Schemata and creative thinking ability in cool-critical-creative-meaningful (3CM) learning

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Abstract

Purpose – This study aims to describe how creative thinking ability could be improved through correcting the thinking schemata using cool-critical-creative-meaningful (3CM) learning model.

Design/methodology/approach – This study implemented mixed methods with explanatory sequential, which means a study that was conducted by collecting quantitative and qualitative data, consecutively. The creative thinking ability was measured through tests and then triangulated with the student teachers answers in the interviews. The qualitative data consisted of creative thinking schemata that were collected with task analysis and think aloud method. The data were analyzed in two stages. Quantitative data analysis was used to identify the effectiveness of 3CM learning. Qualitative data analysis was conducted using Miles and Huberman's analysis.

Findings – The findings presented that 3CM learning model is significantly effective to improve the creative thinking ability of pre-service primary teacher; students with formal, content and linguistic schemata that are good and complete will also have good mathematical creative thinking ability; the mathematical creative thinking ability of student is determined by the completeness of their schemata; and a good and complete schemata (formal, content and linguistic) will help the students to produce several problem-solving alternatives.

Research limitations/implications – Because of the chosen research approach, the research results may lack generalizability. Therefore, researchers are encouraged to test the proposed propositions further.

Practical implications – The results of this study suggest lecturers to give their students a great opportunity to develop their creativity in solving mathematical problems. Lecturers could give the students the opportunity to think systematically by beginning by criticizing the interesting contextual problems and ending with meaningful reflection with adequate learning resources.

Originality/value – 3CM learning model is a model that is proven to be effective in helping the students in shaping the thinking schemata well and able to improve the creative thinking ability of the students.

Keywords Schemata, Creative thinking, 3CM learning model, Mathematics, Geometry

Paper type Research paper

Introduction

Creativity is one of the main components of education in the 21st century (Sternberg, 2005; Sternberg, 2012; Navarrete, 2013; Tindowen *et al.*, 2017; Kawuryan *et al.*, 2018;

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Suryandari *et al.*, 2018). Hence, the contemporary curriculum emphasizes on developing the students' creative thinking ability [Creative thinking ability (CTA); Vale, and Barbosa, 2015; Sternberg, 2006; Apriliani and Suyitno, 2016; Sternberg and Sternberg, 2016]. It is such an importance because CTA would allow students to acquire new knowledge, approach, perspective or method (Istiqomah *et al.*, 2017).

Creativity has been essential (Leikin, 2013; Kadir *et al.*, 2016; Nuha *et al.*, 2018) and encouraged to be developed even starting from elementary school though creative thinking process (Leikin and Elgrabli, 2015; Kadir *et al.*, 2016). Creativity occurs in certain opportunities (Wahyudi *et al.*, 2018a). It is put into action because of a situated atmosphere, environment and community that trigger the creativity (Cahyati *et al.*, 2018; Huang, 2016; Huang, 2020). In generating such condition, a teacher needs to have the ability to develop the students' creativity (including in the ways of thinking) in a proper method (Trnova and Trna, 2014). This is in accordance with the studies conducted by Dyer *et al.* (2011), which mentioned that two-thirds of someone's creativity are acquired through education and the remaining one-third is from genetics. In other words, the probability to improve someone's creativity is higher than forcing to improve the intelligence.

Yet in reality, not every mathematic learning provides the chance to improve CTA. The teaching and learning process tends to be quantity-oriented on the amount of materials delivered and the academic score achieved by students. The learning is conducted to achieve the target of exam instead of providing the experience in thinking, rationalizing and problem solving (Vyas *et al.*, 2011; Surya *et al.*, 2013; Ramlah and Marlina, 2018). Such situation caused the students' thinking ability to be relatively low, including creative thinking in solving problems.

This is proved by the rank of Indonesia in mathematic learning according to Programme Internationale for Student Assessment (PISA) issued by Organisation for Economic Co-operation and Development (OECD). The result of PISA Indonesia in 2015 has indeed been improved; however, it is still below the average. For instance, the score of mathematics is 386, which is below OECD average of 490. Based on this score, Indonesia was ranked 64 out of 72 countries (Kementerian Pendidikan dan Kebudayaan, 2016). Furthermore, based on the result of PISA 2018, the rank of Indonesia was lower than 2015. In literacy, Indonesia was placed in 74th, mathematics in 73rd with the average score of 379 and 71% of Indonesian students were categorized below the minimum competence in mathematics (Kementerian Pendidikan dan Kebudayaan, 2019). Based on this result, it is indicated that PISA Indonesia is below other countries and ought to be improved (Kementerian Pendidikan dan Kebudayaan, 2016; Zulkarnain, 2013; Istiandaru and Mulyono, 2015; Wardono *et al.*, 2016).

This situation also takes place in the University, particularly in the Study Program of Primary Education. Not every university student has the habit of learning mathematics in a way that emphasizes on developing creative ability. It is shown in the previous study by with 105 students from three private universities in Central Java as the subject. The findings presented that 84 students (80%) had relatively fair and low CTA. The aspects of creative thinking which lack in improvement were flexibility and novelty.

Changes are urgently needed in mathematic learning. Mathematic learning should maintain the balance between left brain that is associated with logic and right brain that is in charge of intuition and creativity so that both could develop simultaneously (Barnard, and Herbst, 2018; Ramlah and Marlina, 2018). This could elevate the probability to create critical students with strong logic that would build them into creative students. CTA is the combination of logical and divergent thinking. When someone is using the CTA to solve problem, the divergent thinking ability would help to generate new ideas to solve the problem, whereas logical thinking will involve rational and systematic thinking to check and validate the conclusion of problem-solving created (Siswono, 2010). Besides, it is important to link the mathematics learning with the real-life and cultural context to make mathematic easier to remember, imagine and present (Hersh, 1997; Siswono, 2010; Ernest, 2016; Mahendra, 2017; Zevenbergen *et al.*, 2004; Cartier *et al.*, 2016; Wisarja and Sudarsana, 2017; Wahyudi *et al.*, 2019b).

This way of learning will establish a positive learning environment so that the students will be motivated to learn and create something creative (Tsai *et al.*, 2015). Such learning process will help students in processing new information through adaptation processes (assimilation and accommodation). A good adaptation process can help students to formulate structural concept in the form of orderly and complete concept schemes. These schemes will continue to develop along with the students' experience and method in processing information. These schemes are linked to one another to create a system or procedure which could help them in solving problem, which is called schemata. Schemata portrays systematic thinking and behavioral pattern that are linked to one another. It is formed by experience, stored in memory and functions to set and/or construct new knowledge (Piaget, 1980; Rumelhart, 2017; Neumann and Kopcha, 2018; Longo and Perret, 2018).

During the thinking process and solving problem, students use their schemata to determine the solution to the problem (Zhao and Zhu, 2012; An, 2013). This study focuses on formal, contents and linguistic schemata. Formal schemata represents one's initial knowledge as the prerequisite knowledge to comprehend and understand a new concept. Formal schemata helps students to easily recall and use the schemata stored in their memory. So when a new information occurs, the schemata will set and revise itself. This will make students to absorb the knowledge better and help them to gain new knowledge. Content schemata is a set of students' initial knowledge on what they are going to learn. This is because students do not attend a class without any idea on what the class is going to discuss about. They have their initial experience even though not every situation is stable or well set (equilibrium). Linguistic schemata is a set of knowledge on vocabulary and language structure on the concept that will be studied as the basic to understand the concept or a more complex knowledge. With a good linguistic schemata, students will understand the terms related to the concept they are about to learn (Lawson, 2004).

Schemata serves to acquire, understand, memorize, study and solve a problem (Zhao and Zhu, 2012; An, 2013). The way someone solves a problem depends on the schemata inside their memory. A well-formulated schemata (formal, content and linguistic schemata) may help to develop students' mathematical CTA in solving mathematical problems, particularly two-dimensional figure geometry in this case.

This is the background of this study's novelty where the study of mathematical CTA is analyzed based on several disciplines such as mathematics on two-dimensional figure geometry, education of the use of cool-critical-creative-meaningful (3CM) learning in two-dimensional figure geometry, psychology in learning style and creative thinking schemata. Besides, this study also produces something new that is how adaptation result of new information that is linked to one another into a set of schema could create a system/procedure that will help students in solving problems using new and creative method.

The schemes which are connected and formed into system/procedure are called schemata (formal, content and linguistic schemata). This is what differs this study from the previous studies. The previous studies only focused on processing information into a schema of concept (new knowledge). This study also implements 3CM learning model which is the result of authors' previous study. This model is a learning model that can create a fun yet challenging atmosphere in every learning session and is developed according to the students' learning style. A fun and challenging atmosphere will give students space to learn happily without any burden and ready to face any challenges to think critically to solve the problems presented to them.

Besides, students are given chances to create a creative product, which can be in the form of problem-solving solution or the result of concept implementation in everyday life. This condition will habituate the students to think critically and creatively in producing creative products from contextual problems in their surroundings in a fun and challenging atmosphere. Such setting above may become one of the alternatives on how students' mathematical CTA is prepared in an interesting, challenging and meaningful learning activity (3CM learning) by also putting the students learning style into consideration.

Literature review

Creative thinking ability

The ability to think creatively is a mental activity to increase the authenticity of ideas (originality), and the sharpness of understanding (insight) in developing something (generating) (Coleman and Hammen, 2011) which contains aspects of cognitive and metacognitive skills (Pucio and dan Murdock, 2001). These skills include the skills of identifying problems, compiling questions, identifying data that is relevant and irrelevant, productive, producing many new ideas and containing dispositions, namely, being open, dare to take charge, act quickly, behaving or behaving (Pucio and dan Murdock, 2001). The ability to think creatively is the highest level in the cognitive process (Mohanty, 2015). Creativity may occur during the process of creation or be identified in the production result (Haylock, 1997; Reid and Petocz, 2004).

