Exploring the Teacher's Creative Process Based on Amabile's Creativity Componential Theory: A Case Study During COVID-19 in Indonesia

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Abstract

The COVID-19 pandemic has impacted students' mathematics learning activities by requiring learning from home. Therefore, teachers are expected to be innovative and creative to meet students' learning needs. This study aimed to explore the creativity of teachers and students based on Amabile's creativity componential theory in the midst of the COVID-19 pandemic. The case study approach used in this study involved a 29-year-old teacher and three 10-year-old students. The teacher was selected for his professional achievements as a teacher in South Sulawesi. The data were analyzed through the following stages: (1) Analyze; (2) Perform data reduction (3) Compile data (4) Check data validity, (5) Interpret data/draw conclusions. The results showed that learning by involving projects can increase the creativity of teachers and students in learning mathematics during the COVID-19 pandemic. The research conclusion shows that the creativity that occurs in teachers fulfills the components of Amabile theory. Virtual learning involving projects carried out in the midst of the COVID-19 pandemic can increase the creativity of teachers and students.

Introduction

The implementation of mathematics learning activities is quite challenging for students and teachers, especially during the COVID-19 pandemic when students are required to learn from home. In distance learning, parents play an important role in monitoring children's activities at home when schools are closed in response to the COVID-19 crisis. Mathematics learning that is conducted at home can sometimes be dull if it is not interspersed with other fun activities. Therefore, teachers must be innovative and creative, especially in designing learning tasks. The school used to be a second home for students, but in the midst of the COVID-19 pandemic, the situation has turned back to, at this time, home functioning as a school for students. In order for learning to be more interesting, less monotonous and less stressful, teachers need to develop fun and creative tasks. *"Kreativitas guru menunjukkan bahwa apa yang dilakukan guru saat ini lebih baik dari apa yang dilakukan sebelumnya dan apa yang dilakukan guru di masa depan harus lebih baik dari apa yang dilakukan saat ini"* (Mulyasa, 2010), in english it is interpreted as teacher creativity shows that what teachers are doing now is better than what has been done before and what teachers are doing in the future should be better than what they are doing right now.

According to Schermerhorn et al. (2012), creativity generates new ideas or unique approaches to solving problems. According to Amabile (1983), Amabile & Pratt (2016) and Amabile & Pillemer (2012), creativity arises from the interaction between the three components existing within a person: (a) domain-relevant skills, (b) creativity-relevant processes, and (c) task motivation; and one component outside a person, that is the social environment surrounding the person. Elaborating, domain-relevant skills are factual knowledge and domain of expertise possessed by creative individuals; creativity-relevant processes are general cognitive skills that promote idea generation; while task motivation refers to one's intrinsic motivation to complete a task. Social environment refers to the environment in which the person works (Amabile, 1983; Amabile & Pillemer, 2012).

Several researchers have considered how teachers can make students more creative (Passarella & Passarella, 2022; Starko, 2013; Kaufman & Baghetto, 2013). These researchers have found that helping students be creative requires teachers to have knowledge of what creativity is and what it looks like. To support students' creativity in problem posing, context of significance becomes an important factor in increasing the chances of finding a relationship between mathematics inside and outside the classroom (Passarella & Passarella, 2022). Teachers must provide examples and opportunities for students to be creative. Teachers can do this by prioritizing creativity in classroom learning (Starko, 2013). Modeling and reinforcement must play a major role in making creativity a part of every lesson (Kaufman & Beghetto, 2013). In addition, students need to be encouraged to develop creativity (Garner, 2013), so teachers must carefully choose techniques to motivate students to be creative (Kaufman & Beghetto, 2013), and teachers must always give students the opportunity to show their creativity (Kaufman & Beghetto, 2013).

It is not always easy to promote creativity in the classroom, especially in the mathematics classroom because mathematics contains many complex phenomena that make analysis a difficult task. Hiebert (2013) argues that teaching should consist of interactions between students and teachers on learning content, and should aim to help students achieve learning goals. Inspired by this definition, many previous studies have used multiple perspectives to investigate and analyze mathematics learning. Henningsen and Stein (1997) and Hsu (2013) investigated mathematics instruction and analyzed the types of mathematical problems used in the classroom. Hiebert, Morris, and Glass (2003) analyzed mathematics learning in various countries from various aspects such as presentation and function of mathematics problems, problem types, homework assignments, and available resources. Stein, Remillard, and Smith (2007) suggest that researchers should try to understand the effect of teaching strategies on mathematics learning through analysis of sources, types, and implementation of mathematical problems. All previous research has focused on math problems because the mathematics curriculum consists of math problems (Hsu, 2013 and Stein et al., 2007) and most teachers tend to teach mathematics using the textbook math problems (Grouws, Smith, & Sztajn, 2000 and Hsu & Kuo, 2016).

