The Comparison of STEM approach and SSCS Learning Model for Secondary School-Based on K-13 Curriculum: The Impact on Creative and Critical Thinking Ability

La comparación del enfoque STEM y el modelo de aprendizaje SSCS para la escuela secundaria basado en el plan de estudios K-13: el impacto en la capacidad de pensamiento creativo y crítico

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Abstract
In the 21st century, the significance of competencies is increasing in our everyday lives and in the labor market. Such complex competencies like critical and creative thinking is a topic that are becoming more and more relevant. In the past, researchers have shown a direct link between creative thinking and teaching methods. The project will apply a STEM research method throughout the study and comparing SSCS learning. The study focuses on the critical examination of specific assignments and students' critical and creative thinking. In this study, researchers used prisms and pyramids as stimuli for 125 students to evaluate their imagination. This study uses a quasi-experimental design to explore a different hypothesis about the link between STEM and SSCS on student creativity and critical thinking. To determine whether or not the data collection technique can assist students in improving their critical and creative thinking, it has been put through its paces. MANOVA has been shown to be effective in testing hypotheses in several studies. Compared to the SSCS learning model, the STEM-based K-13 curriculum positively impacts critical and creative thinking. It can be concluded that the STEM approach, as opposed to the SSCS model, can be used as an alternative solution for learning in the industrial era 4.0.
Key words: creative thinking, critical thinking, curriculum, STEM, SSCS

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Resumen

En el siglo XXI, la importancia de las competencias está aumentando en nuestra vida cotidiana y en el mercado laboral. Competencias tan complejas como el pensamiento crítico y creativo es un tema que se está volviendo cada vez más relevante. En el pasado, los investigadores han demostrado un vínculo directo entre el pensamiento creativo y los métodos de enseñanza. El proyecto aplicará un método de investigación STEM a lo largo del estudio y comparará el aprendizaje de SSCS. El estudio se centra en el examen crítico de tareas específicas y el pensamiento crítico y creativo de los estudiantes. En este estudio, los investigadores utilizaron prismas y pirámides como estímulos para que 125 estudiantes evaluaran su imaginación. Este estudio utiliza un diseño cuasi-experimental para explorar una hipótesis diferente sobre el vínculo entre STEM y SSCS en la creatividad y el pensamiento crítico de los estudiantes. Para determinar si la técnica de recopilación de datos puede o no ayudar a los estudiantes a mejorar su pensamiento crítico y creativo, se ha puesto a prueba. Se ha demostrado que MANOVA es efectivo para probar hipótesis en varios estudios. En comparación con el modelo de aprendizaje SSCS, el plan de estudios K-13 basado en STEM tiene un impacto positivo en el pensamiento crítico y creativo. Se puede concluir que el enfoque STEM, a diferencia del modelo SSCS, puede utilizarse como una solución alternativa para el aprendizaje en la era industrial 4.0.
Palabras clave: pensamiento creativo, pensamiento crítico, currículo, STEM, SSCS

1. Introduction

The K-2013 curriculum focuses on developing attitudes, knowledge, and skills (Afari, 2013; Defazio et al., 2010; Haridza & Irving, 2017). The experience gained from applying the 2013 curriculum, particularly in the learning process, is reflected in the results' orientation, specifically the capacity to think creatively and critically. Thus, the 2013 Curriculum places a premium on study, exploration, and experimentation activities and the development of creative activities that require imagination, intuition, and discovery through divergent thinking.

Critical thinking abilities encompass mental processes such as the capacity to frame problems, present and analyze arguments, make observations, formulate hypotheses, conduct deductions and inductions, assess, and make decisions and carry out actions (Ampountolas et al., 2019; Koch et al., 2015). Students must cultivate their creative thinking talents throughout the educational process, as strong mathematics creative thinking abilities are proportional to their critical abilities (Aizikovitsh-Udi & Cheng, 2015). Creative mathematics can help pupils develop logically and conceptually critical thinking skills (Pringle & Sowden, 2017).