Thus, the ability to think creatively can be interpreted as the ability to think (mentally) that leads to the acquisition of new insights, ideas, approaches, perspectives or ways of understanding a problem so that solutions are found in the form of great creative products resulted by method/strategy used and involve many concepts arranged systematically and clearly. The aspects of creative thinking and description are adopted and developed from the opinions of Torrance (2000) and Kim *et al.* (2011), which cover aspects of fluency, flexibility, novelty and elaboration (Table 1).

Aspect	Description	Explanation
Fluency	The ability of students to generate many ideas of true value in a short time	Judging from the idea/idea of the answer and the number of ideas/ideas of the right answers are generated
Flexibility	The ability of students to produce many categories of answers that are true value	Viewed from the student's correct answers and explored in-depth in interviews and discussions so as to elicit another idea/another way to check again the correct answer given
Novelty	Students' ability to use new/unique, or unusual strategies/answers (different from other students) to solve problems and be true	Viewed from student answers and compared with other student's answers to see new things different from other friends as well as deeply dug in the interview
Elaboration	The ability of students to explain in detail and coherent to certain mathematical procedures, answers or mathematical situations as a solution to the correct problem that he/she gave	Judging from the explanation of the correct answers given and explored in-depth through interviews and discussions

Source: Wahyudi *et al.*, 2019a, 2019b

Table 1.
Description of aspects of CTA

Schemata in creative thinking

Schemata is a plural form or collection of concept schemes that represent generic concepts stored in memory (Rumelhart *et al.*, 1985) and are mental representations of some aspects of something in the world that serve to compare the knowledge that someone has with new information coming into him (Gardner, 1993; Cook, 1989) . The system formed will show the knowledge that has been arranged in interrelated patterns in one's mind that are built from all previous experiences and make it possible to predict the person's future experience (Cook, 1989; Piaget, 1980; Rumelhart and Norman, 1985; Neumann and Kopcha, 2018; Longo and Perret, 2018). Schemata also grown in line with the capacity of experience. In other words, schemata is proportional to experience. The more the experience, then the scheme formed will also be better than someone's experience. In its development, the previous scheme is an integral part of the new scheme. Schemata will experience development through two processes, namely, assimilation and accommodation (Piaget, 1980).

Capacity, speed and efficiency in the ability to process information are part of a person's biological development and knowledge, including metacognition (Flavell, 2004). In other words, when a person is able to organize and compile information using his/her experience, he/she will also more often use his/her metacognitive abilities. This is also called the ability to think creatively, so the scheme is very closely related to the development of the ability to think creatively and has an important role in the development of one's logic of thinking (Corcoran, 2006; Wahyudi *et al.*, 2019a, 2019b).

Thus, it can be concluded that the schema is a cognitive/knowledge structure that describes patterns of thought and behavior that are interrelated and systematic, built from experience, stored in memory and functioning to establish and/or shape new knowledge through adaptation processes that are assimilation and accommodation. Schemata is not a real object that can be seen, but a series of processes in human memory, and it has no physical form and cannot be seen. Schemata develops in line with experience capacity, so the scheme is directly proportional to experience through two processes, namely, assimilation and accommodation. Schemata functions to receive, understand, remember, learn and solve a problem. The way a person solves a problem depends on the scheme possessed in his memory.

In accordance with the definitions and things related to the scheme, the schema in thinking in portraits is in accordance with Mayer's thinking (2014); Maclin and Solso (2008), namely, thinking is a cognitive process that occurs in the mental or mind of a person, is not visible, but can be inferred from visible behavior. Thinking is a process that involves some knowledge manipulation in the cognitive system. Thinking activities are directed to produce problem solving by observing the behavior, statements and writing of students when participating in learning, doing assignments/ tests and interviews. In this study, data related to the schema in creative thinking is obtained by the task analysis method (Someren *et al.*, 1994) and think out aloud. Task analysis is done by giving a test of the ability to think creatively and think out aloud by interviewing.

The type of schemata in this study used opinions by Dixon *et al.* (2012), An (2013), and Wahyudi *et al.* (2019a, 2019b), which have been modified in accordance with the needs of the research, namely, about mathematics, creative thinking and geometry material of plane as in Table 2.

Cool-critical-creative-meaningful learning model

The concept of this learning model is inspired by the learning patterns promoted by Yohanes Surya, namely, GASING (easy and fun). This concept of learning holds that

Table 2.
Type and descriptions of the schemata in thinking

Type of schematic	General definition	Special definition in learning to build plane geometry
Formal schemata	Schemata that refers to the initial knowledge a person has as a prerequisite knowledge to be able to understand a new concept well	Schemata that refers to the prerequisite knowledge that has been possessed before learning a plane in terms of rectangles that include geometric definitions of plane geometry, geometric objects (points and lines), relationships of geometric objects (angles and distances) and types of plane geometry
Content schemata	Schemata referring to prior knowledge about new concepts that will be studied	Schemata referring to prior knowledge about new concepts that will be studied are plane rectangular geometry (definition, types and characteristics, relationships between waking flat rectangle, area and perimeter of rectangles and combined flat quadrilateral)
Linguistic schemata	Referring to the knowledge of vocabulary and grammar associated with the concepts to be learned which serve as the basis for understanding more complex concepts or knowledge	Schemata related to knowledge about vocabulary and grammar related to 2D shapes such as points, lines, relationships between lines (parallel, intersecting, coinciding), angles, corresponding angles, acute angle, right angle, obtuse angle, area, circumference, similar and congruent, combination of 2D shapes, area combination of 2D shapes, application of the concept of 2D shapes, problem solving related to 2D shapes, etc.

Source: Wahyudi *et al.*, 2019a, 2019b

learning mathematics will be maximal and successful if mathematics is made xylophone, interesting (cool) and a fun activity. The key to the GASING method is a step-by-step process, which is arranged in such a way that the mastery of the material is built on understanding the previous material. The importance of this step-by-step process in the GASING method is reflected when children learn a topic, and there is a critical point that they must pass. After reaching this critical point, they will not be difficult to work on the questions in the topic.

In this GASING learning method, students are invited to play and explore with teaching aids so that they really feel and imagine the concept they want to convey. So the abstract always starts with something concrete, so students can understand and apply the concepts taught much easier.

Different things from the GASING learning process with 3CM are students who are faced with conditions that require them to think critically to find solutions to problem solving, think of producing creative products or applied products as new solutions generated from concepts learned and take meaning from. This way, they would understand the benefits of the mathematical material in their lives (meaningful learning). The concept of meaningful learning is taken from the concept of learning from Brownell (1982) and Mayer (2002), namely, meaningful theory and from Ausubel (1960) that learning will be more meaningful if it is associated with the contextual problems of students' life.

3CM learning activity was done in seven syntaxes, namely, motivation, contextual problems, contextual problem critics, problem-solving concept implementation in creative product, confirmation. The reflection is presented in Table 3.

Table 3. Description of syntax and 3CM learning activity

3CM learning aspect	Learning syntax	Description
Cool	Motivation Contextual problems	Plays a significant role in motivating the students by giving contextual problems in an enjoyable learning atmosphere. This initial stage enables the students to criticize the contextual problems given
Critical	Contextual problem criticism Problem solving	Students are asked to provide the solutions from the contextual problems given by criticizing them first
Creative	Creative product implementation	Students are expected to think about the potential creative product that might be produced as the implementation of the previous concept
Meaningful	Confirmation Reflection	Teacher and students discuss the result to give meaning from the lesson learned and make a decision in implementing the concept in real life

Source: Wahyudi *et al.*, 2019a, 2019b

Methodology

Types and design of research

This study implemented mixed methods with explanatory sequential design that collect qualitative data and quantitative data consecutively (Creswell, 2012; Giddings, 2006). The first step is collecting and analyzing qualitative data to gain the description and the mapping of creative thinking based on the students' learning style as well as the relationship between thinking schemata and CTA. The second step is collecting and analyzing quantitative data to gain the description on CTA and test the effectiveness from the implementation of 3CM learning.

Population and sample

The population of this research is the first-year elementary school teacher and students with the subject of Basic Mathematics Concepts. The reasons for choosing students as research subjects are as follows:

- Students have not received much influence from learning in college.
- The level of thinking of students varies because they have completed high school/ equivalent.
- Students are at the formal level, so they are able to think more abstractly to solve problems.

In quantitative research, the sampling technique used is simple random sampling. Simple random sampling is a random sampling technique. The study sample consisted of one experimental class and one control class. In the experimental class, students were taught using 3CM learning, whereas the control class with cooperative learning is appropriate for ongoing learning.

In qualitative research, the subject selection technique used is a non-probability sampling technique, which is taking a subject where each member of the population taken does not have the same opportunity to be the subject of research. The type of non-probability sampling used is purposive sampling, which is the taking of subjects used if the researcher has certain considerations with certain objectives. In this study, the subject was taken from each level of creative thinking skills as many as one sample for each level.

Technique and data collection instrument

The technique and instrument in collecting the data is categorized into two: quantitative data collection and qualitative data collection. Quantitative data (CTA) is measured through test and triangulated with interview based on the answer in the test. The instrument used to collect the quantitative data is test based on the aspect of CTA that administers before and after the learning activity is conducted (Leikin, 2013). Quantitative data in the form of creative thinking schemata is collected using *task analysis* (Someren *et al.*, 1994) and *think aloud* method (Charters, 2003) by distributing test and conducting interview according to the students' answer in the test and the component of their thinking schemata. It is carried out based on Mayer (2014) and Solso *et al.* (2008), which mentioned that thinking is cognitive activities that take place in someone's mind, which is invisible, but can be inferred through the attitude.

Prior to collecting both of the data, questionnaires are given to the samples to identify their learning style. In other words, the data of learning style are acquired through questionnaire. Aspects and criteria of learning style are adopted and developed from those generated by DePorter *et al.* (2014) and Knoll *et al.* (2017).

