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Three Parts of 21 Century Skills: Creative, Critical, and Communication Mathematics through Academic-constructive Controversy

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Abstract This study aims to analyze the characteristics of critical, creative and communication thinking after participating in learning academic-constructive controversy. Sequential explanatory design with sequential phase design analysis was used for the test results of two classes of junior high school students. The results showed that the experimental group was better than the control group for creative, critical, and communication mathematic. Completeness of the characteristics of the three abilities is in line with the ability of students, but they experience obstacles to communicating. Unfortunately, this study is only limited to quadrilateral topics. Academic-Constructive controversy learning can be used to develop three skills or even develop character qualities going forward.

Keywords Lack of Generalization, Academic-constructive Controversy, Creative Thinking, Critical Thinking, Communication Skills

1. Introduction

Critical thinking skills, creative thinking, and communication skills are three important elements in school, work success, and daily life [1]. Critical thinking is the basic skill that individuals must possess [2]. Creative mathematical reasoning is better than algorithmic reasoning for constructing knowledge [3]. Critical and creative thinking is needed to solve problems [6]. Therefore, creativity is an important goal in the curriculum [4, 5]. Communication skills are needed to argue, discuss or debate based on facts, and decision making [7]. Decision making is part of critical thinking [8]. Social communication skills are important components related to performance in the workplace [9]. These skills, as part of 21st-century skills, are important to develop [10].

Communication is defined as the ability to discuss mathematics, express, interpret, contextualize and evaluate mathematical ideas in writing and verbally, and express everyday problems into the language of mathematics [46, 1, 10]. This communication ability will be seen from six aspects, namely: 1) Students are able to connect real objects, images, and diagrams into mathematical ideas; 2) Students can explain ideas, situations, and mathematical relations verbally or in writing, with real objects, images, graphics, and algebra; 3) Students can express daily events in the language of mathematics; 4) Students are able to listen, discuss, and write about mathematics; 5) Students are able to read by understanding a written mathematical presentation; and 6) Students can create conjectures, compile arguments, formulate definitions and generalizations.

Some researcher defines Critical thinking with various meaning. Logically and reflective thinking is focused on deciding what is believed and done [11]. Planned self-assessment to produce interpretations, analyzes, evaluations, and conclusions as well as an explanation of the evidence, conception, methodology, logical criteria or conception that forms the basis of the assessment, which is then revised to reflectively reflect what must be calculated or what must be trusted [12, 13, 14]. Critical thinking can also be interpreted from an educational perspective. Critical thinking is the ability to analyze arguments, claims or evidence [11, 14, 15, 16]. Critical thinking is making conclusions using inductive or deductive reasoning [11, 12, 16, 17]. Critical thinking is the ability to asses, evaluates [18, 12, 12, 19], or the ability to make decisions or solve problems [14].

Torrance [20] stated 4 components of creative thinking; fluency, originality, flexibility, and elaboration. Corrected by Ball & Torrance [21] to be; fluency, originality, elaboration, the abstractness of title, and resistance to

premature closure. Supported also by Kim [22] states that the Torrance Creative Thinking Test (TTCT), developed by Torrance and Ball, is very good for measuring to identify creative thinking in education, but it is also good to discover the creativity of the general public in everyday life. Classified into 2 factors by Krumm, Filippetti, Lemos, Koval& Balabanian [23] namely: (1) Factors of Innovation consisting of fluency and authenticity, and (2) Adaptive factors consisting of resistance to premature closure, the abstractness of titles, and elaboration.

Communication is the ability of students to justify, represent in various types, and interpret mathematically [24]. Communication is characterized by the ability of students to articulate mathematical thoughts and ideas verbally and in writing, the ability to listen effectively to the reason of their friend and repeating their explanation [1].

Sternberg [25] suggested learning to develop analytical thinking through; 1) analysis of issues, 2) evaluation of issues, 3) explain how 4) compare and contrast, and 5) judge the value of characteristics something. Whereas learning to develop creative thinking through; 1) create a problem, 2) inventory of new ways of solving problems, 3) exploration of new ways, 4) imaginative (what if), 5) suppose (what would have?), and synthesize. This learning must be based on a particular set of principles including 1) agency, 2) reflection, 3) collaboration, 4) culture, 5) deep discipline, and 6) developmental corridors [26].

Critical thinking can be developed effectively by providing opportunities for dialogue, exposure of students to authentic problems/examples faced by students, and giving guidance [27]. Critical thinking can be developed by creating a constructive learning environment by providing a context in the classroom [28], and to teach thinking through mathematics rather than remembering formulas [29].

Potential learning strategies are needed to develop students 'creative thinking abilities, critical thinking skills and inferential thinking skills and students' problem-solving abilities [30]. Teachers must create creative contexts in classrooms, monitor developments, encourage sharing of creativity [31].

Mathematical communication can be effectively improved through ASSURE learning (analysis, conditions, selection, use, needs, and evaluation) [32]. in addition, Socio Scientific Issues (SSI) are effective for developing basic communication components [7].

The study above shows the importance of learning strategies that contain mathematical contexts, learning constructive thinking environments, argumentative dialogue, mentoring the learning process. These four things are in line with the elements of cooperative learning [3, 33]. which is contained in 2 main categories of cooperative learning namely argumentative dialogue and constructive thinking environment [33]. Furthermore, by providing intellectual conflict [34], called learning CAC (Constructive Academic Controversy) [35]. Which is then called learning Academic-Constructive Controversy [36].

Various benefits of CAC / CC have been recommended by researchers. These include high-quality decision making and group function improvement [37], growing team loyalty and innovation [39], developing risk-taking to improve innovation and recovery risk management [39], developing reasoning strategies, more critical thinking, more creative solutions to complex problems, building curiosity, and being able to view issues from various perspectives [34].

However, studies on the application of CAC / CC to mathematics are rare, especially in developing critical thinking skills, creative thinking, and communication.