During the COVID-19 pandemic era, there was a decline in quality of education (Muzaini et al.,2021). However, it is possible that teachers can slowly re-develop creativity. There were 14 schools that we visited in stages, and succeeded in conducting interviews with all teachers through a mixed method virtual survey, data in the form of information was collected using various virtual survey methods or a combination of virtual and face-to-face methods. The results of our preliminary observations indicate that teachers mostly make one-way interactions in distance learning. Most teachers only give assignments to students, resulting in exhausting them. Some students even feel that the tasks given by the teacher are extremely challenging even though they are designed as multiple choice questions. If the teaching and learning process is only conducted by giving and doing assignments, some educational aspects cannot be achieved because apart from involving two-way dialogue, education must accommodate students' thoughts and feelings.

Based on the results of several previous studies and of the preliminary observations, it can be concluded that teacher creativity in mathematics learning in the midst of the COVID-19 pandemic needs to be investigated carefully. Creativity will be analyzed based on the Amabile's creativity componential theory.

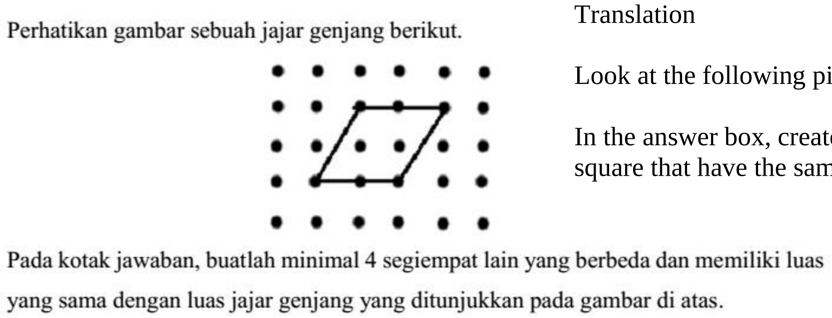
Research questions

The focus of the study was formulated into the following questions. During the COVID-19 pandemic, what creativity components have been developed

- by teachers, based on the Amabile's creativity componential theory?
- by teachers and students, perceived from domain-relevant skills?
- by teachers and students, perceived from the creativity-relevant processes?
- by teachers and students, perceived from task motivation?

Methods

This study was designed as a qualitative case study (Yin, 2013). The participants for this study were purposefully chosen among all students from all elementary schools in Makassar. The selected teacher-participant represented outstanding teachers from South Sulawesi. The selection of outstanding teachers is based on the achievements that teachers have achieved in the selection of outstanding teachers at both regional and national levels. Of the 110 students, we managed to collect 30 students as research participants, and 4 students who would be observed creative processes based on Amabile's creativity componential theory. A pre-test to assess students' cognitive flexibility (as presented in Fig. 1) was administered. The selection of four students as the focus of our observation was based on their performance as indicated on the pre-test.



Translation

Look at the following picture of a parallelogram

In the answer box, create at least 4 different any square that have the same area as the parallelogram

Figure 1. Instruments for measuring students' cognitive flexibility abilities. Translation: Look at the following picture of a parallelogram. In the answer box, create at least 4 different any square that have the same area as the parallelogram

Therefore, the sample of this study consisted of one teacher and four students. Even though the observations only focused on four students, the learning process continued as usual, consisting of 1 teacher and 30 students. Pseudonyms were used to protect the confidentiality of the participants' identity.

There was no conflict of interest towards the participants. The participants were purely selected based on the following criteria: (1) the participants possessed good communication skills; they were able to communicate ideas clearly so that it was easy to reveal their creativity; (2) the participants were willing to be involved in the study. The participants were then briefed on the material that was going to be used in the learning process. The process of video-taping the instructional process was carried out in a special room so that the teacher-participant felt more relaxed during the teaching and learning process. Vanessa (pseudonym) is a 29-year old alumnus from the Graduate School of Malang State University. She graduated from the university with cum laude honors. Vanessa was one of the participating teachers in a national event on outstanding teachers in 2019. The national event was attended by 694 teachers and education personnel from 34 provinces in Indonesia. Vanessa is also an instructor at one of the private courses in Makassar.

Setting
The study was conducted through an online learning process in April 2020. The main goal of the learning process was to familiarize students with the theoretical framework needed to critically evaluate information and create visual depictions of information related to the area and circumference of two-dimensional shapes. The teaching and learning process lasted for 6 weeks, taking place every Monday.