Data analysis technique

Data analysis in this study consists of two stages: the analysis of qualitative data and quantitative data. The mechanism of data analysis in this study is further discussed as follows.

Quantitative research findings analysis. Quantitative analysis in this study is conducted to identify the effectiveness of 3CM learning model on improving the students' CTA. The result of the score in mathematical CTA is synthesized into several categories of CTA. It consists of three categories such as CTA 3 (creative), CTA 2 (fairly creative) and CTA 1 (less creative). The classification of this category is based on the four aspects of creative thinking: fluency, flexibility, novelty and elaboration. The criteria of leveling this ability can be seen in Table 4.

The test used to measure the CTA is presented in the form of essay questions. The validity of the test, both pre-test and post-test, is carried out by experts based on three categories, which include test instruction, test content and language used in the test. The validation results from the experts are presented in Tables 5 and 6. The result of reliability test can be seen in Table 7.

Table 4. Guidance in determining the category of creative thinking ability (CTA)

Criteria	Symbol	Score of CTA (x)
Creative	CTA 3	$x > \bar{x} + SD$
Fairly creative	CTA 2	$\bar{x} - SD \leq x \leq \bar{x} + SD$
Less creative	CTA 1	$x < \bar{x} - SD$

Notes: x: score of creative thinking ability (CTA); $\bar{x}$: average of CTA score; SD: standard deviation of CTA score

Table 5. Validation result of pre-test

Indicator	Ideal score	Actual score Expert 1	Expert 2	Expert 3	Average score	PS* (%)	Category
Test instruction	10	9	8	8	8.3	83.3	Very high
Test content	30	26	27	26	26.3	87.7	Very high
Language	15	13	12	12	12.3	82.2	Very high

Note: *PS (percentage score) $= \frac{\text{Actual score}}{\text{Ideal score}} \times 100\%$

Based on the result of experts validation on the pre-test and post-test, the score gained for both tests is categorized as very high (NP $\geq$ 61%). Therefore, they are considered valid and proper to be used. The result of reliability test is acquired from the pre-test score, Cronbach's alpha 0.704 and post-test Cronbach's alpha 0.719, and hence, considered reliable and applicable.

Qualitative research findings analysis. Qualitative data analysis is carried out to analyze and map the mathematical creative thinking schemata through several stages as developed by Miles and Huberman (1994), Creswell (2012) and Bazeley and Jackson (2013); those are data reduction, data presentation and conclusion drawing.

Data reduction. Data reduction is the activity to filter the data, focusing the data on the problem studied, as well as simplifying, abstracting and transforming the data. The stages involved in the data reduction of this study are as follows:

- From every category of creative thinking, one subject from the five learning style is selected.
- The subjects are interviewed based on the their answers and the observation result during test to discover their schemata in creative thinking according to their experience.
- Based on their answer, the schemata will be mapped in accordance with the creative thinking category and learning style.
- Based on all the data collected, a final summary of thinking schemata from every subject is made according to their creative thinking category and learning style.
- Based on the mapping result, the relationship between thinking schemata and CTA is identified to generate new findings for this research.
- This finding will be the foundation to formulate the contribution of 3CM learning in helping to build a good and complete thinking schemata and improve mathematical CTA.

Data presentation. Data presentation consists of the process to classify and identify data. This stage focuses on writing a set of well-organized data to draw a conclusion from them. The data presentation in this study is displayed in the form of tables and charts of thinking schemata in a cognitive map from every subject based on the criteria of mathematical CTA and learning style, description and the chart portraying the relationship pattern between thinking schemata and mathematical creating thinking, and also description and findings

Table 6. Validation result of post-test

Indicator	Ideal score	Actual score Expert 1	Expert 2	Expert 3	Average score	PS* (%)	Category
Test instruction	10	8	8	9	8.3	83	Very high
Test content	30	28	24	30	27.3	91	Very high
Language	15	13	14	12	13	86.7	Very high

Note: *PS (percentage score) $= \frac{\text{Actual score}}{\text{Ideal score}} \times 100\%$

Table 7. Reliability test result of pre-test and post-test

Category of test	Cronbach's alpha	Cronbach's alpha based on standardized items	No. of items
Pre-test	0.704	0.708	3
Post-test	0.719	0.898	3

on the contribution of 3CM learning in forming a good and complete thinking schemata as well as improving mathematical CTA.

Conclusion drawing. Conclusion drawing is the final stage of this study. It is performed based on the result of data analysis that has been compiled, particularly in this case are those acquired from test, observation, interview, data analysis result and discussion. The findings gained are thinking schemata based on the mathematical CTA and learning style, description and chart displaying the relationship pattern between thinking schemata and mathematical creative thinking, and also the description and findings on the contribution of 3CM learning in forming a good and complete thinking schemata as well as improving mathematical CTA.

Result and discussion

Teaching quality of cool-critical-creative-meaningful learning models

Before administering test to assess the students, the students followed learning sessions with 3CM learning models for 10 weeks. Learning is done face-to-face and online. Implementation of 3CM learning is done in seven steps of learning (syntax), that is, motivation, contextual problem, critical issue, problem solving, concept implementation in creative product, confirmation and reflection. The model that has been developed is then validated by experts, including learning experts, media experts, teaching materials experts and learning resources, as well as learning evaluation experts (Table 8).

Based on the feasibility criteria of the developed model, the results obtained were very high and of high categories (PN $\geq$ 61%) so that the model was feasible to use. The next step in the model is implemented on a limited scale to see the practicality of the model. Limited testing is done with one lecturer and eight students. The results obtained are shown in Tables 9 and 10.

Based on the results of the model assessment and implementation of the model by peers, the value of learning designs (face-to-face and online), media and teaching materials developed in the category of very high and high (PN $\geq$ 61%) so that the practical model is used.

Table 8. Results of expert assessment for 3CM learning models

No.	Indicator	Ideal score	Actual score Expert 1	Actual score Expert 2	Average	PN* (%)	Category
1	Learning activity plan	60	54	55	54.5	9	Very high
2	Learning media	30	22	22	22	73	High
3	Teaching aid and source	35	25	25	25	71	High
4	Learning evaluation instrument	55	40	41	40.5	74	High

Note: *PN (percentage number) $= \frac{\text{Actual score}}{\text{Ideal score}} \times 100\%$

Table 9. Peer assessment

No.	Indicator	Ideal score	Actual score	PN* (%)
1	Lesson plan	60	51	85
2	Learning media	55	44	80
3	Teaching aid and resource	30	23	77
4	Learning evaluation instrument	35	26	74

Note: Model practicality test

Mathematical creative thinking initial level

The effectiveness of 3CM learning model is determined based on three aspects, which include mastery test, mastery proportion test and comparative test. Prior to conducting the three tests, below is the example of creative thinking ability for 3CM learning class and problem-solving class (as control class) (Tables 11-13).

Effectiveness testing of the implementation of cool-critical-creative-meaningful learning

The implementation of 3CM learning is effective if:

- more than 75% of students gained the score of mathematical CTA test of no less than 65 (reaching the given passing grade);
- the proportion of mastery for the mathematical CTA that is taught using the 3CM learning is better than the students taught in problem-solving model; and
- mathematical CTA of the students that are taught using the 3CM model learning is better than the students that are taught using the problem-solving model.

		Students' respond									
No.	Aspect responded	VD	(%)	NG	(%)	GE	(%)	G	(%)	VG	(%)
1	Lesson plan	0	0	0	0	1	12.5	4	50	3	37.5
2	Learning media	0	0	0	0	2	25	4	50	2	25
3	Teaching aid and resource	0	0	0	0	1	12.5	3	37.5	4	50
4	Learning evaluation instrument	0	0	0	0	1	12.5	5	62.5	2	25

Notes: *VG, very good; G, good; GE, good enough; NG, not good; VB, very bad

Table 10. Students test limited response (model practicality test)

Model	*N*	Minimum	Maximum	Mean	SD
3CM learning	22	19	81	50.23	14.74
Problem solving	19	13	67	51.26	12.99

Table 11. Initial score of mathematical creative thinking ability of both classes

Model	*N*	Minimum	Maximum	Mean	SD
3CM learning	22	48	98	74.09	11.96
Problem solving	19	35	83	63.26	16.67

Table 12. Final score of mathematical creative thinking ability of both classes

		Class of 3CM learning	
Criteria	Symbol	Initial	Final
Creative	CTA 3	4	9
Fairly creative	CTA 2	14	10
Less creative	CTA 1	4	3

Table 13. Improvement of total of students

Mastery test

The mastery test is used to find out the individual and classical achievement of mastery of the students in the topic of triangles. The individual mastery test is used to find out the average mathematical CTA of the students whether it reached the score of 65 or not.

The average score of the classical mastery test is used for the one-side testing. The statistical hypothesis is as follows:

H_0: $\mu \leq 65$ (the average of mathematical CTA of students who are taught with the 3CM learning model $\leq$65).

H_0: $\mu > 65$ (the average of mathematical CTA of students who are taught with the 3CM learning model > 65).

The criteria that the H_0 is refused if $t_{count} \geq t_{table}$ with $dk = (n - 1)$ and the degree of significance used is 5%. The calculation of t_{count} on this research used the SPSS program. Table 14 shows the output result of SPSS testing on individual mastery.

Table 14 shows the $t_{\text{count}} = 3.368$ and the t_{table} with $dk = 21$ and the degree of significance used is 5% = 1.720. Because the $t_{\text{count}} = 3.368 > t_{\text{table}} = 1720$, with the sig.(two-tailed) = 0.003, so that for the one-side testing (right side of the brain) is gained the score of sig.(one-tailed) = $\frac{0.0015}{2} = 0.0015$. Because the score of sig.(one-tailed) = 0.0015 < 0.05, H_0 is refused and H_1 is accepted. This result indicated that the average score of mathematical CTA of the students who are taught using the 3CM learning model is more than 65.