Table 1. The relation between process of controversy with critical, creative and communication

The process of Controversy[34]	**Benefits for students**
Categorizing, organizing, and deriving conclusions from present information andexperiences	Elementary or advanced clarification,inference, originality,
Involvement in a controversy.	
active representing and elaboration of position and rationale	Explain mathematics ideas, elaboration
being challenged by opposing views	Advanced clarification
experiencing, conceptual conflict, uncertainty, and disequilibrium	Clarification, fluency
Epistemic curiosity; active search for more information and understand opposing positions and rationale	Strategy and tactics, clarification, originality
Reconceptualization; the accuracy of perspective-taking; incorporation of opponents' information and reasoning; attitude and position change; transition to higher stages of cognitive reasoning	writing from mathematics presentation, discussion mathematics
Productivity: high quality decision making, high creativity; achievement and retention; high continuing motivation	Creatively, critically, reading comprehension about mathematical
Epistemic curiosity: active search for more information and understanding opposing positions and rationale	Disposition of critical and creative thinking

This study was conducted to explore whether the three skills can develop after following Academic-Constructive Controversy learning?

2. Methods

2.1. Procedures

This study aims to analyze the characteristics of critical, creative and communication thinking skills through sequential explanatory design [40]. The first stage of giving treatment in the form of learning CAC for the experimental class (Class VII-D) and expository learning for the control class (Class VII-C). The second stage, data analysis through 2 phases. The first phase is quantitative, where data is collected through descriptive tests to measure differences in critical thinking skills, creative thinking and student communication between the experimental and control groups. The second phase is called the qualitative phase, to explain more about the characteristics of the three abilities for the experimental group. Qualitative data were taken from 2 high group students, 2 medium group students, and 2 low group students. This qualitative data was taken from the results of interviews to explain the results of their test answers [41].

2.2. Data Collection Technique

Quantitative data is collected through descriptive tests to measure critical, creative and communication thinking skills. Critical thinking tests include basic classification aspects, basic support, inference, further clarification, and strategy and tactics [42] on the topic of building a rectangular flat with 6 items. Creative thinking tests include aspects of fluency, flexibility, originality, and elaboration with 4 items [20, 43]. Communication skills test refer to the NCTM with a number of 6 items in question [44]. Qualitative data were collected through student answer documents and interviews were used to collect characteristics of critical thinking, creative thinking, and student communication skills [40].

2.3. Data Analysis Technique

Data analysis refers to the design of the sequential phase [45]. Quantitative analysis was used to assess the significance of differences in statistical critical, creative and communication skills between the experimental group and the control group. Qualitative analysis is used to examine the differences in the characteristics of critical, creative and communication thinking skills based on student categories. The examine is done with the Mann-Whitney U test.

3. Results

The results of the study in this study are arranged in 3 main parts. First, characteristics of students' critical thinking, characteristics of students' creative thinking, and thirdly differences in abilities and characteristics of student communication. The third difference in ability was seen statistically among students who attended CAC learning with those who participated in expository learning. The characteristics of the three abilities are seen qualitatively from the achievement of the third aspects of the ability of the experimental group students based on the group of high, medium and low students.

3.1. Differences and Characteristics of Critical Thinking

Critical thinking in this study includes 5 aspects, namely: basic clarification, basic support, inference, further clarification, and strategies and techniques. This data is then analyzed quantitatively and qualitatively. Quantitative data showed in the following Table 2.

Table 2. Independent Sample t-Test of critical thinking skills

	Critical Thinking Ability
T	7,170
Df	60
Sig. (2 tail)	,000
Mean Difference	30,387
Std. Error Difference	4,238

Table 2 shows that the average critical thinking ability of students who followed CAC learning is higher than the average student who followed expository learning. In more detail, the average of each aspect of critical thinking skills between the experimental group and the control group can be seen in Figure 1 below;

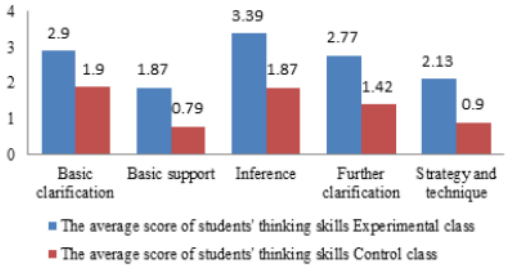

Figure 1. The average score aspect of critical thinking

Based on the data in Figure 1, students who learn through CAC have a higher average for each aspect of critical thinking compared to students who learn through expository. The inference aspect is the highest aspect achieved by the experimental group students, while the

basic support aspect becomes the lowest aspect. Furthermore, to find out more about these critical thinking, interviews were conducted with several students. The following are a few examples of the results of interviews conducted through representation from every aspect (A), queestion (P), and level of students' critical thinking (T-S-R).

Tabel 3. Data of critical thinking interviews

Aspect	Interview Questions	Response
A_1 Basic clarification	**P_2** Apa saja yang ditanyakan pada soal tersebut? *[What is asked about that problem?]*	**T-6_2** Mencari sisi yang sama panjang, sudut yang sama besar dan sumbu simetri dari belah ketupat. *[Looked for sides of the same length, equal angles and symmetry axis from the rhombus]* **T-7_2** Menentukan sisi yang sama panjangnya, sudut yang sama besarnya dan sumbu simetrinya *[Determining the side of the same length, the same angle and the axis of symmetry]* **S-5_2** ditanyakan sisi yang sama panjang, sudut yang sama besar dan sumbu simetri dari belah ketupat. *[asked the same length, the same angle and the axis of symmetry of the rhombus]* **S-13_2** Ditanyakan a. menentukan sisi yang sama panjangnya, b. sudut yang sama besarnya dan c. sumbu simetrinya dari belah ketupat *[Asked a. Determine the side of the same length, b. the same angle and c. the axis of symmetry is from the rhombus]* **R-1_2** Tentukan sisi yang memiliki sama panjang, tentukan sudut besar yang sama dan tentukan sumbu simetri belah ketupat itu. *[Determine the sides that have the same length, determine the same large angle and determine the axis of the rhombus symmetry]* **R-9_2** Sisi yang memiliki panjang yang sama, sudut yang besarnya sama, dan sumbu simetri yang dimiliki oleh belah ketupat. (membaca soal) *[The side that has the same length, the angle of the same magnitude, and the axis of symmetry that is owned by the rhombus. (reading questions)]*
A_2 Basic support	**P_3** Bagaimana cara kamu menjawab pertanyaan dalam soal kedua? *[How do you answer the question in the second problem?]*	**T-6_3** Dicari sisi yang miring ini, pake phytagoras ya pak? Jadi, C = 144. Terus dikali 4. Gak tau sih Bu sebenernya ini soal tuh udah pusing banget. *[Look for this slanted side, use Pythagoras, sir? So, C = 144. Continue to be multiplied 4. I don't know, ma'am, actually it's a matter of which is really dizzy]* **T-7_3** Nah soal ini pusing pak,,, pertama itu dicari yang miring ini (maksudnya garis GF). Hasilnya $12\sqrt{2}$. Lalu dicari luasnya jadi 288. Lau dikurangi sama yang didalemnya 144. Jadi hasilnya 144 cm^2. *[Well, the matter is dizzy, sir,,, the first thing to look for is this slant (meaning of line GF). The result is $12\sqrt{2}$. Then look for the area to be 288. Then subtract the same in the palace 144. So the result is 144 cm^2]* **S-5_3** hehe.. gak tau pak ini ngasal. Jadi kan panjang sisinya 24 lalu dibagi 2 jadi 12. Terus dikuadratin jadi 288 terus dibagi 2 ditambah 4 jadi 152 hasilnya. *[hehe .. I don't know, sir. So the length of the side is 24 and then it is divided into 2 into 12. Then it is squared to be 288 and it continues to be divided into 2 plus 4 into a result 152]* **S1-3_3** **…...** **R-1_3** Gak bisa ngerjain Pak,,,, ! *[Can't do it, sir ...!]*