Over six weeks, the following competencies were covered:

1. Describing and determining area and volume in non-standard units using concrete objects;
2. Solving area and volume problems in non-standard units;
3. Describing fold and rotational symmetries of shapes;
4. Identifying fold and rotational symmetries in shapes;
5. Explaining and determining the perimeter of a two-dimensional shape and;
6. presenting and solving problems related to the perimeter of the shape.

To understand the description of the learning stages carried out during the research process, the researcher will attach examples of learning stages for one basic competency.

In week 1, the activities were organised as follows:

a) To orient students to the problem, the teacher asks questions about the high-low and long-short conditions of objects around your house: *"What objects in your house are made of wood?"... .....“Who made the tables, chairs and cupboards?”.*
b) The teacher shows a video of the work of making a table with emphasis on the measurement *aspect:"What was the first step that the carpenter took?”...make a table?”...."The wood that the craftsman has is taller, bigger lower, longer, and shorter....With what tool, sir?....would you measure the material to make the table?”...."If you don't have the tools that a carpenter has, ow do you measure this object?".*
c) Students listen and try to answer.
d) The teacher makes an agreement with the students that the students will measure objects in each student's house that are made of wood but using non-standard units.

In the activity of guiding individual or group investigations: (a) Students work together with groups in solving problems; (b) Teacher with observation sheet monitors activities and development of problem solving via zoom; (c) The teacher invites students to do simple ice breaking like mentioning different sizes with hand movements, playing interesting videos related to object size comparisons such as *"Blackboard, Big*" while "*Notebook, Small*". The second meeting in the first week involves activities to develop and present work results: (a) Each group carries out a polite discussion to produce problem solving solutions; (b). Each group presents the results of the discussion confidently in turn. Activities of analyzing and evaluating the problem solving process: (a) Each group makes a presentation while the other groups give appreciation in the form of questions or provide good feedback

(b) The teacher and students conclude the material by singing the song "Non-Standard Measurement Tool" which is played on YouTube.

Every week, the students would be asked to watch a video made by Vanessa. Next meeting, the students would work on a project using presentation, discussion and question and answer methods. During the learning process, the researcher observed each learning activity taking place with reference to each indicator of Amabile's creativity componential theory, namely (a) domain-relevant skill, (b) creativity-relevant process, or (c) task motivation. Domain-relevant skill categorization is when research participants, both students and teachers, are able to bring up threads that lead to the process of acquiring knowledge about the material content that is the focus of the problem. The creativity-relevant process is characterized by the occurrence of a teacher activity process that is able to trigger students to find something new in the form of non-routine mathematical problem solving processes such as defining problems, gathering information, organizing information, combining concepts, generating ideas, evaluating ideas, implementing solutions, or monitoring solutions. Task motivation is characterized by the occurrence of behaviors such as praising, approving, criticizing, or answering student responses or questions. Domain-relevant skills refer to sources of information or knowledge obtained, such as from textbooks, experience/habits or from other sources.

Data Collection and Analysis

The data were collected through Think Out Loud (TOL) protocols. Olson, (2000), explains that the Think Out Loud method aims to study how a person solves problems. TOL allows recording of what a person is thinking when solving a problem, so that the person's cognitive processes can be analyzed and identified based on the given problem. Interviews with participants were conducted via Zoom (https://zoom.us/), assisted by interview guidelines (Creswell, 2017). To obtain relevant data, prompts were used during the interviews Creswell, (2017) The interview transcripts and physical behavior shown by the participants were analyzed using the following steps: (1) Analyzing and scrutinizing all available data from various sources, such as from the interviews and Think Out Loud videos; (2) Performing data reduction by making abstractions. Abstraction is an attempt to summarize the core, process, and statements delivered by the participants of a study; (3) Arranging the data into units and categorizing them by coding; (4) Checking the validity of the data through time triangulation and analyzing interesting findings, for example the behavior of the participants that was unplanned and not related to the research objectives; (5) Interpreting the data/drawing conclusions.

Data Reduction

Data analysis was carried out through data reduction. Data reduction is the process of analyzing data to sharpen and classify research findings based on the research focus. To get the required information, prompts and threads are needed. Prompts are the interviewer's initial statements that are used to dig deeper into the required information. Threads are responses that arise from students after prompts.

Prompts and threads were coded based on the Amabile's componential theory (Amabile, 1983 & (Amabile & Pillemer, 2012), suggesting that creativity consists of: (a) domain-relevant skills, (b) creativity-relevant processes, and (c) task motivation. Research findings were categorized as domain-relevant skills if the research participants, both students and the teacher, were able to generate threads that led to the process of acquiring knowledge about the materials discussed in the study. Research findings were categorized as a creativity-relevant process when the teacher carried out a process that could trigger students to discover something new or solve non-routine mathematical problems such as defining problems, gathering information, organizing information, combining concepts, generating ideas, evaluating ideas, implementing solutions, or monitoring solutions (Mumford, Giorgini, Gibson & Mecca, 2013). Research findings were categorized as task motivation when there was a process/activity of praising, approving, criticizing, or answering student responses or questions (Karakaya & Demirkan, 2015).