Mastery proportion testing

The formulation of hypothesis to test the proportion of mastery with the degree of mistake $\alpha = 0.05$ is presented in the following:

H_0: $\pi \leq 0.75$ (proportion of students on the learning using 3CM learning model who achieved the minimum mastery criteria has not passed or equal to 75%).

H_1: $\pi > 0.75$ (proportion of students on the learning using 3CM learning model who achieved the minimum mastery criteria has passed 75%).

Table 14. Result of mastery test of CTA class of 3CM learning

One-sample test Test value = 65.5						
					95% Confidence interval of the difference	
	t	df	Sig.(two-tailed)	Mean difference	Lower	Upper
3CM	3.368	21	0.003	8.591	3.29	13.90

Table 15. Result of mastery proportion testing

		Category	N	Observed prop.	Test prop.	Exact sig. (one-tailed)
3CM	Group 1	≤65.5	4	0.18	0.25	0.323[a]
	Group 2	>65.5	18	0.82		
	Total		22	1.00		

Note: [a]Alternative hypothesis states that the proportion of cases in the first group < 0.25

Type schemata	Data from student answers and interviews
Formal schemata	Subject 1 had very good initial knowledge as a prerequisite concept. The concepts included angle, side, base, height, parallel, right angle, area and circumference, and even the concept of triangle, square and rectangle. This was what facilitated Subject 1 to produce several alternative answers in a variety of ways by determining the relationship between the concepts
Skematakonten	The theme content of Subject 1 was also very good. The subject understood in detail what parallelogram was as the main problem to solve. The subject was able to explain the definition and characteristics of parallelogram, and thus it makes it easier for the subject to solve the problem. The relationship between concepts as a prerequisite can also be associated with the parallelogram concept well, making it easier to solve problems
Linguistic schemata	Subject 1's linguistic/language schematic was also very good. Many terms can be conveyed by the subject such as angle, side, base, height, parallel, right angle, width, circumference, perpendicular up to straight, parallel and diagonal side, and even the subject had a special term to make it easier to memorize the concept of parallelogram, namely, parallelogram p xl only the width is the parallelogram height. This was done so that there would not be too many things to be stored in the brain

Table 16. Schemata subjects with creative categories

Type schemata	Data from student answers and interviews
Formal schemata	Subject 2 had initial knowledge not yet complete as a prerequisite concept. The concepts possessed include area, base, height and triangle. This concept helped Subject 2 to produce several alternative answers
Content schemata	The theme of Subject 2 content about parallelogram was only limited as a stand-alone rectangular building. Subject 2 only memorized the wide parallelogram, i.e. x height. The relationship between concepts as a prerequisite was only related to triangle because Subject 2 only saw that the parallelogram in the question was composed of two triangles, without looking at other possibilities
Linguistic schemata	Subject 2 linguistic schema/language was limited to area, base, height, triangle and parallelogram. This also limited Subject 2 to produce other problem-solving alternatives

Table 17. Schemata subjects with creative enough categories

Type schemata	Data from student answers and interviews
Formal schemata	Subject 3 did not have good initial knowledge as a prerequisite concept. Only rectangular concepts in general, and forgot the concepts that existed in the problem given. The subject also experienced confusion in building a rectangle that was the problem. This happens because the presentation of parallelogram images was not as usual, so Subject 3 was confused
Content schemata	The content schemata of Subject 3 on parallelogram was very weak, even having difficulty identifying that the problems presented are related to parallelogram. This happens because the parallelogram images are different from the pictures presented earlier

Table 18. Schemata subjects with less creative categories

Based on the proportion of the accomplishment of CTA for the 3CM class learning, it is gained that sig.(one-tailed) = 0.323. Because the score of sig.(one-tailed) = 0.323 > 0.05 with the amount students that gained the score of >65.5 is 82%, then H_0 is refused and H_1 is accepted. It means that the accomplishment proportion test for the mathematical creative thinking ability (CTA) of the students that are taught using the 3CM learning model reached the classical mastery score that is set, that is more than 75%.

Comparison test for the score of creative thinking ability

The result of the test on students' accomplishment and the proportion of accomplishment that has been gained needs to the supported with the advance testing, that is the comparison testing. Comparison testing must begin with the prerequisite testing which includes the normality test and homogeneity test of the variation of both groups.

The normality testing on each groups of data used the Shapiro-Wilk testing (with the data of less than 30). Based on the Shapiro–Wilk testing about the Test of Normality, the degree of significance of class 3CM and problem-solving class are Sig. = 0.076 and Sig. = 0.021. Based on this result, it is gained that the 3CM class gained the score of significance that is bigger than 0.05 so that it can be concluded that the data score of mathematical CTA has a normal distribution, whereas the problem-solving class gained the score of significance that is less than 0.05, which means it is not normally distributed.

Because of the mathematical CTA of the problem-solving class that is not normally distributed, the testing of average difference used the nonparametric testing. The statistical test that is used is the Mann-Whitney testing with the degree of significance of $\alpha = 0.05$. Based on the Mann-Whitney testing result, it is gained the sig. score (two-tailed) = 0.028, so that for the one side-brain testing (right side of the brain) gained the sig. score (one-tailed) = $\frac{0.028}{2} = 0.014$. Because the significance score (one-tailed) = 0.014 < 0.05, then H_0 is refused and H_1 is accepted. Thus, it can be concluded that both classes are significantly different, where the mathematical CTA of the students in the class of 3CM learning model is higher than the KBK score of the students in problem-solving class.

Schemata in creative thinking

The schema in creative thinking can be seen from student answers and interviews based on these answers which include formal schemata, content schemata and linguistic schemata. To give a description of creative thinking schemes, three subjects with the ability to think creatively in the creative category, creative enough and less creative for Question number 1 are selected as an example.

Subject 1 (creative category). As per the answer to Subject 1 (creative), the next step taken was an interview. The interview results for Subject 1 (creative) can be seen from the recap of the following interview (Figure 1).

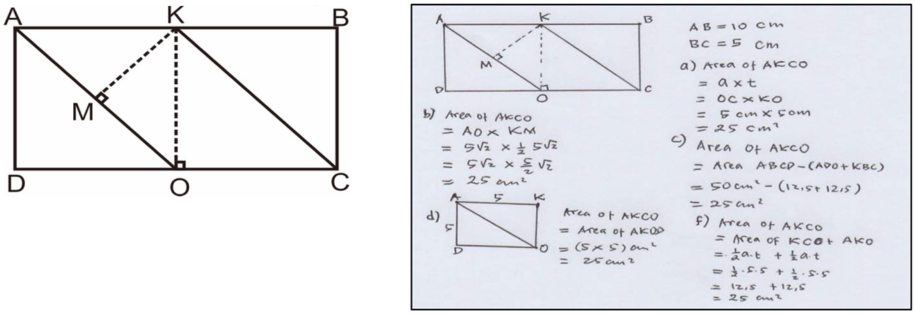
Question 1: How do you respond to the questions given?

Subject 1: It's easy and I can do it.

Question 2: What are the related concepts related to?

Subject 1: Build a rectangular plane, namely, parallelogram.

Question 3: Explain in your own language the concept?



Notes: The ABCD build is a rectangle. K is located right in the middle of the side AB, and O is located right in the middle of the side of the CD, length AB = 10 cm and BC = 5 cm. Determine the size of the AKCO according to the way you think until you get the right result!

Figure 1. Example of answers to subjects with creative categories

Subject 1: Parallelogram is a rectangular plane building that has 2 pairs of parallel sides, the angles have to be the same.

Question 4: What mathematical terms are related to this problem?

Subject 1: Side, angle, area, circumference, height, base, parallel, right angle.

Question 5: Pay attention to alternative answers 1, 2, 3 and 4, what concepts do you use?

Subject 1: Parallelogram, triangle, rectangle, square.

Question 6: Are there other concepts that can be used to answer this question?

Subject 1: No, only that.

Question 7: Why did you choose these concepts?

Subject 1: As per the picture, the concept is related.

Question 8: Tell the relationship between the concepts?

Subject 1: The image on the question consists of 4 for the same triangle, thus the area of the parallelogram can be searched from 2 times the area of the triangle. You can also use the ABCD Rectangle then subtract the area of 2 triangles. If the 2 triangles that suckle the parallelogram is arranged then it can also form a square with a side length of 5, thus the area of the parallelogram is equal to the area of square. That's all, sir.

Question 9: How can the concept be used to solve the problems?

Subject 1: Well because it is interrelated like the answer, according to the picture it has something to do with Rectangle, Square, Triangle to solve parallelogram problems.

Question 10: Do you think of new ways to solve this problem?

Subject 1: No.

In accordance with the answers in the interview, then Subject 1 can be identified when thinking creatively according to the answer to Question number 1.

These results indicate that subjects with creative categories have excellent and complete schemata in formal, content and linguistic/linguistic schemes. This is what makes the assimilation process work well. Existing concepts are well organized and can be used to solve problems. In addition, the existing concept is able to produce new ways through the accommodation process so that new concepts are found that are relationships between concepts, for example, a student saw that the images in the question were composed of four concurrent triangles (ΔADO, ΔAOK, ΔKOC and ΔKCD). This raised a new idea for the subject to see parallelogram as a plane composed of two concurrent triangles, namely, OKAOK and ΔKOC, and thus the width of parallelogram can be determined from the area of ΔOK + area ΔKOC.

Besides that, the subject also thought if ΔKOC was moved and occupied ΔADO, then it will form an ADOK square, and thus the width of the parallelogram can be determined from the area of ADOK square. Based on these results, it can be concluded that the subject has a good and complete scheme, and thus the ability to think creatively is also good (creative). This condition also has not changed much after learning with the 3CM learning model. Subjects still have good schemes and good creative thinking skills. Things that change were only in learning interests and learning challenges that were getting better because there was a sequence of activities that required a continuous mindset, start contextual problems, criticize problems, produce creative products as solutions to problems and are useful in everyday life. This makes Subject 1 feel challenged to produce products that are always new and creative.