With the changing times of the twenty-first century, study on creative and critical thinking in mathematics was a significant topic. There are numerous discrepancies in research findings in this area (Glăveanu, 2015; Rahardjanto, 2019; Zubkova et al., 2019; Zulnaidi et al., 2021). Rahardjanto (2019) on the study was explianed that students with creative thinking skills will be able to change, reuse, or even invent new ideas or goods in the modern period. The other perspective by Glăveanu (2015) takes a sociological approach to creativity in his study. An actor's ability to carry out “material or symbolic acts that result in the creation of new modes of information transmission is defined as creativity by this research”. There is also an examination of the proposed concept's social, physical, and chronological aspects (Widyastuti et al., 2020; Zubkova et al., 2019).

Numerous research has been conducted to investigate creativity in various sectors (Corebima et al., 2017; Karwowski et al., 2018; Yasin & Fakhri, 2020). In secondary school, creativity is a critical talent (mathematics in particular). Numerous research have shown SSCS's beneficial effect in the field of mathematics (Milama et al., 2017; Rakhmi et al., 2018; Zulnaidi et al., 2021). Additionally, Hu et al (2016) discovered a strong association between virtual reality immersion and levels of creative thinking. As a result, it was discovered that standard learning is less effective than creative learning. Additionally, Montag-Smit & Maertz Jr (2017) discovered that providing knowledge can be quite beneficial in the process of resolving conflicts. “Using working memory tasks and the procedure associated with the validation of the hypothesis under investigation”, and Pringle & Sowden (2017) demonstrated that switching between the two improves critical performance and also creative thinking (Komarudin et al., 2020; Suherman et al., 2021). Aizikovitsh-Udi & Cheng (2015) research demonstrates that model mathematics lessons enhance students' critical thinking. Currently, the primary research focuses on developing novel education forms (Dasaprawira, 2019; Hassett & Curwood, 2009). Today, the most often used method is Search, Solve, Create, and Share (SSCS), which complements traditional education (TL). Saregar et al (2018) also have been examined the effect of cognitive problem-solving on science education in their study. Although it has been established that TL causes students to become more passive, SSCS provides an excellent opportunity for skill development.

Internationally, there is a wide range of understanding and application of STEM skills (Ernst et al., 2018). When it comes to qualifications obtained in STEM subjects, the supply is relatively well defined, though the definition of STEM subjects can differ (Fitzakerley et al., 2013). Mathematics, chemistry, computer science, biology, physics, architecture, civil engineering, electricity, electronics, communication, mechanics, and chemical engineering are some of the subjects that typically receive high STEM scores (Stoet & Geary, 2018). According to a meta-analysis, men prefer to work with objects, whereas women prefer to work with other individuals (McCullough, 2011).

It is possible that women's preferences for socially oriented work are motivated by altruism, as women have greater desires than men to help others and benefit society as a whole (Panorama, 2014). STEM careers are frequently regarded as being incompatible with common goals, leading many women to avoid pursuing them. Women are more likely than men in the STEM field to choose a career path that emphasizes community service or people-oriented activities (Siry & Gorges, 2020). Women, for example, achieve higher levels of education in biomedical engineering and the environment than men do in mechanical or electrical engineering (Stoet & Geary, 2018). Evidence suggests that preferences may outweigh abilities, even among women who pursue careers in the sciences and mathematics (STEM) (Hill et al., 2010; Sagala et al., 2019). According to the findings of a study conducted by Catherine et al. at the American Association of University Women, nearly one-third of new students (29 percent) were men, with only 15 percent of female new students planning to major in STEM in 2006. (Figure 1).