Furthermore, the categorization of domain-relevant skills was broken down into several sub-categories which indicate the source of domain knowledge. The codes used were (a) textbooks, (b) experiences/habits, and (c) additional sources. The sub-categorization codes for creativity-relevant processes included (a) cognitive flexibility, (b) cognitive fluency, (c) imagination, (d) action, (e) observation (f) harvesting (Rahayuningsih, Sirajuddin & Ikram, 2021; Singer, Voica & Pelczer , 2017). Furthermore, the sub-categorization codes for task motivation consisted of (a) praise (b) feedback and (c) criticism. The codes used for types of responses generated from the prompts and threads used in this study were (a) student feedback, (b) teacher feedback, and (c) new question. The arrangement of the coding units is presented in Table 1.

Table 1. Coding units

The components of the creativity model	Categorization Code	Sub-categorization Code	Code for Types of Responses
Domain-relevant skills	D	• Textbooks (bt) • Experiences/habits (p) • Additional sources (st)	• Student feedback (ubs) • Teacher feedback (ubg) • New question (pb)
Creativity-relevant processes	C	• Cognitive Flexibility (cfx) • Cognitive fluency(cfl) • Imagination (ima) • Action (act) • Observation (obs) • Harvesting (har)	• Student feedback (ubs) • Teacher feedback (ubg) • New question (pb)
Task motivation	T	• Praise (pu) • Feedback (ub) • Criticism (k)	

In this research, coding was used through a deductive approach. The reason for using a deductive approach was because the themes being researched had been determined previously. However, in the middle of the research, there were several codes that we obtained from the inductive approach as well. such as the terms Cognitive Flexibility (cfx), Cognitive fluency (cfl), Imagination (ima), Action (act), Observation (obs) and Harvesting (har). This component appears when researchers abstract from the data that has been collected. The emergence of sub-categorization code in Creativity-relevant processes appears in unexpected data. So researchers can conclude that the coding used in this research uses a mixed approach (deductive and inductive), this is called a hybrid coding approach (Swain, 2018)

Abstraction

The data abstraction process is described as follows. After reducing the data, any interesting findings found in the field were defined. At the abstraction stage, there was a new creative process that appeared in the creativity-relevant process. This process triggered the emergence of creative behavior that led to the discovery of various and new problem solutions. This process was formed when the students attempted to complete the project from the teacher. Then, a new creative process appeared in the domain-relevant skills, such as when the students recounted daily habits related to the project presented by the teacher, e.g. measuring neighbor tiles and buying tiles to fill a floor area. The following is an abstraction model of the creative process found in this study.