Subject 2 (fairly creative). Meanwhile, Subject 2 (fairly creative) managed to answer two questions correctly. Based on these answers, interviews are then carried out and the results are as follows (Figure 2):

Question 1: How do you respond to the questions given?

Subject 2: Make you confused at first.

Question 2: What are the related concepts related to?

Subject 2: Build a rectangular plane, namely, parallelogram.

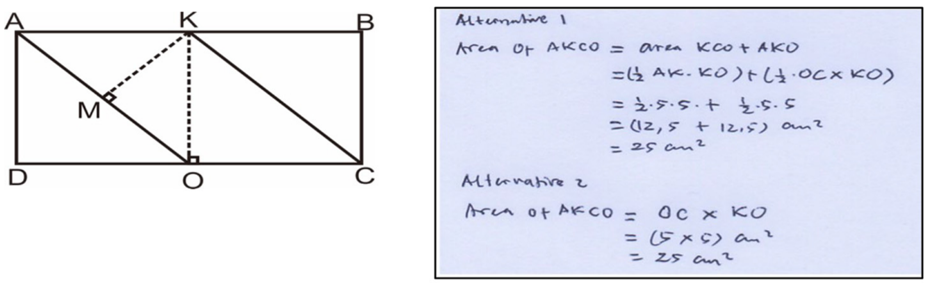


Figure 2.
Example of answers to subjects with creative enough category

Notes: The ABCD build is a rectangle. K is located right in the middle of the side AB, and O is located right in the middle of the side of the CD, length AB = 10 cm and BC = 5 cm. Determine the size of the AKCO according to the way you think until you get the right result!

Question 3: Explain in your own language the concept?

Subject 2: Parallelogram is a rectangular plane building.

Question 4: What mathematical terms are related to this problem?

Subject 2: Spacious, pedestal, high.

Question 5: Pay attention to the alternative answers you produce, what concepts do you use?

Subject 2: Parallelogram and Triangle.

Question 6: Are there other concepts that can be used to answer this question?

Subject 2: No, only that.

Question 7: Why did you choose these concepts?

Subject 2: The picture shows only parallelogram and triangle.

Question 8: Tell the relationship between the concepts?

Subject 2: In the picture, the parallelogram is made up of 2 triangles, so the area is directly added up.

Question 9: How can the concept be used to solve the problems in the question?

Subject 2: As per the picture, it has something to do with Triangle and Parallelogram.

Question 10: Are there other concepts related to the problem?

Subject 2: Nothing, first when I studied parallelogram, I discussed it myself about parallelogram has nothing to do with others. This is a coincidence that I see a triangle that forms a parallelogram. Even then, I was still confused because the picture of the parallelogram was different from the usual one.

Question 11: Can you describe the pattern of relations between rectangular flat shapes?

Subject 2: What do you mean, sir, I don't understand.

Based on the answers in the interview, Subject 2 can be identified when thinking creatively according to the answer to Question number 1.

These results indicate that Subject 2 with a fairly creative category has an incomplete schemata, only focusing on two concepts, namely, parallelogram and triangle. Nevertheless, the assimilation process went well, especially those related to parallelogram, and thus it was able to provide two solutions to the problem. Subject 2 has not seen other concepts such as rectangles and squares, which causes Subject 2 to only produce two solutions. What is interesting from the results of interviews is that learning patterns of plane were done partially, not paying attention to the relationship between plane building, so when asked about the relationship and classification the subject was confused and failed to describe the relationship.

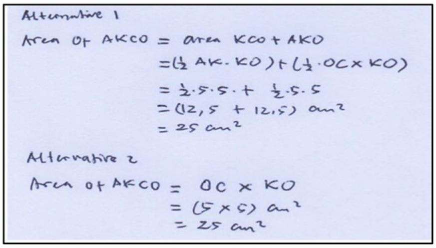
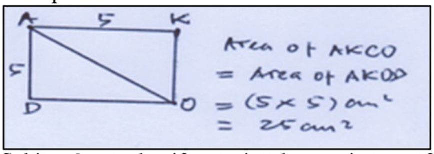
The following are schematic changes and Subject 2's creative thinking skills after learning with the 3CM learning model (Figure 3).

These results indicate that the 3CM learning model is able to change the subject's schema, and thus it is able to associate a new concept with the problem at hand, namely, the square concept with parallelogram. This is related to formal schemes, namely, other concepts as prerequisites and linguistic/linguistic schemes, namely, concurrent words, the same, the same area makes Subject 2 able to find alternative solutions to other problems. With the increasing alternative solutions to the problems given, Subject 2's CTA has also increased, especially the aspects of fluency, flexibility and elaboration, and for the novelty aspect, it has not been seen because the answers are still the same as the other subjects.

Subject 3 (less creative category). With regard to the answer from Subject 3 (less creative), the subject was unable to answer any of the problem given. Based on this answer, interviews were then carried out and the results are as follows (Figure 4):

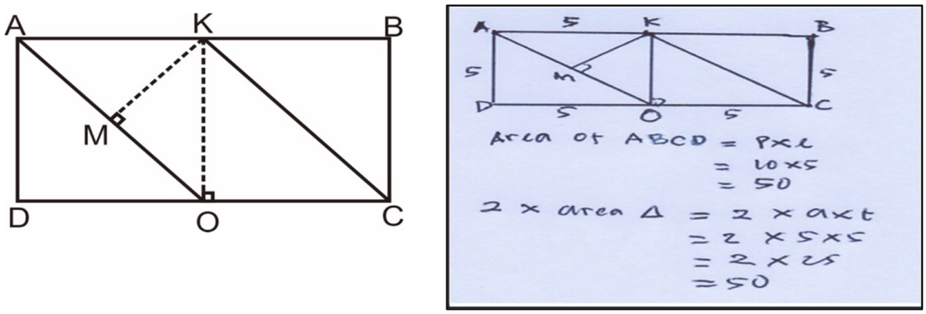
Question 1: How do you respond to the questions given?

Subject 3: I am confused, sir.

<table>
<tr><th>Beforeimplementing 3CM learning</th><th>After implementing 3CM learning</th></tr>
<tr><td>There are 2 solutions

</td><td>There is 1 additional solution with the Square concept


Subject 2 sees that if two triangle constituents of parallelogram if arranged by moving ΔKOC, they will form a square. Thus the width of the parallelogram is equal to the area of square.</td></tr>
</table>

Figure 3. Example of before and after implementing 3CM learning



Notes: The ABCD build is a rectangle. K is located right in the middle of the side AB, and O is located right in the middle of the side of the CD, length AB = 10 cm and BC = 5 cm. Determine the size of the AKCO according to the way you think until you get the right result!

Figure 4. Example of answers to subjects with less creative category

Question 2: What are the related concepts related to?

Subject 3: Two-dimensional figure.

Question 3: Explain in your own language the concept?

Subject 3: I forgot sir.

Question 4: What mathematical terms are related to this problem?

Subject 3: Square, broad.

Question 5: Pay attention to the alternative answers you produce, what concepts do you use?

Subject 2: Rectangle.

Question 6: Are there other concepts that can be used to answer this question?

Subject 3: I forget.

Question 7: Why did you choose these concepts?

Subject 3: I remember, sir.

Question 8: Are you sure that your answer is correct?

Subject 3: I'm not sure, sir.

Question 9: Sorry, your answer is still not correct? Do you know why your answer is not correct?

Subject 3: I don't know sir.

Question 10: Do you like learning mathematics?

Subject 3: I don't like it sir.

Question 11: What causes you not to study mathematics?

Subject 3: It's hard, sir, and it's not good for learning. I am often scared during math class.

Question 12: Good, it will be discussed after learning tomorrow. Hopefully after learning you will better understand this concept.

Based on the answers from the interview, then Subject 1 can be identified when thinking creatively according to the answer to Question number 1.

These results indicate that Subject 3 in the less creative category has an unfavorable scheme. This caused Subject 3 cannot provide a solution to the problem. The acquisition process did not go well, many forgotten concepts even some were unknown to them. What's interesting about the results of the interview is that Subject 3 did not like learning mathematics. Subject 3 did not feel comfortable and happy while studying mathematics, and even tended to be afraid. This is what caused not many mathematical concepts stored in the Subject 3's memory.

Figure 5 shows the schematic changes and Subject 2's creative thinking skills after learning with the 3CM learning model.

Subject 3 still did not really understand that what was asked was to determine the width of the parallelogram because parallelogram images are presented in different forms. The subject only knew the parallelogram given by his teacher. So to determine the area of AKCO, Subject 3 used the concept of rectangle and triangle as above. This solution is also correct.

Discussion

This result indicated that the CTA can be improved by improving the schemata of the students whether in the formal, content or linguistic schemata with 3CM learning model. There are several phases of learning using 3CM learning model, it is systematic and graded (hierarchy) that encourage the students to be able to criticize problems, which generated based on interesting and challenging real life problems. The interesting and challenging problem here gives the opportunity for the students to criticize the problem differently without stressing them out become the pressure for them psychologically (Critical) that is done in the group.

Besides, this model enables the students to see the way in solving the problem that is creative and innovative with interesting approach so that it inspires them to produce the solution with new ways. This is according to the principles of creativity that occurs because of the opportunity. The teaching enables the opportunity for 3N activities (Niteni, Nerokke, Nambahi) that is taught by Ki Hajar Dewantara. This concept creates the thought that the creativity will occur if the students are given the opportunity. The occurring creativity is still on the level of watching the example first. The result of interview supports this statement, students in the early phase tend to copy so that it brings idea to think of other creative creation. This is in line with the statement of Morais and Azevedo (2011), a good teacher must be innovative so that they can be an example for the students to create further. Apart from the innovation that can be performed in front, creativity of the teacher is also a habit of creative thinking of the best teacher, and always develop and develop (Henriksen *et al.*, 2016; Wahyudi *et al.*, 2018a, 2018b).