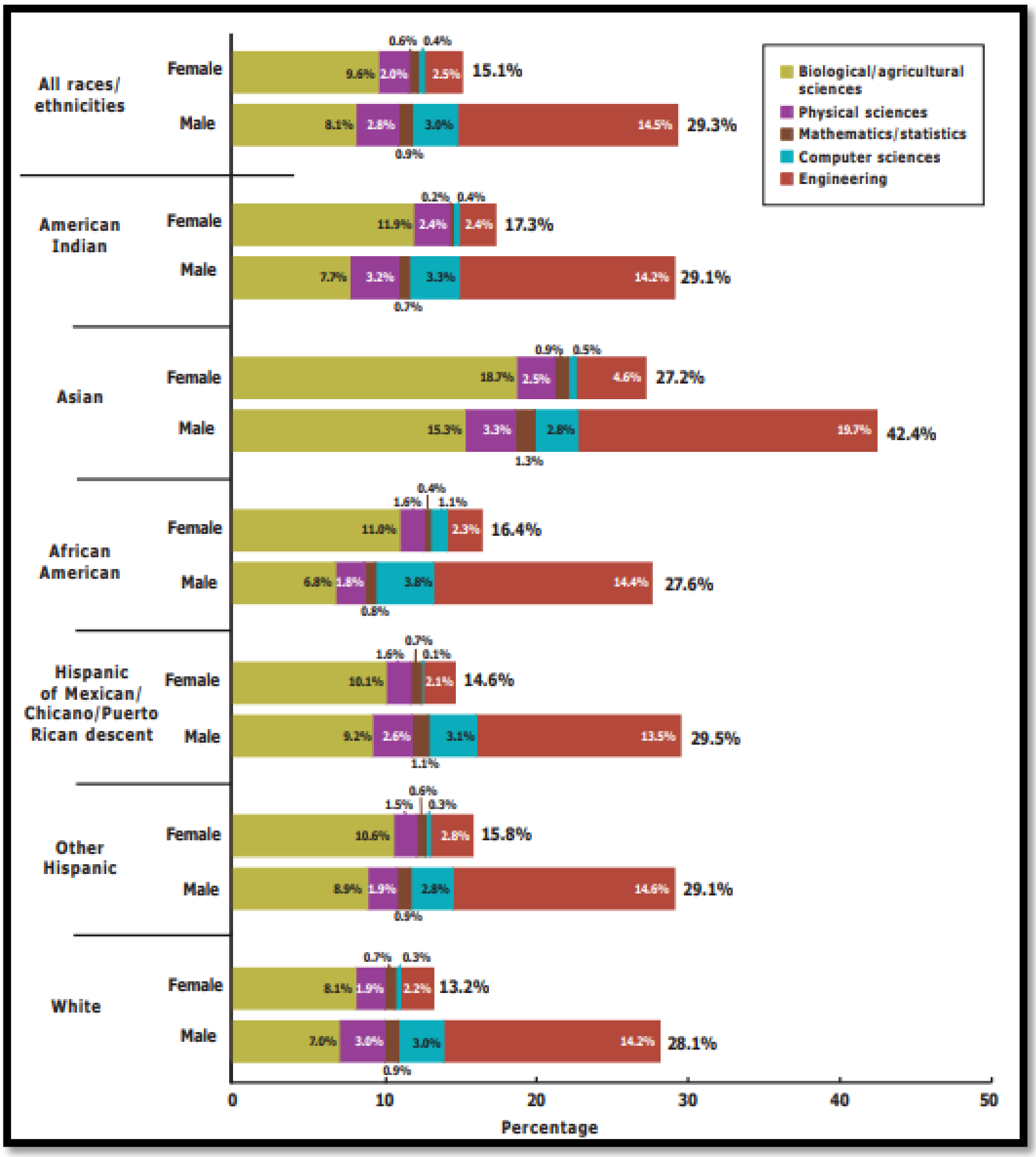

Figure 1. First-year STEM Majors by Gender and Ethnicity (Hill et al., 2010).

Figure 1 demonstrates the fact that there are several ethnic groups (American, Indian, Asian, African, American, Hispanic, and non-Hispanic). Even before compared to females, men prefer engineering, physics, mathematics, and technology. Females, on the other hand, favor biology. Essentially, all of these fields are intertwined with one another. STEM education is one of the learning solutions for integrating a number of these disciplines.

In regard to SSCS learning, this method is a rapidly growing field of research (Wahyu et al., 2019; Yusnaeni, 2017; Zulnaidi et al., 2021). With respect to the four phases of teaching and learning, the SSCS model begins with investigating the problem (search), planning the solution (solve), producing the answer (create), and ultimately conveying the solution gained (share). SSCS has also been shown to be effective in improving students' mathematics disposition, conceptual math understanding (Rakhmi et al., 2018), reasoning (Choi & Kim, 2017), learning achievement (Liao et al., 2019), math critical thinking (Milama et al., 2017), and metacognition (Fauzi et al., 2019; Siagan et al., 2019; Yusnaeni, 2017). Furthermore, the primary finding is that SSCS is beneficial throughout the training process.