		R-9$_3$ Kurang paham Pak,,,! jadi ngisinya jawabannya aja. *[Lack of understanding, sir ... so just answered.]*
A$_3$ Inference,	**P$_2$** Bagaimakah cara kamu menarik kesimpulan dalam menemukan luas layang-layang tersebut? *[How do you draw conclusions in finding the area of the kite?]*	**T-6$_2$** Bagian layang-layang yang kiri dan kanan sama. Jadi, untuk mencari luas layang-layang tinggal menjumlahkan setiap 4 segitiga. Jadi, L = 12 + 12 + 36 + 36 = 96 cm^2. *[The left and right side of the kite is the same. So, to find the area of a kite, you just add up every 4 triangles. So, L = 12 + 12 + 36 + 36 = 96 cm^2]* **T-7$_2$** Segitiga ADP = DPC dan segitiga APB = CPB. Jadi luas layang-layang = DPC x 2 + APB x 2 = 12 x 2 + 36 x 2 = 24 + 72 = 96 cm^2. *[triangle of ADP = DPC, and triangle of APB = CPB . So the area of the kite = DPC x 2 + APB x 2 = 12 x 2 + 36 x 2 = 24 + 72 = 96 cm^2]* **S-5$_2$** Luas DPA = DPC = 12 cm^2. Luas APB = CPB = 36 cm^2. Jadi, L = 12 + 12 + 36 + 36 = 96 cm^2. *[Area of DPA = DPC = 12 cm2. Area of APB = CPB = 36 cm^2. So, L = 12 + 12 + 36 + 36 = 96 cm^2]* **S-13$_2$** Jadi, L = 12 + 12 + 36 + 36 = 96 cm^2. [*So, L = 12 + 12 + 36 + 36 = 96 cm^2*] **R-1$_2$** Jadi luasnya itu 12 x 2 + 36 x 2 = 24 + 72 = 96 cm^2. *[So the area is 12 x 2 + 36 x 2 = 24 + 72 = 96 cm^2]* **R-9$_2$** Jadi luasnya s + s + s + s = 96 cm^2 *[So the area of s + s + s + s = 96 cm^2]*
A$_4$ Further clarification,	**P$_2$** Bagaimankah cara kamu menyelesaikan soal tersebut? Coba jelaskan! *[How do you solve the problem? Try to explain!]*	T-6$_2$ Jadi kan GHCD = APGH = PHFB dan sisanya bangun segitiga. Nah, kalau digabungkan segitiga tersebut menjadi bangun trapesium. Jadi trapesium yang ada di dalam trapesium ABCD ada 4 trapesium besar dan 1 trapesium kecil. Jadi perbandingannya 4: 1. [*So GHCD = APGH = PHFB and the rest build triangles. Well, if combined the triangle becomes a trapezoidal shape. So the trapezoid that is inside the ABCD trapezoid is 4 large trapezoid and 1 small trapezoid. So the ratio is 4: 1.]* **T-7$_2$** Dimisalkan CD = 10 cm, Karena AB = 2 CD jadi AB= 20 cm. GH = 10: 2= 5 cm, kalau T yang trapesium besar = 4 cm, jadi t trapesium kecil = 2 cm. jadi kalau kita cari luasnya gitu Bu (menunjuk jawaban) jadi hasilnya GHCD = 15 cm^2 dan ABCD = 60 cm^2. Jadi perbandinganya 15: 60 = 1: 4. *[Suppose CD = 10 cm, because AB = 2 CD so AB = 20 cm. GH = 10: 2 = 5 cm, if a large trapezoid T = 4 cm, so a small trapezoid T = 2 cm. so if we look for the width so sir (pointed answer) so the result is GHCD = 15 cm2 and ABCD = 60 cm2. So the comparison is 15: 60 = 1: 4]* **S-5$_2$** : Dimisalkan a = 4, karena b = 2 a, jadi b= 8 dan t = 2 jadi kalau kita jadi luas ABCD = 12 cm^2. Selanjutnya Dimisalkan a = 4: 2 = 2, karena b = 2 a, jadi b= 8: 2= 4 dan t = 2:2 =1 jadi kalau kita jadi luas GHCD = 3 cm^2. Jadi, perbandingannya 12: 3= 4:1. *[Suppose a = 4, because b = 2 a, so b = 8 and t = 2 so if we become area of ABCD = 12 cm^2. Next Suppose a = 4: 2 = 2, because b = 2 a, so b = 8: 2 = 4 and t = 2: 2 = 1 so if we become an area of GHCD = 3 cm2. So, the ratio is 12: 3 = 4: 1]* **S-13$_2$** karena berdasarkan AD=BC dan AB =CD. Jadi perbandingannya 4:1. Dikira-kira sih pak,,!! *[because based on AD = BC and AB = CD. So the ratio is 4: 1. I am estimating, sir ..!!.]* **R1$_2$** Jadi perbandingannya GHCD: ABCD = 1: 4. Alasannya AD= BC dan AB = 2CD *[So the comparison is GHCD: ABCD = 1: 4. The reason is AD = BC and AB = 2CD]*