This learning concept is also according to the principle of a teacher from Ki Hajar Dewantara, that is "ingngarso sung tulodo, ingmadyomangunkarso, tut wurihandayani". Teacher must be able to become the example for their students and able to build their motivation, but also must give opportunity as wide as possible for the students to learn further in exploring the learning sources, and elaborating it so that the students will become

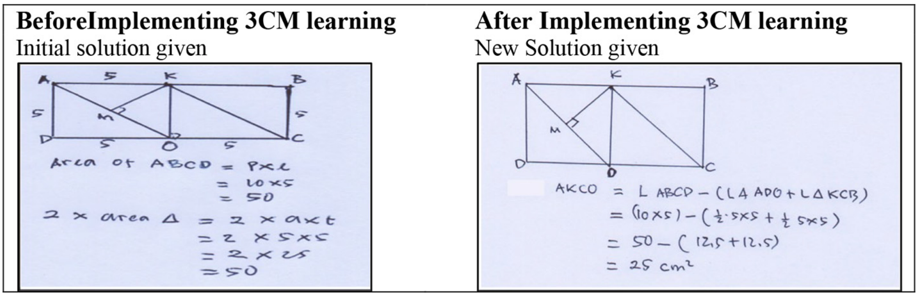


Figure 5.
Example of before and after implementing 3CM Learning

an independent individual. Learning should be based on one's willingness, and does not need to wait for someone to teach them, but searching and discovering instead.

The success of 3CM learning model improves the mathematic CTA in solving mathematical problem, also because of the presence of opportunity for the students to make a creation (creative) that is a product of their creative thinking in solving a problem. Students are given a wide open chance for discussion with their team, searching adequate information and data with unlimited time and space, as well as the role of lecturer directly. This is according to the statement of Boelens *et al.* (2017) and Amabile (2012), teaching must be able to initiate the students interaction, facilitating their learning process, and supporting the good learning atmosphere that is also affective. Each of their learning activities has already been designed and prepared from the beginning and is explained to the students what is the target product that must be produced and how they can fulfill the target. Hence, they will work as a team to fulfill the set target.

The creativity of the students in solving the mathematical problem is also supported by the learning environment that supports the growth of creativity among the students (Soh, 2017; Amabile, 2012; Richardson and Mishra, 2017; Wahyudi *et al.*, 2020). The presence of opportunity for the group to present their result in every meeting will push the other group to create a better creation. This very positive environment will stimulate the students and their teams to keep improving their creation. A positive learning environment is also provided by the lecturer in the form of learning simulation by the lecturer using the media of animation, picture or even video of real-life situation that is close to the students and easy to understand. This is according the research of Tsai *et al.* (2015) that the positive learning environment will create motivated and creative students to create something useful. This is according to the paradigm of the recent learning mathematics, that is, when mathematics is close with human, mathematics is a part of human culture (Hersh, 1997; Siswono, 2010) and is a part of the social reality (Hersh, 1997; Zevenbergen *et al.*, 2004). This is also according to the research of Wahyudi *et al.* (2018a, 2018b) that teaching in a correct and interesting manner as well as using the contextual issues can motivate the students to have the willingness in learning mathematics and to be able to solve the mathematics problems. The result of the interview also showed things that can motivate is to show some interesting, contextual, imaginable things instead of only showing some formula and numbers, making them attracted and willing to learn mathematics deeper.

This result supports that mathematics is close with human, mathematics is a part of culture (Hersh, 1997; Van, 2002; Siswono, 2010) and is part of the social reality (Hersh, 1997; Zevenbergen *et al.*, 2004; Wahyudi *et al.*, 2018a, 2018b). Learning mathematics must be easy to remember, imagine, to be represented, manipulated, and arranged in the cognitive scheme so that it eases the students in understanding mathematics without the burden of so many mathematics formula. This thing is the cause of adaptation process upon the new information through the assimilation and accommodation that works well so that the brain process continues the information from the short-term memory to the long-term memory (Kay and Kibble, 2016). This process caused the construction of new knowledge that is interconnected well in the shape of schemes of concept. This is according to the scheme theory, where the schemata that is constructed will indicate the arranged knowledge is in such a pattern that is interconnected in the one's mind that is constructed from the entire previous experience (Cook, 1989; Piaget, 1980), Rumelhart (2017), Neumann and Kopcha (2018), Longo and Perret (2018). Schemata developed through two processes, namely, assimilation and accommodation (Piaget, 1980), and the previous schemata is a part that is inseparable from the new schemata (Hebscher *et al.*, 2019).

The result of critical thinking of every group will result in the problem solving that are varied and unique, with the addition of activity that provides opportunity of each group to make a creative product and even new/different from the others whether it is an idea in solving a problem as well as a creative concept implementation (Creative). This is according to the thinking concept of Best and Thomas (2007), Torrance and Horng (1980), McGregor (2007) and Brownell (1942) that to create something that is creative as the result of creative thinking process (mathematics, in this case), it needs the direct involvement of the students in producing new, original idea to solve the existing problem properly and coherently. If someone is unable to think of a solution even failed to understand the problem given, then one will not be able to create a solution for the problem or being demanded to create many and new solutions. Even, to achieve creative thinking, especially in mathematics, it needs a high level of curiosity with the observation and exploration process, as well as high imagination and original thoughts (Vale and Barbosa, 2015). If someone is no longer liking what they learn, then the thinking process of theirs will be slowed down, let alone if being demanded to think creatively. The final step (Meaningful) from the 3CM learning model is to take the meaning from the lesson. The thing that is done in this step is confirmation and reflection. The result of the presentation and group discussion are confirmed together to identify how many problems made by each group and the quality of each problems as and also the solution from the problem made by each groups. Based on the problems that are made and the result of discussion, lecturer and students formulate the connectivity between concept that is learned with their life and the benefit gained from the concept. With this learning pattern, students can learn from the real life, the activity that is close to them and taking its advantage for their life. This is according to the learning concept of Brownell (1982), that is, the meaning theory; Brownell (1948) mentioned the involvement of students in fun environment to solve problem and David Ausubel mentioned that teaching will be more meaningful if it is related to the contextual problem in the life of the students. Creativity of the students in solving the mathematics problems is also supported with the learning environment that grows the creativity among the students (Soh, 2017; Henriksen *et al.*, 2017; Wahyudi *et al.*, 2020). The teaching gives opportunities for every group to present their result in the meeting, so that it motivates other groups to produce something better and better. Positive learning environment here can also stimulate the students and their teams to keep improving their creation. Positive learning environment is also provided by the lecturer in the form of simulation using the media of animation, picture or even real-life video that is close to the students so that it is easy for them to understand. This is according to the research of Brownell (1948), Tsai *et al.* (2015) and Fan (2019) that the positive and fun learning environment will make the students to be motivated and creative to create something useful as well as able to solve problem well.

Besides, the teacher also attempted to show empathy with the experiences gained when learning mathematics and the importance of a teacher in mastering the material taught, as well as able to deliver the material in a funny way. The experiences here are apparently effective in building the commitment of the students to learn mathematics. This is seen from the impression of the students after following the lesson written in the online open questionnaire that is provided. The example of students' responses towards the open-ended questions on 3CM learning.

This result is according to the experience of Rogers (1982), where the psychological security and freedom (psychotherapy) for the students will encourage and build the creativity of the students in creating. This situation can fix the learning process and the mindset of the students about mathematics. Besides, in the final part of the syntax, 3CM learning (confirmation and reflection) also gives the opportunity to the students to gain meaning about what they learn from the concept taught and what it does to their life. This is done so that they can value the concept they learned and able to implement it when they teach later. In this phase, students along with the lecturer discuss the result gained to give more meaning from the teaching done as well as determining the implementation and benefit of the concept in the daily life.

Conclusion

This paper has presented the following:

- 3CM learning model is effective significantly in improving the mathematical CTA of the students.
- Students with CTA score of "less creative", has the formal schemata, incomplete content and linguistics, so that it cannot produce the proper problem solving.
- Students with the CTA score of "fairly creative" has the complete and good content schemata, but the formal schematic and linguistics are not complete yet so that there are limited exploration of initial knowledge to search for the relationship between the concepts of two-dimensional object properly, and hence the total answer as the creative product is still limited.
- Students with the mathematical creative thinking level of "creative" have the formal schemata, with complete and good content and linguistics, so that they are able to explore the initial knowledge properly to search for the relationship between concepts of two-dimensional object, so that they can create various correct problem solving.

Suggestion from this research is that the 3CM learning model is a model that is proven to be effective in helping the students in shaping the thinking schemata well and able to improve the CTA of the students. Based on this, then the lecturer can implement this model here in the lecturing meeting of mathematics because this model is able to give the fun but challenging environment in every teaching session and is developed according to the learning style of the students. The happy and challenging atmosphere here will give more spaces and entrance for the students in learning with joy and less pressure and also ready in facing the challenges to think critically upon the problem provided. Besides, students have the chance to make creative product whether in the form of solution of problem as well as the implementation for the result of concept in the daily life. Mathematical CTA is determined by the completeness of the schemata owned (formal, content and linguistics), so that the teaching of mathematics must be able to facilitate students in processing the information properly through the adaptation process so that the thinking schemata is shaped well, systematic and complete. A complete schemata will help them creating the solution in mathematical problems solving that are various and unique (new).

References

Amabile, T.M. (2012), "Componential theory of creativity", *Harvard Business School*, Vol. 12 No. 96, pp. 1-10.

An, S. (2013), "Schema theory in reading", *Theory and Practice in Language Studies*, Vol. 3 No. 1, pp. 130-134.

Apriliani, L.R. and Suyitno, H. (2016), "Kemampuanberpikirkreatifmatematisberdasarkankecemasanmatematika pada pembelajaran creative problem solving berteknik SCAMPER", *Unnes Journal of Mathematics Education Research*, Vol. 5 No. 2, pp. 131-138.