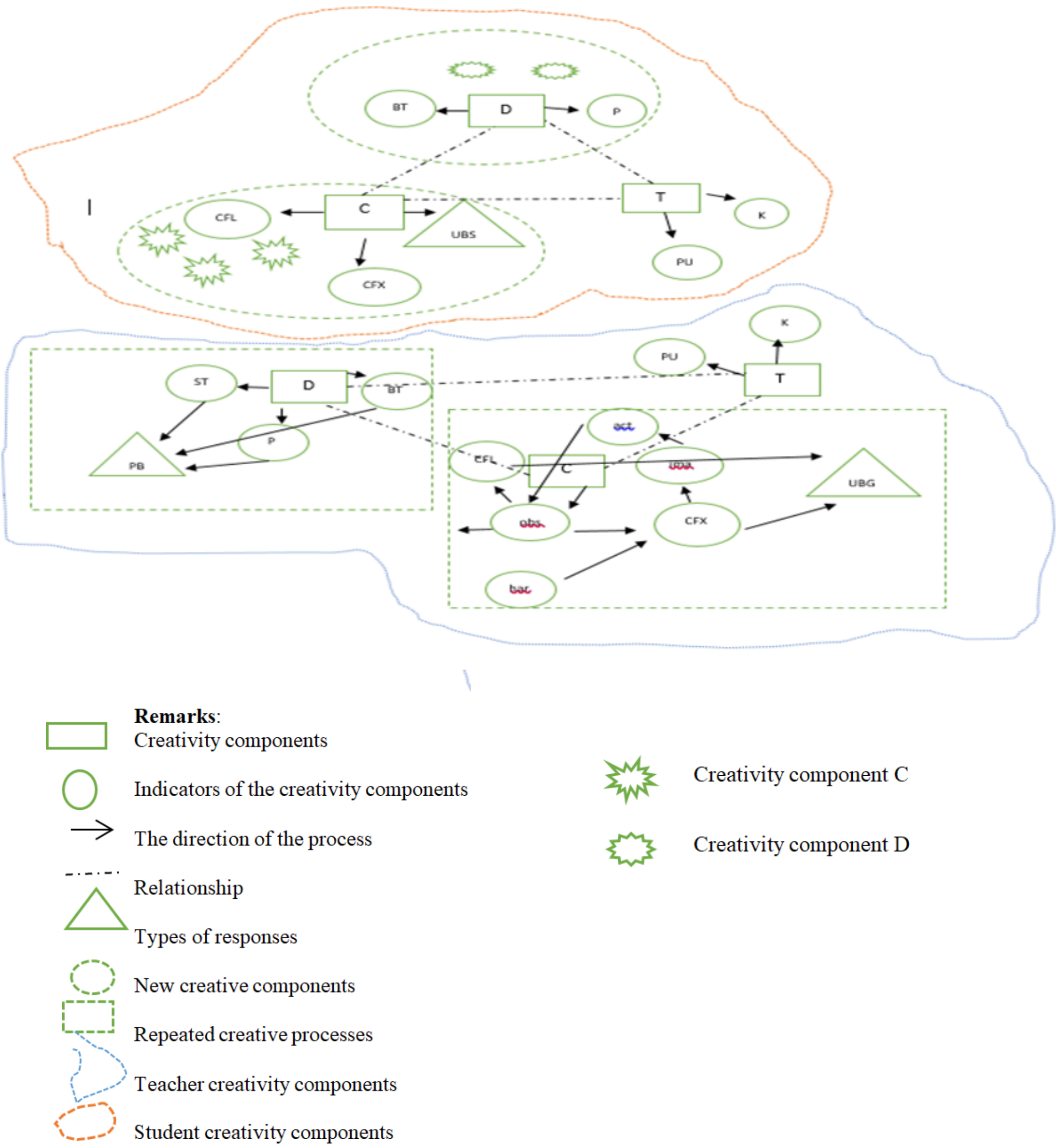


Figure 2. Creative Process Abstraction

Results

The findings of the study will be discussed based on the research questions that were presented in the introduction section of this paper. The answers to these questions can be identified from the abstraction process described in the previous section. Before answering the general question "What creativity components have been developed by teachers during the COVID-19 pandemic, based on Amabile's creativity componential theory?", the specific problems should be solved first. The following sections will discuss each of the specific questions posed in this study.

What creativity components have been developed by teachers and students during the COVID-19 pandemic, perceived from domain-relevant skills?

At the beginning of the learning process, the teacher directed the students to take part in learning using Zoom and Google Classroom applications. Each student was given access to a Zoom ID and a Google Classroom ID. Before conducting learning, the teacher had developed a textbook, project worksheets and assessment sheets. The creative processes carried out by the teacher that were categorized as domain-relevant skills will be presented in the form of think out loud recording transcriptions, such as follows.

> *…"I have developed teaching materials, a book, assessment sheets and project assignments, are you ready to learn today? I'll explain the learning method that you will follow over the next few weeks….."(Student-teacher interaction, TOL0045, 2020)*

The excerpt of the teacher's TOL process showed the teacher's domain-relevant skills. The teacher used a project-based learning model and also developed a textbook, project assignments and project assessment sheets. The textbook, project assignments and project assessment sheets were developed using graphic design applications. Since learning was carried out online, animations were involved.

> *Researcher : Explain what have you prepared for learning?*
> *Teacher: I have developed a fun learning textbook for the third grade students. They are going to like the contents of the book.*
> *R : How did you develop the books?*
> *T : I used some applications available on the playstore; some materials are translated into animations, I also used the applications to develop the project assessment sheets.*
> *(Teacher interview, WG10.21, 2020).*

The use of prompts during the interviews helped the researchers to focus more on exploring information related to the research objectives. The following table contains the frequency of responses after prompts.

Table 2. The Frequency of Responses after Prompts

Creativity components	Responses
Domain-relevant skills	516
Creativity-relevant processes	130
Task motivation	712
Others	34
Total	1392

Prompts were also helpful for the students to develop ways of thinking that are relevant to creativity as shown in the following interview excerpt:

> *Researcher: please describe how you obtain information about the project given by Mrs. Vanessa?*
> *Student: I watched a lot of videos on YouTube and it was so fun, I thought the problem was easy to solve.*
> *R: How so?*
> *S: My father is a builder. I sometimes help him when the school is closed on holidays. I am used to calculating the number of tiles to fill a floor area.*
> (Student interview, WS01.25.21, 2020).