		R-9$_2$ kalau dilihat tuh pak„ pada gambar trapesium sama kaki ada 4 trapesium kecil. Perbandingannya ada *[if you look at that, sir„ in the image of an isosceles trapezoid 4 small trapezoidal. The comparison is there]*
A$_5$ Strategies and techniques	**P$_1$** Cara apakah yang kamu gunakan untuk menyelesaikan soal tersebut? *[What method did you use to solve the problem?]*	T-6$_1$ Luas kawasan wisata dikurangi luas dari setiap bagian yang lainnya *[The area of the tourist area is reduced by the area of each of the other sections]* **T-7$_1$** Dihitung luas dari setiap tempatnya lalu dikurangkan dari luas wisata yang keseluruhan *[Area calculated from each place and then subtracted from the total area of tourist attractions]* **S-5$_1$** Menghitung luas dari setiap bagian, terus dikurangkan dari luas kawasan wisata. *[the calculate the area of each section, then subtracted from the area of the tourist area]* **S-13$_1$** Dihitung luas dari setiap tempatnya lalu dikurangkan dari luas wisata yang keseluruhan. *[Area calculated from each place then subtracted from the total tour area]* **R-1$_1$** Kurang paham soalnya pak„. *[Lack of understanding, sir ...]* **R-9$_1$** dicari luas dari setiap tempatnya lalu dikurangkan dari luas wisata yang keseluruhan *[calculate the area of each place and then subtracted from the total area of tourism]*

Furthermore, a qualitative analysis was carried out on 2 low-category students, 2 moderate category students, and 2 high category students. Based on the reduction of answer documents explored through interviews, it can be categorized the thinking skills of the experimental group as in the following Table 4.

Table 4. Stages of mathematical critical thinking ability

Subject	Wholeness	Critical category	Stages of critical thinking				
			Basic clarification	Basic support	Inference	Further clarification	Strategy and technique
R1	low	low	-	√	-	-	-
R9	low	Medium	-	-	-	√	√
S5	Medium	low	-	√	√	√	√
S13	Medium	high	√	√	-	-	-
T6	high	high	√	√	√	√	√
T7	high	high	√	√	√	√	√

Description: (√) shows students have been able to go through the stages, Strip marks (-) shows students have not been able to go through this stage

The data in Table 4 show that high category student can go through all stages of critical thinking. High category student have the characteristics to be able to provide basic clarification, provide basic support, make inferences, provide further clarification, and are able to use strategies and tactics in solving problems related to a quadrilateral. Moderate-category student have less systematic characteristics of critical thinking where there is a jump in critical thinking from one stage to another in critical thinking. While low group students only have one or two stages of the characteristics of critical thinking and also non-systematic stages.

3.2. Differences and Characteristics of Creative Thinking

The creative thinking ability of students studied includes aspects: fluency, flexibility, originality, and elaboration. In general, the average creative thinking ability of the experimental group students reached score 2,62, while control group students reached score 1,62. While the achievement of each aspect of creative thinking for both groups can be seen in the following Figure 2.

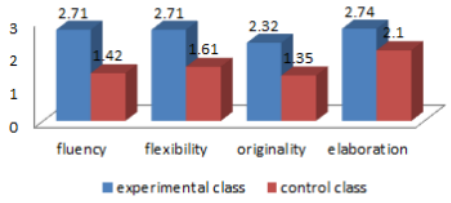

Figure 2. Average Score aspect of Creative Thinking

Based on the data in figure 2, the ability of each aspect of critical thinking of the experimental group was higher than the control group. The students becomes fluency, flexible, spark the ideas to use strategies to solve quadrilateral problems. This ability indicates that CAC learning can develop creative strategies in solving problems [34]. The stages of CAC learning can encourage creativity [31]. CAC learning becomes a potential alternative for developing students' creative thinking skills [30]. Statistically, the difference test was carried out using the Mann-Whitney U test to see the significance of the differences.

Table 5. Test Statistics of creative thinking

	Value of Creative Thinking
Mann-Whitney U	212,000
Wilcoxon W	708,000
Z	-3,809
Asymp. Sig. (2-tailed)	,000
Grouping Variable: class	

The data in Table 5 shows that there are significantly differences in creative thinking skills between the experimental group and the control group. The creative thinking ability of experimental students is more developed compared to the control group students. This shows that CAC learning is potential and effective for developing students' thinking skills with the existence of stages or learning scenarios that can encourage students to think creatively.

Qualitative analysis showed that there are differences in the characteristics of creative thinking for high group students, moderate groups, and low groups. This differences in characteristics showed by the aspect of creative thinking such as aspects of fluency, aspects of flexibility, aspects of originality, and aspects of elaboration.

High group-students have the characteristic to generate lots of ideas and answers to solve problems, and they are very fluent in delivering in their language. These characteristics are in line with fluency aspects. While the group students are giving answers at the minimum request alone with a fair fluency explanation. On the contrary, low group students still experience illiteracy in generating ideas and not fluent in conveying their answers.

The following are the results of interviews related to creative thinking presented in Table 6.