Ausubel, D.P. (1960), "The use of advance organizers in the learning and retention of meaningful verbal material", *Journal of Educational Psychology*, Vol. 51 No. 5, p. 267.

Barnard, B. and Herbst, D. (2018), "Entrepreneurship, innovation and creativity: the creative process of entrepreneurs and innovators", available at: SSRN 3195912.

Bazeley, P. and Jackson, K. (Eds). (2013), *Qualitative Data Analysis with NVivo*, Sage Publications.

Best, B. and Thomas, W. (2007), *The Creative Teaching and Learning Toolkit*, Continuum International Publishing Group, NewYork.

Boelens, R., De Wever, B. and Voet, M. (2017), "Four key challenges to the design of blended learning: a systematic literature review", *Educational Research Review*, Vol. 22, pp. 1-18.

Brownell, P. (1982), "A field study examination of budgetary participation and locus of control", *Accounting Review*, pp. 766-777.

Brownell, W.A. (1948), "Learning theory and educational practice", *The Journal of Educational Research*, Vol. 41 No. 7, pp. 481-497.

Cahyati, H., Muin, A. and Musyrifah, E. (2018), "Efektivitas teknik SCAMPER dalamMengembangkan KemampuanBerpikirKreatifMatematisSiswa", *Journal of Medives : Journal of Mathematics Education Ikip Veteran Semarang*, Vol. 2 No. 2, pp. 173-182.

Cartier, P., Dhombres, J., Heinzmann, G. and Villani, C. (2016), "Mathematics and reality", *Freedom in Mathematics*, pp. 9-37, doi: 10.1007/978-81-322-2788-5_2.

Charters, E. (2003), "The use of think-aloud methods in qualitative research an introduction to think-aloud methods", *Brock Education: A Journal of Educational Research and Practice*, Vol. 12 No. 2.

Coleman, J.C. and Hammen, C.L. (2011), *Contemporary Psychology and Effective Behavior*, Foresman, and Co., Glenview, Scot.

Cook, G. (1989), *Discourse*, Oxford University Press. Oxford.

Corcoran, J. (2006), "Schemata: the concept of schema in the history of logic", *Bulletin of Symbolic Logic*, Vol. 12 No. 2, pp. 219-240, doi: 10.2178/bsl/1146620060.

Creswell, J.W. (2012), *Research Design PendekatanKualitatif, Kuantitatif Dan Mixed. (Alihbahasa, AchmadFawaid)*, PustakaPelajar, Yogyakarta.

DePorter, B., Reardon, M. and Singer-Nourie, S. (2014), *Quantum Teaching*, PT Mizan Pustaka, Bandung.

Dixon, L.Q., Zhao, J., Shin, J.-Y., Wu, S., Su, J.-H., Burgess-Brigham, R., Gezer, M.U. and Snow, C. (2012), "What we know about second language acquisition: a synthesis from four perspectives", *Review of Educational Research*, Vol. 82 No. 1, pp. 5-60, doi: 10.3102/0034654311433587.

Dyer, J.H., Gregersen, H.B. and Christensen, C.M. (2011), *The Innovator's DNA: Mastering the Five Skills of Disruptive Innovators*, Harvard Business Press, Boston MA.

Ernest, P. (2016), "Values and mathematics: overt and covert", *Culture and Dialogue*, Vol. 4 No. 1, pp. 48-82, doi: 10.1163/24683949-12340004.

Fan, M. (2019), "How does creative learning environment foster student creativity? An examination on multiple explanatory mechanisms", *5th Annual International Conference on Social Science and Contemporary Humanity Development (SSCHD 2019), Atlantis Press*.

Flavell, J.H. (2004), "Theory-of-Mind development: retrospect and prospect", *Merrill-Palmer Quarterly*, Vol. 50 No. 3, pp. 274-290, doi: 10.1353/mpq.2004.0018.

Gardner, H. (1993), *Creating Minds: An Anatomy of Creativity Seen Through the Lives of Freud*, Einstein, Picasso, Stravinsky, Eliot, Graham, and GandhZ Basic Books, New York, NY.

Giddings, L.S. (2006), "Mixed-methods research", *Journal of Research in Nursing*, Vol. 11 No. 3, pp. 195-203, doi: 10.1177/1744987106064635.

Haylock, D. (1997), "Recognizing mathematical creativity in schoolchildren", *Zentralblatt Für Didaktik Der Mathematik*, Vol. 29 No. 3, pp. 68-74, doi: 10.1007/s11858-997-0002-y.

Hebscher, M., Wing, E., Ryan, J. and Gilboa, A. (2019), "Rapid cortical plasticity supports long-term memory formation", *Trends in Cognitive Sciences*, Vol. 23 No. 12, pp. 989-1002.

Henriksen, D., Mishra, P. and Fisser, P. (2016), "Infusing creativity and technology in 21st century education: a systemic view for change", *Educational Technology & Society*, Vol. 19 No. 3, pp. 27-37.

Henriksen, D., Mishra, P. and Deep-Play Research Group (2017), "Between structure and improvisation: a conversation on creativity as a social and collaborative behavior with Dr Keith Sawyer", *TechTrends*, Vol. 61 No. 1, pp. 13-18.

Hersh, R. (1997), *What is Mathematics, Really*?, Jonathan Cape, London.

Huang, C.E. (2020), "Discovering the creative processes of students: multi-way interactions among knowledge acquisition, sharing and learning environment", *Journal of Hospitality, Leisure, Sport and Tourism Education*, Vol. 26, p. 100237.

Huang, C.H. (2016), "Students' use of intuitive reasoning to decide on the validity of mathematical statements", *American Journal of Educational Research*, Vol. 4 No. 14, pp. 1025-1029.

Istiandaru, W. and Mulyono, (2015), "PBL PendekatanRealistikSaintifik dan asesmen pisa UntukMeningkatkanKemampuanLiterasiMatematika", *Unnes Journal of Mathematics Education Research*, Vol. 3 No. 2, available at: https://journal.unnes.ac.id/sju/index.php/ujmer/article/view/4620

Istiqomah, F., Rochmad, R. and Mulyono, M. (2017), "Mathematical creative thinking ability of the seventh grade students in terms of learning styles to the preview-question-read-reflect-recite-review (PQ4R) learning", *Unnes Journal of Mathematics Education*, Vol. 6 No. 2, pp. 258-267, doi: 10.15294/ujme.v6i2.17201.

Kadir, K., Lucyana, L. and Satriawati, G. (2016), "The implementation of open-inquiry approach to improve students' learning activities, responses, and mathematical creative thinking skills", *Journal on Mathematics Education*, Vol. 8 No. 1, pp. 103-114, doi: 10.22342/jme.8.1.3406.103-114.

Kawuryan, S., Sri Hastuti, W. and Supartinah, S. (2018), "The influence of traditional games-based and scientific approach-oriented thematic learning model toward creative thinking ability", *JurnalCakrawala Pendidikan*, Vol. 37 No. 1, doi: 10.21831/cp.v37i1.18323.

Kay, D. and Kibble, J. (2016), "Learning theories 101: application to everyday teaching and scholarship", *Advances in Physiology Education*, Vol. 40 No. 1, pp. 17-25.

Kementerian Pendidikan dan Kebudayaan (2016), "Peringkat dan capaian PISA Indonesia MengalamiPeningkatan", Diakses pada 18 Januari 2018 dari, available at: www.kemdikbud.go.id/main/blog/2016/12/peringkat-dan-capaian-pisa-indonesia-mengalami-peningkatan

Kementerian Pendidikan dan Kebudayaan (2019), "Hasil PISA Indonesia 2018: Akses Makin Meluas, SaatnyaTingkatkanKualitas", Diakses pada 10 Desember 2019 dari, available at: www.kemdikbud.go.id/main/blog/2019/12/hasil-pisa-indonesia-2018-akses-makin-meluas-saatnya-tingkatkan-kualitas

Kim, K.H., Lee, H., Chae, K., Andersen, L. and Lawrence, C. (2011), "Creativity and confucianism among American and Korean educators", *Creativity Research Journal*, Vol. 23 No. 4, pp. 357-371.

Knoll, A.R., Otani, H., Skeel, R.L. and Van Horn, K.R. (2017), "Learning style, judgements of learning and learning of verbal and visual information", *British Journal of Psychology*, Vol. 108 No. 3, pp. 544-563.

Leikin, R. (2013), "Evaluating mathematical creativity: the interplay between multiplicity and insight1", *Psychological Test and Assessment Modeling*, Vol. 55 No. 4, pp. 385.

Leikin, R. and Elgrabli, H. (2015), "Creativity and expertise: the chicken or the egg?", *Discovering Properties of Geometry Figures in DGE*, Diaksesdari, available at: https://hal.archives-ouvertes.fr/hal-01287306/document (accessed 26 November 2018).

Longo, G. and Perret, N. (2018), "Rhythms, retention and protention: philosophical reflections on geometrical schemata for biological time", *Building Theories*, Springer, Cham, pp. 245-259.

MacLin, M.K. and Solso, R.L. (2008), *Experimental Psychology: A Case Approach*, Pearson/Allyn& Bacon.

Mahendra, I. (2017), "Project based learning BermuatanEtnomatematikaDalamPembelajarMatematika", *JPI (Jurnal Pendidikan Indonesia)*, Vol. 6 No. 1, pp. 106-114, doi: 10.23887/jpi-undiksha.v6i1.9257.

Mayer, R.E. (2002), "Rote versus meaningful learning", *Theory into Practice*, Vol. 41 No. 4, pp. 226-232.

Mayer, R.E. (2014), "Incorporating motivation into multimedia learning", *Learning and Instruction*, Vol. 29, pp. 171-173, doi: 10.1016/j.learninstruc.2013.04.003.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*, Sage.

Mohanty, A. (2015), "Information processing and creative thinking abilities of residential and non-residential school children: a pilot study", *SAGE Open*, Vol. 5 No. 4, doi: 10.1177/2158244015611452.