The enormous impact of SSCS and STEM on creativity and critical thinking was also highlighted in the study, which examined a decline in mathematics performance. In an experiment with science students, identical results were reached (Overton & Randles, 2015). The present article examined the effectiveness between creative thinking, critical thinking, and teaching and learning as type of model. Given that both models include a creative learning step, it will be possible to determine which model has a greater influence on the ability to think creatively. On the other hand, no one has ever compared STEM and SSCS to creative and critical thinking, so this study will deliver novel findings. This study aims to strengthen students' creative and critical thinking abilities through the intentional application of the STEM approach and SSCS learning paradigm in the experimental class. While STEM learning models have been extensively investigated, they have never been applied to students' creative and critical thinking abilities.

2. Literature Review

Creative Thinking

Regarding PISA, PISA defines creative thinking as the competence to engage productively in the generation, evaluation, and improvement of ideas, resulting in original and effective solutions, advances in knowledge, and impactful expressions of imagination (OECD, 2019). Moreover, Creative thinking is a necessary competence for today’s young people to develop (Lucas & Spencer, 2017). It can help them adapt to a constantly and rapidly changing world, and one that demands flexible workers equipped with 21st century’ skills that go beyond core literacy and numeracy. Creative thinking is often described in divergent thinking terms, and most creative thinking assessments have focused on measuring divergent thinking cognitive processes. However, the literature clearly highlights that convergent thinking cognitive processes, such as analytical and evaluative skills, are also important for creative production (Reiter-Palmon & Robinson, 2009; Tanggaard & Glaveanu, 2014).

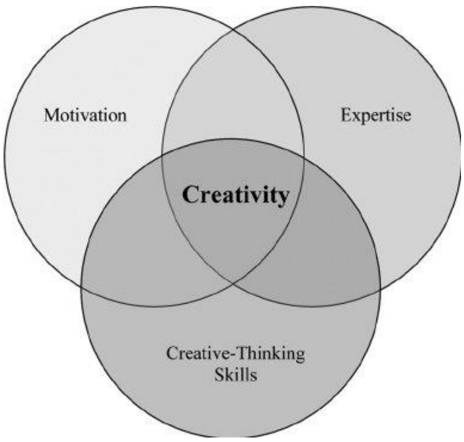

Figure 2. The Creativity Competencies (Zhu et al., 2011)

The occurrence of creative ideas is difficult to predict, but there are three critical components that have been identified as being closely associated with human creativity. As depicted in Figure 2, these three components are (1) expertise, (2) creative-thinking skills, and (3) motivation, with expertise being the most important.

Critical Thinking

Education in the 21st century gives much more emphasis on gaining skills to learn. Education must also aim at the development of a generation of people who will be able to acquire knowledge and skills. People in the field of education have become aware of the need to modify or reconstruct the education systems to develop requisite knowledge, skills, and dispositions necessary to satisfy the need for 21st century. This condition makes people have a highly capable skill to come up with the rapid development of skills. Learning and thinking are some of the skills needed in this era. This term has been defined in many ways (Bers et al., 2014), it includes four competencies critical thinking, creative thinking, collaboration, and communication (Bekteshi, 2017). Thus, conduct those skills, creative thinking at least as important to success in life as are memory and analytical skills (Sternberg, 2003), and new ways in which of considering and resolution issues (Barak & Doppelt, 2000a). The indicator of creative thinking was fluency, flexibility, originality, and elaboration (Suherman et al., 2021; Suherman & Vidákovich, 2022)

Critical thinking is the capacity to think abstractly through the process of analyzing and evaluating information received or in problem solving (Lucas & Spencer, 2017), or the definition of critical thinking is thinking to ascertain the truth of information received or in problem solving (Montag-Smit & Maertz Jr, 2017); critical thinking is calm (Alper, 2010); avoid becoming emotional (Salavera et al., 2017); put logic first (Chai, 2019); understand the problem; analyze and evaluate the results; then make a decision or take action (Suherman et al., 2020).