Tabel 6. Data from interviews of creative thinking

Interview Questions	Response
P_2 *Apa saja yang kamu buat? Coba Jelaskan!* *[What did you make? Explained it !]*	**T-6_2** itu ada gunung dan jalan terbuat dari segitiga warna coklat dan merah sama jalannya dari jajar genjang warna hijau. Terus ada trapesium yang dibuat dari segitiga merah, persegi kuning sama segitiga orange. Ada rumah dan jalan dari segitiga biru, persegi kuing sama jajargenjang hijau. *[There is a mountain and a road made of brown and red triangles and the path of a green parallelogram. Then there is a trapezoid made of red triangle, yellow square and orange triangle. There are houses and roads from the blue triangle, square Kuing with green level bars.]* **T-7_2** : *Gunung terus ada jalannya, amplop atau bisa juga segiempat, kapal yang ada atas air, sama tanda panah.* *[A mountain with the road, amplop or the square, existing ships over the water, with arrow]* **S-5_2** *İtu ceritanya amplop tapi kebalik hehe.., terus ada gunung sama jalan, sama sawah dan rumah.* *[That's the story of the envelope but reversed, then there are the mountain and road, with field and house]* **S-13_2**: Gambar segitiga sama sisi, trapesium sama segitiga sama kaki. *[The picture of equilateral triangle, trapezoidal and isosceles triangle]* **R-1_2** *Ini ada tiga gambar. Segitiga sama trapesium.* *[There are three pictures. triangle and trapezoid]* **R-9_2** Ini tanda panah, atap rumah, dan petunjuk arah. (memberi keterangan saat wawancara) *[There are arrow, rooftop, and the direction)* (give a note when interview*]*
P_3 *Ada berapakah gambar yang kamu buat? Coba jelaskan bentuk dan ukuran yang kamu pilih!* *[How many picture did you make? Try to explain the shape and size you choose!]*	**T-6_3** Pertama persegi panjang, panjangnya 48 m lebarnya 2 m jadi luasnya p x l jadi 96m^2. Kedua jajargenjang alasnya 24m tingginya 4 m jadi luasnya a x t = 96 m^2. Ketiga layang-layang, d_1 = 4 m d_2 = 48 m jadi luasnya = ½ x d_1 x d_2 = ½ x 4 x 48 = 96 m^2. *[First the rectangle, the length is 48 m, the width is 2 m, so the width p x l becomes 96m^2. The two bases are 24m high, 4 m high, so the width is a x t = 96 m^2. The three kites, d1 = 4 m d_2 = 48 m so the area = ½ x d_1 x d_2 = ½ x 4 x 48 = 96 m^2]* **T-7_3** Pertama trapesim, a-nya 12 m b-ya 20 m tingginya 6 mjadi luasnya ½ (12+20) x 6 jadi 96m^2. Kedua jajargenjang alasnya 24m tingginya 4 m jadi luasnya a x t = 96 m^2. kedua persegi panjang, panjangnya 48 m lebarnya 2 m jadi luasnya 48 x 2 jadi 96m^2. Ketiga segitiga, alasnya 16 m tingginya 12 m jadi luasnya = ½ x 16 x 12= 96 m^2. *[First the trapeze, the a is 12 m the b is 20 m with the high 6 so the area is ½ (12 + 20) x 6 so it's become 96m^2. The two bases are 24m high, 4 m high, so the width is a x t = 96 m^2. the two rectangles, the length is 48 m, the width is 2 m, so the width is 48 x 2, so 96m^2 The three triangles, the base is 16 m high 12 m so the area = ½ x 16 x 12 = 96 m^2]* **S-5_3** Pertama persegi panjang, panjangnya 48 m lebarnya 2 m jadi luasnya jadi 96m^2. Kedua jajargenjang alasnya 24m tingginya 4 m jadi luasnya 96 m^2. Ketiga persegi panjang, panjangnya 24 m lebarnya 4 m jadi luasnya jadi 96m^2 *[First the rectangle, the length is 48 m, the width is 2 m, so the area becomes 96m2. The two bases are 24m high and 4 m high so they are 96 m^2 wide. The three rectangles, the length is 24 m, the width is 4 m, so the area becomes 96m^2]* **S-13_3** jadi dibuat persegi panjang ukurannya tuh panjang 12 lebarnya 8. Nah persegi panjangnya dibagi 3 jadi. Jadi, ukurannya itu panjangnya 8 lebarnya 4. Kan kalau dikaliin 8 x 4 = 32 x 3 = 96 m^2

	[so the size of the rectangle is 12 with the width 8. The rectangle is divided into 3. So, the size is 8 width 4 width. Right if it is multiplied 8 x 4 = 32 x 3 = 96 m^2)
	R-1$_4$ Sebenernya tuh liat dari S13 Bu jawabannya. *[Actually, see from S13 for the answer ma'am]*
	R9$_3$ *Pertama persegi panjang, panjangnya 12 lebarnya 2 tingginya 4 jadi luasnya jadi 96. Kedua persegi 14 x 14 jadi luasnya 96 m^2. Ketiga jajargenjang, alasnya 24 tingginya 4 m jadi luasnya jadi 96m^2* *(The first is a rectangle, the length is 12, the width is 2, the height is 4, so the area is 96. The second is 14 x 14, which is 96 m^2. Third level ladder, the base 24 is 4 m high so the area becomes 96m^2)*
P$_2$ *Dapatkah kamu menceritakan bagaimana kamu menyelesaikan soal tersebut?* *[Can you tell how you solved the problem?]*	**T-6$_2$** Pertama ukuran kebunnya dulu kan 20 m x 6 m kemudian dicari kelilingnya pake rumus keliling 2(20+6) jadi 52 m. karena jarak antar pohonnya 2 jadi 52 dibagi 2 jadi 26 pohon. Karena disetiap pojoknya harus ada pohon makanya dikurang 4. *[First the size of the garden used to be 20 m x 6 m then looked around using the formula around 2 (20 + 6) to 52 m. because the distance between the trees is 2 to 52 divided by 2 to 26 trees. Because in every corner there should be a tree so that's minus 4].* **T-7$_2$** *Sebenernya salah Bu jawabannya. Udah dihitung lagi di rumah buru-buru waktu itu jawabnya.* *[Actually it is the wrong answer. It was counted again at home and that time it was counted in a hurry]* **S-5$_2$** Pilih dulu ukuran kebunnya 20 x 6 kemudian dicari pake rumus keliling 2x20+6 jadi 52 m. karena jarak antar pohonnya 2 jadi 52 dibagi 2 jadi 26 – 4 = 22 batang pohon (dari temen sih Bu). *[First select the size of the garden 20 x 6 then look for using the formula 2x20 + 6 to 52 m. because the distance between the trees is 2 so 52 divided by 2 to 26 - 4 = 22 tree trunks (from my friend, ma'am].* **S-13$_2$** *kan luasnya 120m^2, jaraknya 2 m jadi 120:2 = 60 m. ukuran tanah pohonnya tuh 12 cm x 5 cm= 60 cm. terus 60cm x 100 cm = 6000 m. dibagi 60 m jadi 100 batang pohon.* *[the area is 120m2, the distance is 2 m so 120: 2 = 60 m. the size of the tree soil is 12 cm x 5 cm = 60 cm. then 60cm x 100 cm = 6000 m. divided 60 m into 100 trees]* **R-1$_2$** Susah, Bu. Kan luas nya 120 jaraknya 2 jadi 120: 2 *[It's difficult, ma'am. The width is 120 the distance is 2 so 120:2]* **R-9$_2$** *Ukuran kebunnya 20 x 6 kemudian dicari pake rumus 2(20+6) jadi 52 m. karena jarak antar pohonnya 2 jadi 52 dibagi 2 jadi 26 – 4 = 22 batang pohon* *[The size of the garden is 20 x 6 then ssearch by formula 2(20+6) become 52 m, Because the distance between the tree is 2 become 52 devided in 2 become 26-4 = 22 tree trunk]*
P$_3$ *Apakah kamu telah mengisi jawaban dengan lengkap dan teperinci? Jika belum apa yang belum kamu cantumkan?* *[Have you filled in the answers completely and in detail? If not what you haven't listed yet?]*	**T-6$_3$** Udah Bu, *[Done, ma'am]* **T-7$_3$** *hmmm.. apa ya.. kayanya rumus deh Bu belum* *[Hmmm .. was it .. i think it's the formula ma'am]* **S5$_4$** Udah Bu kayanya. *[I think it's done, ma'm]*