Morais, M.D.F. and Azevedo, I. (2011), "Escutandoosprofessoresportuguesesacerca de criatividade: algunsresultados e reflexõessobre a suaformação".

Navarrete, C.C. (2013), "Creative thinking in digital game design and development: a case study", *Computers and Education*, Vol. 69, pp. 320-331, doi: 10.1016/j.compedu.2013.07.025.

Neumann, K.L. and Kopcha, T.J. (2018), "The use of schema theory in learning, design, and technology", *TechTrends*, Vol. 62 No. 5, pp. 429-431.

Nuha, M.A., Waluya, S.B. and Junaedi, I. (2018), "Mathematical creative process wallas model in students problem solving with lesson study approach", *International Journal of Instruction*, Vol. 11 No. 2, pp. 527-538.

Piaget, J. (1980), "The psychogenesis of knowledge and its epistemological significance".

Pucio, G.J. and Dan Murdock, M.C. (2001), "Creative thinking, an essential life skill", in Costa, A.L. (Ed.), *Developing Mind for Teaching Thinking*, 3rd Ed., Assosiation for Supervision and Curriculum Development, VT.

Ramlah, R. and Marlina, R. (2018), "Implementasi teknik visual thinking BerbasisPengoptimalanFungsiOtak KananDalamPencapaianKomunikasiMatematisSiswa SMP", *Sigma*, Vol. 2 No. 2, pp. 50-58.

Reid, A. and Petocz, P. (2004), "Learning domains and the process of creativity", *The Australian Educational Researcher*, Vol. 31 No. 2, pp. 45-62.

Rogers, C.R. (1982), "Towards a theory of creativity", in Vernon, P.E. (Ed.), Creativity.

Rumelhart, D.E. (2017), "Schemata: the building blocks", *Theoretical Issues in Reading Comprehension: Perspectives from Cognitive Psychology, Linguistics, Artificial Intelligence and Education*, Vol. 11 No. 1, pp. 33-58.

Rumelhart, D.E. Norman, D.A. Aitkenbcad, A.M. and Slack, J.M. (1985), "Issues in cognitive modeling", Representation of Knowledge'.

Siswono, T.Y.E. (2010), "LevelingStudents'creative", *Journal on Mathematics Education*, Vol. 1 No. 1, pp. 17-40.

Soh, K. (2017), "Fostering student creativity through teacher behaviors", *Thinking Skills and Creativity*, Vol. 23, pp. 58-66.

Solso, R.L. Maclin, O.H. and Maclin, M.K. (2008), "Psikologikognitif. Jakarta: Erlangga".

Someren, M.W., Barnard, Y.F. and Sandberg, J.A.C. (1994), *The Think Aloud Method: A Practical Approach to Modelling Cognitive*, Academic Press, London.

Sternberg, R.J. (2005), "Creativity or creativities", *International Journal of Human-Computer Studies*, Vol. 63 Nos 4/5, pp. 370-382.

Sternberg, R.J. (2006), "The nature of creativity", *Creativity Research Journal*, Vol. 18 No. 1, pp. 87-98.

Sternberg, R.J. (2012), "The assessment of creativity: an investment-based approach", *Creativity Research Journal*, Vol. 24 No. 1, pp. 3-12, doi: 10.1080/10400419.2012.652925.

Sternberg, R.J. and Sternberg, K. (2016), *Cognitive Psychology*, Nelson Education, Belmont.

Surya, E., Sabandar, J., Kusumah, Y.S. and Darhim, D. (2013), "Improving of junior high school visual thinking representation ability in mathematical problem solving by CTL", *Journal on Mathematics Education*, Vol. 4 No. 1, pp. 113-126.

Suryandari, K., Fatimah, S., Sajidan, S., Rahardjo, S. and Prasetyo, Z. (2018), "Project-based science learning and pre-service teachers' science literacy skill and creative thinking", *JurnalCakrawala Pendidikan*, Vol. 37 No. 3, doi: 10.21831/cp.v38i3.17229.

Tindowen, D.J.C., Bassig, J.M. and Cagurangan, J.A. (2017), "Twenty-first-century skills of alternative learning system learners", *SAGE Open*, Vol. 7 No. 3, pp. 1-8, doi: 10.1177/2158244017726116.

Torrance, E.P. (2000), *Research Review for the Torrance Tests of Creative Thinking Figural and Verbal Forms a and B*, Scholastic Testing Services, Bensenville, IL.

Torrance, E.P. and Horng, R.Y. (1980), "Creativity and style of learning and thinking characteristics of adaptors and innovators", *Creative Child and Adult Quarterly*, Vol. 5 No. 2, pp. 80-85.

Trnova, E. and Trna, J. (2014), "Implementation of creativity in science teacher training", *International Journal on New Trends in Education and Their Implications*, Vol. 5 No. 3, pp. 54-63.

Tsai, C.Y., Horng, J.S., Liu, C.H., Hu, D.C. and Chung, Y.C. (2015), "Awakening student creativity: empirical evidence in a learning environment context", *Journal of Hospitality, Leisure, Sport and Tourism Education*, Vol. 17, pp. 28-38.

Vale, I. and Barbosa, A. (2015), "Mathematics creativity in elementary teacher training", *Journal of the European Teacher Education Network*, Vol. 10, pp. 101-109.

Vyas, D., Ottis, E.J. and Caligiuri, F.J. (2011), "Teaching clinical reasoning and problem-solving skills using human patient simulation", *American Journal of Pharmaceutical Education*, Vol. 75 No. 9.

Wahyudi, W., Rochmad, B. and Suyitno, H. (2018a), "Mathematical creative thinking ability and scaffolding process according with learning styles for pre-service teachers", *Anatolian Journal of Instruction*, Vol. 3 No. 1, pp. 39-50.

Wahyudi, W., Suyitno, S.B. and Isnarto, H. (2019a), "Schemata's influence on mathematical problem solving skills", *International Journal of Scientific and Technology Research*, Vol. 8 No. 8.

Wahyudi, D., Waluya, S.B. and Suyitno, H. (2019b), "Development of 3CM (cool-critical-creative-meaningful) learning model to increase creative thinking skill", *Journal of Physics: Conference Series*, Vol. 1321 No. 2, p. 022063.

Wahyudi, D., Waluya, S.B., Rochmad. and Suyitno, H. (2018b), "Assimilation and accommodation processes in improving mathematical creative thinking with scaffolding according to learning style", *Journal of Physics: Conference Series*, Vol. 1097, doi: 10.1088/1742-6596/1097/1/012156, Institute of Physics Publishing.

Wahyudi, W., Waluya, S., Suyitno, H. and Isnarto, I. (2020), "The impact of 3CM model within blended learning to students' creative thinking ability", *Journal of Technology and Science Education*, Vol. 10 No. 1, pp. 32-46, available at: www.jotse.org/index.php/jotse/article/view/588

Wahyudi, D., Waluya, S.B., Suyitno, H., Isnarto, D. and M. Pramusita, S. (2019), "Schemata in creative thinking to solve mathematical problems about geometry", *Universal Journal of Educational Research*, Vol. 7 No. 11, pp. 2444-2448, doi: 10.13189/ujer.2019.071122.

Wardono, S.B., Waluya, S.M. and Candra, S.D. (2016), "Mathematics literacy on problem based learning with Indonesian realistic mathematics education approach assisted e-learning edmodo", in *Journal of Physics: Conference Series*, Vol. 693 No. 1, pp. 1-8.

Wisarja, I.K. and Sudarsana, I.K. (2017), "Praksis pendidikan menurut habermas (RekonstruksiTeoriEvolusi SosialMelalui proses belajar masyarakat)", *Ijer (Indonesian Journal of Educational Research)*, Vol. 2 No. 1, pp. 18-26.

Zevenbergen, R., Dole, S. and Wright, R.J. (2004), *Teaching Mathematics in Primary Schools*, Allen and Unwin, Crows Nest.

Zhao, X. and Zhu, L. (2012), "Schema theory and college English reading teaching", *English Language Teaching*, Vol. 5 No. 11, pp. 111-117.

Zulkarnain, F. (2013), "The effect of using sentence of question in the beginning of mathematics lesson in primary school", *Asian Social Science*, Vol. 9 No. 12, ISSN 1911-2017 E-ISSN 1911-2025.

Further readings

Amabile, T.M. (2018), *Creativity in Context: Update to the Social Psychology of Creativity*, Routledge.

Ausubel, D.P. and Fitzgerald, D. (1961), "The role of discriminability in meaningful learning and retention", *Journal of Educational Psychology*, Vol. 52 No. 5, p. 266.

Brown, B.L. (1998), "Applying constructivism in vocational and career education. Information series no. 378", Columbus: ERIC Clearinghouse on Adult, Career, and Vocational Education, Center on Education and Training for Employment, College of Education, The Ohio State University, 1998. (ED 428 298), available at: http://cete.org/acve/majorpubs.asp

Kim, K.H., Cramond, B. and Bandalos, D.L. (2006), "The latent structure and measurement invariance of scores on the Torrance tests of creative thinking-figural", *Educational and Psychological Measurement*, Vol. 66 No. 3, pp. 459-477.

Leikin, R. (2009), "Exploring mathematical creativity using multiple solution tasks", in Leikin, R. Berman, A. and Koichu, B. (Eds), *Creativity in Mathematics and the Education of Gifted Students*, Ch. 9, Sense Publisher, Rotterdam, pp. 129-145.

Siswono, T.Y.E. (2011), "Level of student's creative thinking in classroom mathematics", *Educational Research and Reviews*, Vol. 6 No. 7, pp. 548-553.

Zhang, L., Zhao, J. and Li, Y. (2018), "Research on the application of right brain thinking in the innovation of architectural design teaching method", *Educational Sciences: Theory and Practice*, Vol. 18 No. 5.

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