Prompts were also useful in developing the students' domain-relevant skills when working on a given project, as shown in the following interview excerpt:

> *Researcher: Wow, this is very interesting, your project is unique, how can you count like that?*
> *Student: I watched several videos on YouTube and found that the area of a plane is a two-dimensional unit that has two directions.*
> *R: Can you explain more?*
> *S: It means that the object has two directions of length and width, 1cm^2 has a length of 1cm and a width of 1cm as well.*
> *R: What can you conclude from that information?*
> *S: That is, to find the area of a square, it is enough to calculate the number of squares 1cm^2 that cover the surface of a large square.*
> *(Student Interview, WS11.54.21, 2020).*

Figure 2. Project-Based Learning Video

The interview excerpt showed that the student understood that the area of the two-dimensional figure can be found by calculating the number of square units that cover the rectangular shape to obtain 32 unit squares or 32cm2.

Figure 3. Project-Based Learning video

In the middle of the learning process, the interaction between the students and the teacher seemed to be able to improve the students' domain-relevant skills, where the teacher answered the questions asked by the students. This interaction was shown in the learning video from week 3. Curiosity made the students feel challenged to seek information from the teacher. Even so, the courage of the students to raise initial questions about the development of the creative process appeared. The students were able to ask questions relating to domain-relevant skills. The following excerpt showed the interaction between Mrs. Vanessa and one of the students:

Student: I found it difficult to figure out the fold symmetry of a circle and this cannot be found in the videos that you presented in the previous week, why?
Mrs Vanessa: Why did you ask the question? don't you think that you don't need to know it yet?
S: It suddenly popped up in my mind and I was curious about fold symmetry.
Mrs Vanessa: You are a genius, Try to think how many fold symmetries can be found in a circle.
S : I can conclude that to find the area of a square it is enough to count the number of squares 1cm^2 covering the surface of the large square.
(Student-teacher interaction, TOL2113, 2020)

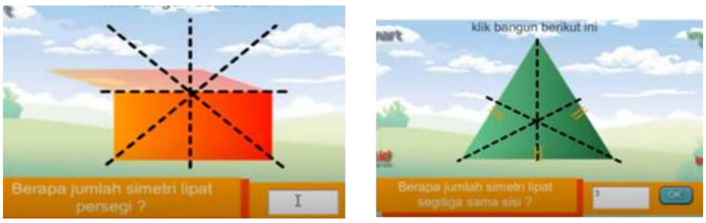


Figure 4. Project-Based Learning video

What creativity components have been developed by teachers and students during the COVID-19 pandemic, perceived from creativity-relevant processes?

Creative processes have emerged at the beginning of learning from both the teacher and the students. The following is a description of the teacher's and students' creativity, perceived from creativity-relevant processes. Students' ability to think flexibly indicates creativity in the process domain. Cognitive flexibility was revealed through the teacher-students discussion that occurred after the students had presented their project. The visible creative condition was that the teacher was able to explain types of two-dimensional shapes that have the same area and circumference. The following excerpts contain TOL transcripts from week 2.

..........”Now, after you understand the definition of area and perimeter, I will give you several different shapes, now can you observe and find out the area of the shapes.”?...
(Student-teacher interaction, TOL902, 2020).

.........”you know the definition of the perimeter of the shape already, who can find the perimeter of each shape in project exercise 2? Try to come up with reasons to support your answer”....
(Student-teacher interaction, TOL924, 2020).

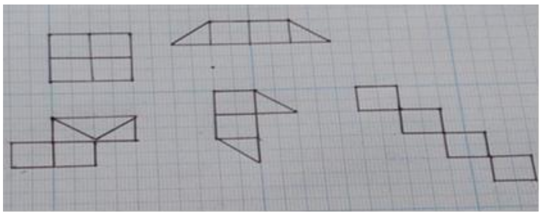
The excerpts above showed that the teacher was able to provide the students with several examples of different questions that required the same answer, and vice versa. When explored further, the questions posed by the teacher were open-ended questions. Cognitive flexibility was also observed in the students’ answers. The following is an excerpt from student interview:

Researcher: Can you give reasons to support your answer?
Student: I drew various kinds of two-dimensional shapes with an area of 4cm^2
R: How many two-dimensional shapes have you created?
S: There are five in total.
R: Can you identify each of them?
S: a square, a trapezoid, a combination of a square and a triangle, the arrangement of four rhombuses.
(Student Interview, WS43.02.21, 2020).

Based on the excerpt above, it is clear that the student was able to perform cognitive flexibility in solving the problem given. The student seemed to understand the problem so well that the student could apply the same strategy to solve different questions and find the right answer to the question and a reasonable argument to support the answer. Furthermore, the students’ ability to describe everyday life experiences related to the problem is shown as follows.