S-13$_4$
Belum Bu.
[Not yet, ma'am]

R-1$_5$
Gak sih, Bu. Sebenernya saya liat (jawaban) dari S13
[Not really, ma'am. Actually i see from the S13]

R-9$_5$
Engga, Bu. Karena masih banyak kurangnya Bu
[Not really, ma'am. Because there are still many shortcomings ma'am]

The ability of various ways and variations in solving the problems faced, consider it, by looking at it from a different perspective held by high group students. The moderate group still has errors in making consideration and using the less varied method. However, this ability does not appear for low group students. In detail, the characteristics of creative thinking from each group of students can be seen in Table 7.

Table 7. Characteristics of creative thinking based on student groups

	Group		
	High	**Medium**	**Low**
Fluency	• The ability to spark more ideas or ideas to solve questions with variety and complexities than other friends; • Explain again the purpose of the questions, the command questions, and the answers of students with their own language smoothly. • Provide more diverse and complex answers than other friends.	• Sparked a lot of ideas or ideas to solve problems at the minimum, but made a few mistakes; • Explain quite fluently with his own language	• Still having difficulties in triggering many ideas or ideas to solve problems; • Not fluent in explaining the ideas found; • Have not been able to see the error from the answer itself
Flexibility	• Produce many different (varied) ways to resolve problems; • See problems and resolve them from different views; • Pay attention to the various considerations he has thought before	• Produce many ways to resolve problems that are not different (vary); • See problems and resolve them from different views; • Pay attention to the various considerations he has thought before even though he is still experiencing errors.	• Produce answers to problems but not yet very and vary; • Not yet able to see any problems and resolve them from different views; • Still not able to exploit in finding different ideas.
Originality	• Disclose his own thoughts in solving problems; • Writing down the answers of the thinker names before the system is still in place but still understood; • Explain the answer written down smoothly; • The ability to detect errors in the answer	• Not yet fully disclosed his own thoughts in resolving the problem; • The writing of the answers is still not systemic and cannot be understood.	• Not yet been able to disclose his own thoughts to resolve problems; • The author's answer is not systemic and difficult to understand or not give answers.
Elaboration	• Develop the ideas displayed in the inner term; • Presents systematic responses, sufficient detail, and complete although there are still errors in accounting.	• Develop images that are displayed by adding to the line in the chart; • Presenting sufficiently systematic answers, details and complete but still available errors in calculations.	• Develop images that are displayed by adding to the line in the chart; • Presenting answers and inaccuracies, details and completeness and are still in error in measurement and calculation.

3.3. Differences and Characteristics of Communication Thinking

The average value of communication skills of the experimental group reached score 70.92, while the control group reached score 51.42. In addition, the achievement of each indicator of communication of the experimental group students was also better than that of the experimental group students. This result is shown in Figure 3.

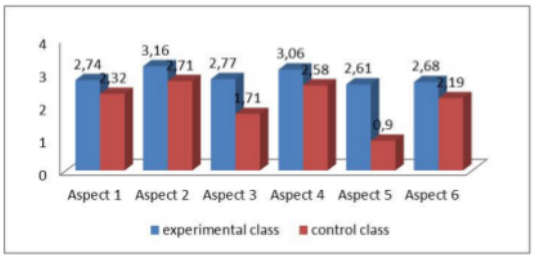

Figure 3. Average score aspect of mathematics communication

The highest score was achieved on the second indicator for the experimental group and the control group, with respectively 3.16 and 2.71. Students are able to state the situation and relations between the length of the land and the area of land into a table and or graph. This ability indicates that the rest can explain ideas, situations, and mathematical

relations verbally or in writing, with real objects, images, graphics. While the lowest score was achieved on indicator 5, reading with an understanding of a written mathematical presentation. Control group students have difficulty understanding the length of the thread as a circumference of the kite.

Figure 3 shows that the communication skills of the experimental group are better than the control group. This indicates that CAC learning has a positive potential in developing students' communication skills. The existence of a mathematical context, constructive-thinking learning environment, argumentative dialogue [34, 33], during the learning process CAC triggers the development of students' communication skills.

This is reinforced by hypothesis testing with a significance of 5% which indicates the difference in communication skills of the experimental group students with the control group as shown in the following Table 8.

Table 8. Test statistics of mathematics communication

	Value of Mathematics Communication
Mann-Whitney U	214,000
Wilcoxon W	710,000
Z	-3,766
Asymp. Sig. (2-tailed)	,000
a. Grouping Variable: Class	

Some of the problems presented for group discussions such as identifying quadratic traits give rise to the possibility of differences of opinion, both between individuals in groups or between groups. This results in good intellectual conflict in deepening student understanding. The ability to explain the properties of the images presented, expressing them in writing is an important aspect of communication to developing better for students after attending CAC learning [46]. During learning, they are accustomed to using oral and written abilities to convey mathematical ideas and thoughts [1].

Tabel 9. Data hasil wawancara berpikir komunikasi matematika

Interview Questions	Response
P2 Coba jelaskan bagaimana cara kamu menemukan jawaban yang telah kamu tulis? *[Try to explain how you found the answer you wrote?]*	**T-6$_2$** Digambar dulu mejanya persegi panjang kemudian digambar persegi kain di atasnya kaya gini (menunjuk jawaban). Gambarnya kan persegi panjang terus dicari luas perseginya. *[I drew the rectangular table first then I drew a square-shaped fabric on top of it like this (the student pointed to the answers). The picture is rectangular then searched square-shaped area]* **T-7$_2$** Digambar meja persegi panjang lalu digambar kain persegi di atasnya (menunjuk jawaban). Bangun yang terbentuk 2 persegi panjang terus kemudian dicari luasnya. *[I drew a rectangular table then I drew a square fabric on it (the student pointed the answer). The building which is formed by two rectangles is then searched for its area.]* **S-5$_2$** Caranya gambar meja persegi panjang terus digambar kain persegi di atasnya. Bangun yang terbentuk 2 persegi panjang terus kemudian dicari luasnya. Jadi luasnya segitu. *[The way I drew a rectangular table and then I drew a square cloth on it. The building which is formed by two rectangles is then searched for its area. So that's the area.]* **S-13$_2$** Pertama saya gambar dulu meja persegi panjang kemudian digambar kain persegi di atasnya, ternyata gambar sisanya persegi panjang terus dicari luas persegi panjang. *[First I drew a rectangular table and then draw a square fabric on it. It turns out the rest of the image is a rectangle, then I look for the area of the rectangle.]*

