, J. A. (2018). [Enhancing students’ mathematical problem-solving skills through bar model visualisation technique](#). *International Electronic Journal of Mathematics Education*, 13(3), 273–279.
- Panbanlame, K., Sangaroon, K., & Inprasitha, M. (2014). [Students’ intuition in mathematics class using lesson study and open approach](#). *Psychology*, 05(13), 1503–1516.
- Permendikbud. (2018). [Permendikbud RI nomor 37 tahun 2018 tentang Perubahan atas peraturan menteri pendidikan dan kebudayaan nomor 24 tahun 2016 tentang kompetensi inti dan kompetensi dasar pelajaran pada kurikulum 2013 pada pendidikan dasar dan pendidikan menengah](#). *JDIH Kemendikbud*, 2025, 1–527.



- Psycharis, S., & Kallia, M. (2017). [The effects of computer programming on high school students' reasoning skills and mathematical self-efficacy and problem solving](#). *Instructional Science*, 45(5), 583–602.
- Pulimood, S. M., Pearson, K., & Bates, D. C. (2016). [A study on the impact of multidisciplinary collaboration on computational thinking](#). *SIGCSE 2016 - Proceedings of the 47th ACM Technical Symposium on Computing Science Education*, 30–35.
- Septiana, R., Febriarini, Y. S., & Zanthi, L. S. (2019). [Analisis kemampuan berpikir kritis matematis siswa SMP](#). *Jurnal Pembelajaran Matematika Inovatif*, 2(8), 393–400.
- Sykora, C. (2021). *Computational thinking for all*. April 23, 2021
- Tiwari, S., Obradovic, D., Rathour, L., Narayan Mishra, L., & Mishra, V. N. (2021). [Visualization in mathematics teaching](#). *Journal of Advances in Mathematics*, 20, 431–439.
- Williams, M. (2017). [John dewey in the 21st century](#). *Journal of Inquiry and Action in Education*, 9(1), 91–102.
- Wing, J. M. (2017). [Computational thinking's influence on research and education for all](#). *Italian Journal of Educational Technology*, 25(2), 7–14.
- Yasar, O., Maliekal, J., Veronesi, P., & Little, L. J. (2017). [The essence of computational thinking and tools to promote it](#). *ASEE Annual Conference and Exposition, Conference Proceedings*,
- Zahid, M. Z. (2020). [Telaah kerangka kerja PISA 2021 era integrasi computational thinking dalam bidang matematika](#). *Prosiding Seminar Nasional Matematika*, 3, 706–713.