...”who can find the same surface area in the image? Come on, does anyone know?
Guru : Rio, can you explain it?
Student 1 : The area of the first goat pen is 60 m^2 because 1 can of paint can cover the surface of the 30 m^2 wall, while Toni's father has used up two cans of paint on the pen’s wall.
Guru: Well, that is a very good explanation, so which area is equal?
Student 2: Toni’s father’s goat pen and Rara’s mother’s kitchen wall. Two cans of paint were spent on each of them.
(Student-teacher interaction, TOL1098, 2020).

The excerpt above indicated the ability of the teacher and the students to develop (development) ways of thinking in a more complex direction. They checked and found out all available information needed to complete the project. Thus, the observation process appeared in the learning process.



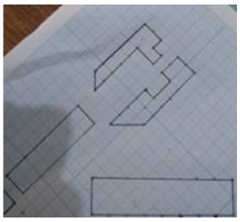


Figure 5. Student answer to project 1

The observation process was followed by a metacognitive process. The students seemed to think and repeat the same process when asked further questions by the teacher. Metacognitive abilities can increase students' creativity when solving problems. The students were able to imagine or create pictures of events based on reality or prior experiences. After describing the existing experiences, the students then concluded (harvested) answers based on the questions contained in each project.

What creativity components have been developed by teachers and students during the COVID-19 pandemic, perceived from task motivation?
The interactions between the teacher and the students during the learning process were able to improve students' task motivation. The interactions that occurred during learning including teacher feedback, positive reinforcement, motivation and praise are the processes that appeared during the learning activities.

.....” You're so great, Verny, where did you find that idea from? ... Come on, how about the others? Does anyone have any different ideas? Come on, maybe the others can improve their friend's opinion a little...”.
(Student-teacher interaction, TOL546, 2020).

The teacher tried to motivate those who had not understood the material yet, and paid special attention to the students to figure out their difficulties in solving the problem by also providing scaffolding. Providing scaffolding in the form of directions, encouragement and occasionally giving similar examples is a good way to increase student task motivation. The following is an example of teacher scaffolding.

Mrs Vanessa (T): Have you found difficulty solving the problem?
Student (S) : It is difficult to determine the area of this shape.
Mrs Vanessa: Yes? Which one is difficult? You can ask me if you cannot understand it. I’ll help you out.
S: Hmm, how can I draw another two-dimensional shape, besides a square? Only the square is 4cm^2, isn’t it? What is the other? I could not find it.
T: What shapes did you draw on your gridded paper? If I describe it like this, can you see the area of the shape?
S: Oh wait, it is also 4cm^2.
T: Can you draw another two-dimensional shape with the same area?
(Student-teacher interaction, TOL681, 2020).

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......”a little more, your answer is close to perfect, let's correct a few sentences so that they become perfect”....
(Student-teacher interaction, TOL1143, 2020).

Anxiety greatly affects task motivation. The students expressed experiencing anxiety during virtual learning. When Mrs. Vanessa greeted the students, the students chose to remain silent and were afraid to ask questions about problems that might interfere with learning in the next few minutes.

> *Student 1: when can we go back to school? we feel that seeing the teacher in person is better than having to meet in front of a laptop, it's very uncomfortable and makes me sad..."*
> *Student 2 : this is like a nightmare!*
> *Teacher: Is it why you don't study hard?*
> *Student 3: I am actually enjoying it; I can play a lot of games at home (laugh)*
> *Teacher: What games?*
> *Student 3: My mom always invites me to play puzzles and it's fun*
> *Student 1: Wow, that's great, and didn't you realize that puzzle resembles the way you put the square pieces together.*
> *Student: I also thought about that while working on that project*
> *(Student-teacher interaction, TOL145, 2020).*

However, the positive reinforcement given by Mrs. Vanessa was able to revive the enthusiasm of the students who were initially discouraged. Thus the next learning process could run well. The following excerpt contains teacher interview at the end of the learning program.

> *Researcher: Are there any obstacles found during the learning process?*
> *Mrs. Vanessa: Some students were worried that they would never see their friends and teachers in person again. They regret going to virtual learning forever.*
> *Researcher: What did you do after hearing this?*
> *Mrs. Vanessa: I tried to calm and give understanding to the students to keep them motivated because soon enough they will meet their friends and teachers again. Schools will reopen, they can play together again. Because they must believe that their future life will continue to improve. That way students don't have to worry anymore about this pandemic, so that their enthusiasm for learning can continue to increase.*
>
> *(Teacher interview, TOL213, 2020).*

Discussion

Project-based virtual learning during the COVID-19 pandemic was able to increase the teacher's and students' creativity based on Amabile's Componential Theory of Creativity (Amabile, 1983 & Amabile & Pillemer, 2012). In line with the opinion of DeNoyelles, Mannheimer Zydney and Chen (2014), project-based learning is able to develop student creativity, where the teacher asks students to solve problems by developing projects. Although many studies have revealed the failure of virtual learning during a pandemic, such as Sari, Pektaş, Çelik and Kirindi's (2019) findings showing that computer-based laboratory practices are more effective in developing students' abilities to draw, understand and interpret graphs than virtual laboratory applications.