	R-1$_2$ Caranya sebenernya ngasal Bu. Jadi, gitu Bu hasilnya 1,2 m. *[The way I actually did it by guessing ma'am. so I immediately wrote the results 1.2m]* **R-9$_2$** Caranya dicari luas persegi panjang kemudian dibagi 2 jadi hasilnya 20 cm. *[The way I found for rectangular area then the results are divided by 2 so the result is 20 cm.]*
P3 Bagaimana cara kamu menemukan luas tanah ke D-F sehingga didapatkan grafik seperti yang kamu buat? *[How you found the area of D-F land like in the graphic image that you made?]*	**T-6$_3$** Dicari panjang tanah ke D E F, kalau dliat itu ditambah 2 dari panjang tanah sebelumnya. Lebar dari setiap tanah itu sama 6 m. Jadi tinggal panjangnya dikali lebarnya yang 6. *[I found for the length of the land to D E F, if you saw it plus 2 from the length of the previous land. The width of each land was the same 6 m. So the length was 6 times the width.]* **T-7$_3$** Pertama cari panjang tanah ke D E F, kalau diteliti tuh Bu kelipatan 2 jadi terus ditambah 2. Lebar dari setiap tanah itu sama 6 m. Luasnya tinggal dikaliin aja Bu panjang sama lebarnya *[First, found for the length of the land to D E F, if we examine it, the multiples of 2 will be added to 2. The width of each land is the same as 6 m. The area of living is just being multiplied by the same length, ma'am]* **S-5$_2$** Dikira-kira sih Bu. Kan C nya 14 nah sebelumnya tuh ditambah 2 jadi pasti selanjutnya 16. Luasnya juga gitu kalau ditambahin kan sebelumnya 72, kalau dikira-kira 84 selanjutnya. Gitu kayanya Bu. *[I found with guessing ma'am. The C is 14 before adding 2 so it must be 16. then the area will be similar if you add 72 beforehand, so you can guess about 84. I think so, ma'am.]* **S-13$_2$** Sama seperti luas bangun sebelumnya. *[Same as the area of the previous build.]* **R-1$_2$** Kan C nya 14 nah sebelumnya tuh ditambah 2 jadi pasti selanjutnya 16. Luasnya juga gitu kalau ditambahin kan sebelumnya 72, kalau dikira-kira 84 selanjutnya. Gitu kayanya Bu. *[The C is 14 before adding 2 so it must be 16. then the Area will be similar if you add 72 beforehand, if you guess about 84 next. I think so, ma'am.]* **R-9$_2$** Sama seperti luas sebelumnya. *[Same as the previous area]*
P1 Apakah kamu menuliskannya dalam notasi/rumus/simbol matematika? Apa saja itu? *[Did you write it in mathematical notation / formula / symbol? What are those?]*	**T-6$_1$** Iya, pake penjumlahan, pengurangan pembagian dan rumus bangun datar. *[Yes, I use addition, subtraction of division and plane formula.]* **T-7$_1$** Iya Bu, ada penjumlahan, perkalian, pengurangan sama rumus persegi dan persegi panjang Bu. *[Yes ma'am, there are addition, multiplication, subtraction equals formula square and rectangle ma'am]* **S-5$_1$** Iya, pake penjumlahan, perkalian dan rumus bangun datar persegi dan persegi panjang. *[Yes, use the sum, multiplication and formula of square and rectangular plane.]* **S-13$_1$** Iya Bu, ada penjumlahan, perkalian, sama rumus persegi dan persegi panjang Bu. *[Yes ma'am, there is a addition, multiplication, and formula of square and rectangle ma'am]* **R1$_1$** Gak tau Bu. *[I didn;t know ma'am.]* **R9$_1$** Ada kayanya, penumlahan sama pengurangan kayanya Bu. *[There seems to be, the addition and the reduction like Ma'am.]*
P$_1$ Apa yang kamu pahami pada soal? *[What did you understand about the problem?]*	**T-6$_1$** Terdapat kerangka layang-layang diminta mencari panjang benang dan luas kertas yang dibutuhkan. *[There was a kite frame that asked to find the length of thread and area of paper needed.]*

	T-7$_1$ Ada seorang pengusaha layang-layang yang mana kerangka layang-layang dari dua buah bamboo dengan ukuran kaya digambar Bu. Diminta cari benang yaitu kelilingnya dan kertas yaitu luasnya Bu. *[There was a kite businessman in which the kite frame is made of two bamboo with the size as in the picture, ma'am. That asked to find a thread as the circumference and paper as the area of kite, ma'am.]* **S-5$_1$** Pak Budi merupakan seorang pengusaha layang-layang yang kerangka layang-layang dengan ukuran kaya digambar Bu. Diminta mencari panjang benang yang dibutuhkan yaitu kelilingnya dan kertas yang dibutuhkan yaitu luasnya Bu *[Mr. Budi is a kite businessman whose frame of a kite is the size like in the picture, Ma'am. That was asked to find the length of thread needed is the circumference and the paper needed is the area of the kite, ma'am]* **S-13$_1$** Ada kerangka layang-layang diminta mencari panjang benang dan luas kertas yang dibutuhkan. *[There was a kite frame and that was asked to find the length of thread and area of paper needed.]* **R1$_1$** Ada layang-layang ini Bu, ditanyain panjang benang minimal dan yang b kertas yang digunakan untuk layang-layang itu. *[There was this kite ma'am, that was asked for the minimum thread length and amount the paper used for the kite.]* **R-9$_1$** Pak Budi pengusaha layang-layang ini yang dicari keliling sama luasnya. *[Mr. Budi, the kite businessman, that found for circumference and area of kite.]*
P$_2$ *Did you make conclusions with your own language? If not try to make that conclusion!*	**T-6$_2$** jadi, uang yang perlu dikeluarkan adalah 17.500 rupiah *[so, the money that needs to be spent is 17,500 rupiah]* **T-7$_2$** iya Bu sudah *[yes ma'am, already]* **S-5$_2$** Jadi, uang yang perlu dikeluarkan rahadian yaitu Rp. 17.500. *[So, the money that needs to be spent is Rp. 17,500.]* **S-13$_2$** Jadi, uang yang dibutuhkan 35.000 *[So, the money needed was 35,000]* **R1$_2$** gimana ya Bu bingung. *[what should I do ma'am, I'm confused.]* **R-9$_2$** Jadi, uang yang diperlukan 17.500 *[So, the money needed was 17,500]*

Qualitative data analysis revealed differences in the characteristics of communication skill of high, moderate, and low groups. Differences in these characteristics can be classified based on each indicator. Table 10 below shows the communication characteristics possessed by each group of students.