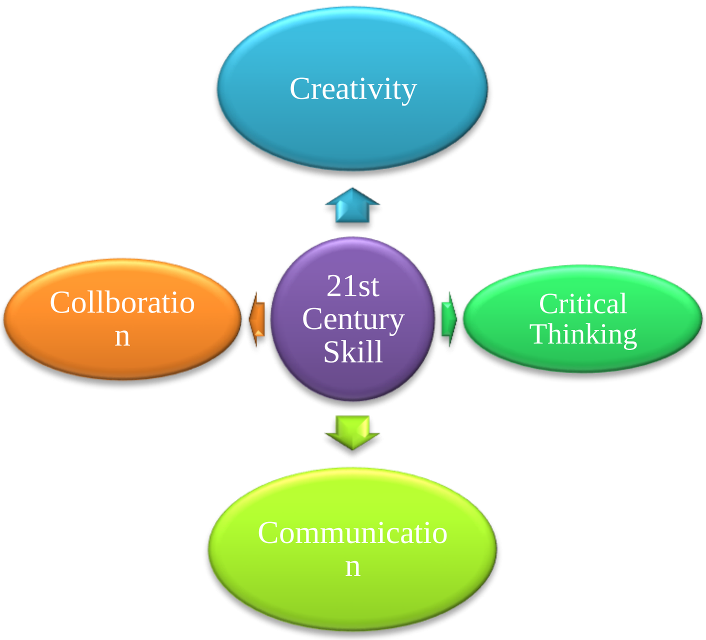

Figure 3. Critical Thinking as Parrt of 21st Century Skill

Critical thinking is a type of higher order thinking that can be used to assist students in developing their conceptual systems, investigate how others think. According to John Dewey, schools must teach students how to think correctly. Then he defines critical thinking as "active, persistent, and careful examination of a belief or any form of knowledge obtained from a variety of perspectives of reasons that support and conclude it." (Williams, 2017). Additionaly, the indicator of critical thinking in this research as followed.

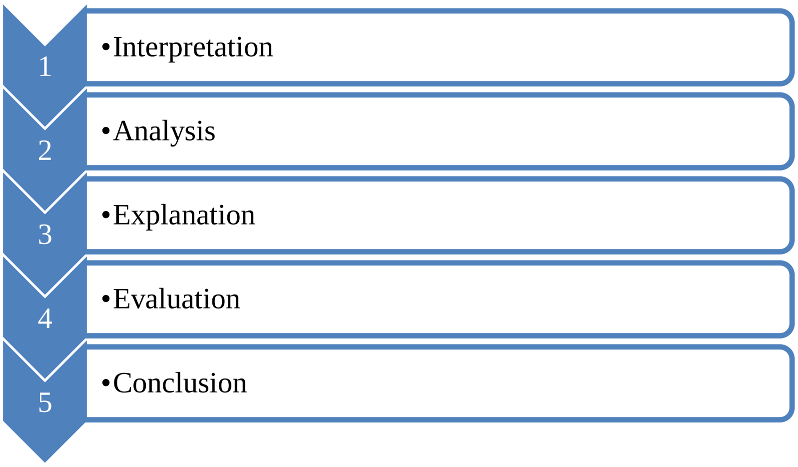

Figure 4. The Indicator of Critical Thinking (Khasanah et al., 2017)

STEM Approach

An interdisciplinary approach to education that integrates rigorous academic concepts with real-world applications is known as STEM (science, technology, engineering, and mathematics) (Force, 2014). Students' learning is enhanced when two or more STEM domains are taught in a single STEM class (Kelley & Knowles, 2016). Because of this, STEM encourages knowledge construction by engaging students in technology- and engineering-based learning opportunities. By using investigation and the resolution of real-world problems, this approach encourages students to inquire about and explore their surroundings (Acar et al., 2018).

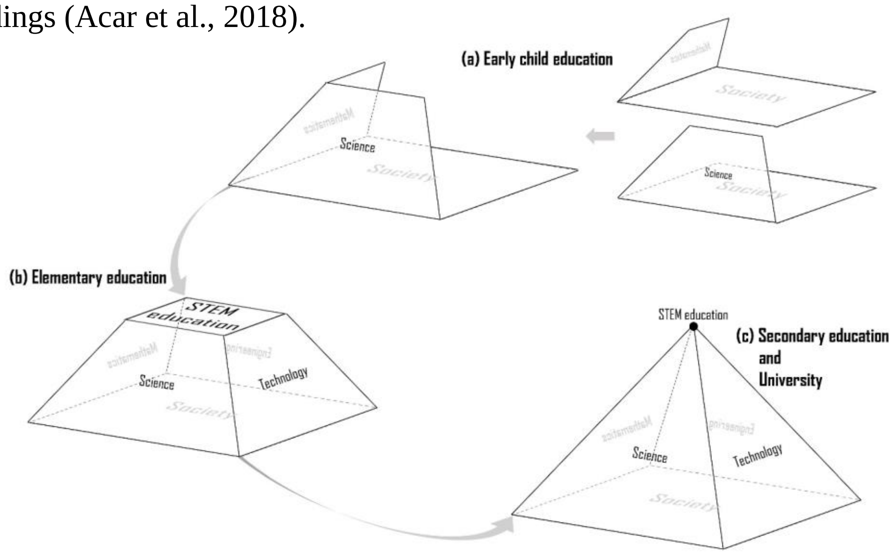

Figure 5. The Disciplinary Integration Consensus in STEM Education (Aguilera et al., 2021)