The ability of the teacher to manage the class, develop learning tools in the form of textbooks, project worksheets and assessment sheets reflects her creativity in domain-relevant skills.

Akyol and Garrison (2011a, 2011b) state that the ability of teachers to prepare teaching materials such as textbooks, teacher-created videos, or additional sources on real world issues may stimulate students to develop cognitive processes during learning. Students' ability to design a project to solve problems is a form of students' domain-relevant skills. Students' domain-relevant skills in this study were visible when the students were asked to complete a series of project assignments. The students connected their daily experiences and activities to watch YouTube videos with the problems presented by the teacher to obtain information and develop knowledge.

The teacher was able to present learning information effectively, the learning flow was in accordance with the planned learning objectives. The teacher was also able to analyze the way the students thought and acted when solving problems. Teachers can explain how students can think and act when completing tasks if they are equipped with the ability to hypothesize learning (Gómez, 2018; Clements, Sarama, Spitler, Lange, & Wolfe, 2011) and analyze information to improve planning (Chick, 2007; Charalambous, Philippou, , & Kyriakides, 2008; Wilson, 2009; Clarke & Roche, 2010). It is thus important to develop a program to assist teachers in formulating and developing students' capacities that are connected to the learning goals, especially in the midst of the COVID-19 pandemic.

The creativity-relevant processes frequently appeared during the discussion process. The teacher provided the students with various examples of problems relevant to the topic being discussed, allowing either the teacher or the students to perform cognitive flexibility. In line with this finding, Deak, Ray, and Pick (2004) explain that cognitive flexibility of a person can be defined as the dynamic activation and modification of cognitive processes in response to changes in task demands, which results in representations and actions that are well adapted to the altered task and context. In other words, cognitive flexibility addresses the readiness with which a person's concept system changes selectively in response to appropriate environmental stimuli (Deák et al., 2004 & Scott, 1962).

When solving a problem, the students tended to adopt the solutions that are usually found in previously encountered problems. The students always attempted to associate the problems with relevant themes or experiences found in everyday life. This statement is in line with the results of the discussion of Singer, Voica and Pelczer (2017), whose research explains that students tend to pose mathematical problems related to the content area of their choice and their cognitive ability.

Other findings from this study also indicated that the problem solving process carried out by the students involved metacognitive abilities. Likewise, Abdullah et al., (2020), argue that students with higher levels of mathematical ability will possess well-developed metacognitive skills. This means that metacognitive skills indeed affect student performance when solving mathematical problems. Furthermore, Zan (2000) explains that metacognitive intelligence will affect student performance in mathematics, especially in solving math problems. The teacher's and students' task motivation in this study increased gradually despite learning conducted amid the COVID-19 crisis. The teacher always fostered the students' motivation at the beginning and end of the lesson so that the students' task motivation could improve from time to time. Karakaya & Demirkan (2015) found that a high frequency of feedback from evaluators could increase task motivation. Providing feedback to students is able to help students find solutions in solving the problems at hand (Zaranis, Kalogiannakis & Papadakis, 2013). In addition, Higgins, Frankland and Rathner (2021) revealed that self-regulated learning with metacognitive strategies correlates with academic performance in higher education, so it is necessary to consider Self-Regulated Learning with metacognitive strategies to be used in increasing students' creative problem solving during a pandemic.

Conclusion

Virtual learning that was conducted amid the COVID-19 pandemic could improve teacher and student creativity based on the Amabile's componential theory. The teacher's ability to manage the class, develop learning tools in the form of a textbook, project worksheets or project assessment sheets reflected the teacher's domain-relevant skills. The creativity-relevant processes existed during the discussion process in which the students were offered with various problems to solve. The teacher's and students' task motivation also improved from time to time due to the teacher's efforts to always encourage the students to learn at the beginning and the end of the lesson. Other findings from this study also indicated that the students' problem-solving processes involved the students' metacognitive abilities.

For further research, it is hoped that researchers will try to involve other variables to observe their involvement in bringing out teacher creativity amidst the pandemic, especially those related to task motivation abilities. A student's cognitive domain ability do not have enough influence on the readiness of teachers and students to face sudden changes in learning patterns, but what is very influential is the ability to process positive feelings and thoughts (affective and psychomotor domains)

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