Table 10. Mathematical communication diversity students in the experimental Group

Aspect	Group		
	High	Medium	Low
Connecting real objects, images, and diagrams into mathematical ideas	Fulfill well	Fulfill well	Make a picture but the answer is wrong
Explain ideas, situations, and mathematical relations verbally or in writing, with real objects, images, graphics, and algebra.	fulfill with technical error	Can explain but not systematically	There are attempts but many mistakes
Express daily events in the language of mathematics.	Meet with technical errors	Writing completely, not neatly, and easily understood	Writing is incomplete, and difficult to understand
Listening, discussion, and writing about mathematics	Write completely, neatly, and easily understood	Tends to write completely, neatly, and easily understood	A small portion is written in full, difficulty identifying
Read by understanding a written mathematical presentation.	Identify information well, there is a calculation error	not yet systematic, and complete in identifying	Difficulty understanding mathematical writing
Make conjectures, compile arguments, formulate definitions and generalizations	Both in compiling arguments, definitions and generalizations even though they are incomplete	Both in compiling arguments, definitions and generalizations even though they are incomplete, and incorrect	Tends to be able to arrange arguments, definitions and generalizations even though they are incomplete, and incorrect

The data in Table 10 show that high group students have fulfilled the ability to connect problems to real objects, images, and diagrams into mathematical ideas. They are also able to explain ideas, situations, and mathematical relations both in writing in the form of tables and graphs with little technical error. Indications in expressing events in everyday life into mathematical language or mathematical models are also in the form of notations, formulas or symbols. They are also fluent in writing the properties of all rectangular flat shapes in a complete, clear and understandable manner. They can identify information that needs to be understood, the main problem in the problem, how to find a solution to the problem in the problem. However, students cannot fully find the right answer. In addition, they have the ability to create conjectors, form arguments, formulate definitions and make generalizations even though they are still incomplete and there are still errors. This finding supports Johnson et al., [34], where constructive controversy forms active students in seeking new information to complement perspectives so that reconceptualization and conclusion formulation are better.

Medium group students have fulfilled the ability to connect problems to real objects, images, and diagrams into mathematical ideas. They are also able to explain ideas, situations, and mathematical relations both in writing in the form of tables and graphs, although they are not systematic. Indications in expressing events in everyday life into mathematical language or mathematical models are also in the form of notations, formulas or symbols, although they are not neat. They tend to be able to write the properties of all flat rectangular shapes completely, clearly, and comprehensively. They can identify information that needs to be understood, the main problem, how to find a solution to the problem, although it has not been systematic and fully found the right answer. In addition, they have the ability to create conjectors, form arguments, formulate definitions and make generalizations even though they are still incomplete and incorrect.

Low group students have fulfilled their efforts to connect problems to real objects, drawings, and diagrams into mathematical ideas even though they are not correct. They also tried to explain ideas, situations, and mathematical relations both in writing in the form of tables and graphics even though they were still wrong. They are still incomplete in expressing events in everyday life into mathematical language or mathematical models and are not so neat that they are difficult to understand. They have difficulty writing down the properties of all flat rectangular shapes in a complete, clear and understandable manner. They have difficulty in identifying information that needs to be understood, the main issue is the problem, and how to find a solution, although it is not systematic and the answer is incorrect. They lack the ability to conjecturing arguing, formulating, and generalizing even though they are still incomplete and incorrect.

4. Discussion

The findings described above show that learning Academic- Constructive Controversy (CAC) has the potential to develop the 3 abilities needed in 21st-century skills, namely the ability to think critically, think creatively and communicate with students.

Students who take CAC learning are accustomed to holding dialogues and presenting the results of problem-solving in constructive learning environments [28] that provide opportunities for thinking through mathematics [29] making it effective for developing critical thinking. Students of the experimental class are accustomed to using logical thoughts to make conclusions [3] and dare to make decisions [47] relating to quadrilateral problems. The basic clarification aspects of the

experimental group students are also high. They can provide simple explanations relating to quadrilateral properties

The stages of CAC learning are able to encourage creativity [31]. CAC learning can develop creative strategies in problem-solving [34]. CAC learning becomes a potential alternative for developing students' creative thinking skills

The existence of a mathematical context, constructive-thinking learning environment, and argumentative dialogue [34, 33]during the process AC learning triggers the development of students' communication skills. This is reinforced by several problems presented for group discussions such as identifying quadratic traits giving rise to the possibility of differences of opinion, both between individuals in groups or between groups. This results in good intellectual conflict in deepening student understanding. The ability to explain the properties of the images presented, expressing them in writing is an important aspect of communication [46], developing better for students after learning CAC. During learning, they are accustomed to using oral and written abilities to convey mathematical ideas and thoughts.

5. Conclusions

Based on the results of research and discussion can be concluded as follows:

- CAC learning has good potential to develop students' critical, creative thinking and communication skills. Each CAC learning step that is carried out is able to develop one or both or the third of these abilities. CAC learning can be an effective alternative strategy for developing critical thinking skills, creative thinking, and student communication.
- Aspects of critical, creative, and communication thinking skills are owned by high group students after participating in CAC learning activities. However, for the medium group and the low group, they have not fulfilled all aspects. Basic aspects of support in critical thinking, originality aspects of creative thinking, and aspects of reading with understanding a written mathematical presentation in communication still need to be developed.
- The ability to communicate the idea of generalizing students still needs to be improved for students in the early grades in the level of education. This will be needed to be able to further increase their contribution in sharing ideas and ideas in mathematics in the following classes.

More in-depth studies are still needed such as examining the relationship of the stages of CAC learning with 4C, assessing CAC learning potential in developing life and career skills, such as adaptation, initiative, productivity, and social skills

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