It is possible to define the embedded STEM approach as a method of acquiring domain knowledge that strongly emphasizes real-world scenarios and problem-solving techniques. To ensure that the subject's integrity is maintained, one of the material contents is given precedence over another (Brezovnik, 2015). Integrated STEM approaches are the other option available. A common goal of the integrated approach is to eliminate distinctions between STEM content areas and their associated teaching and learning activities, in this case by treating them as if they were one single subject. Taking an integrated approach is expected to spark greater interest in STEM fields, particularly if it begins earlier in a child's life. In the secondary school, STEM approach is a best suject. As pay attantion that the STEM in the top subject than other subject.

Roberts and Cantu developed three distinct approaches to STEM learning for educators: the silo approach, the embedded approach, and the integrated approach (Winarni et al., 2016). Due to the possibility of a lack of student interest in one of the STEM fields, silo learning tends to diminish the expected benefits of STEM learning. Women, for example, are less interested in engineering fields such as civil engineering, mechanical engineering, and electrical engineering, according to research findings. Without practice, students may struggle to grasp the natural integration between STEM lessons and the real world, impeding their academic growth (Canning et al., 2019; Davies et al., 2013). This occurs because the silo approach encourages teachers to rely on lecture-based methods rather than practice, despite the study's findings indicating that students prefer practical activities for learning (Erdogan et al., 2016; Han et al., 2016). The silo approach places a premium on material content. This can limit cross-curricular stimulation and students' comprehension of the relevance of what they are learning.

The Search, Solve, Create, and Share (SSCS) Learning Model

The SSCS model is a problem-solving approach that is intended to improve critical thinking abilities and comprehension of scientific concepts (Yasin & Fakhri, 2020). Students investigate something, generating interest in asking questions and solving real problems through the Search, Solve, Create, and Share model.

This model contains four stages or phases. Other concepts that simplify and identify and develop researchable questions or problems in science are included in the Search phase. The solve phase focuses on the specific problem defined in the search phase and requires students to develop and implement a plan to solve it. During the solve phase, students reorganize the concepts acquired during the search phase into "high order" concepts that identify possible solutions to the problem and the desired answer. Students must create a product related to the problem, compare the data to the problem, make generalizations, and modify it if necessary. The share phase's fundamental tenet is to engage students in communicating solutions to problems or responses to questions.

3. Method

Participant

This study used paperwork and assessments to collect data from 65 students in experiment class I and 60 students in experiment class II at a private school in Bandar Lampung, Indonesia, with ranged age of 12-13 years old. Apart from these constraints, the sample of students was drawn at random from a secondary school in Bandar Lampung (Indonesia). A random drawing was used among the secondary school instructors in Bandar Lampung to choose the students, who were then picked by consensus among the participants. Notably, we do not consider respondents' gender or social status, as these variables have no discernible impact on the study's outcome.

Table 1.
The Demographic Profile of The Participnt in This Research

Demographic		**Frequency**	**Percentage (%)**
Gender	Girls	78	62.40
	Boys	47	37.60
Ethnicity	Lampung	35	28
	Jawa	70	56
	Sunda	6	4.8
	Batak	4	3.2
	Others	10	8

Note: N = 125 (M = 12.46, SD = .89)

Research Model

This study employed a quasi-experimental design, which included two experimental and control classes. The experimental class I will be taught using the SSCS model based on the K-13 Indonesian Curriculum, whereas the experimental II class will be taught using a STEM approach. A Posttest-Pretest Control Group Design will be used for the investigation. The research methodology is as follows:

Figure 6. The Learning Steps for STEM

The experiment I group used a SSCS learning model. The experienced group's teaching processes are depicted in Figure 7.

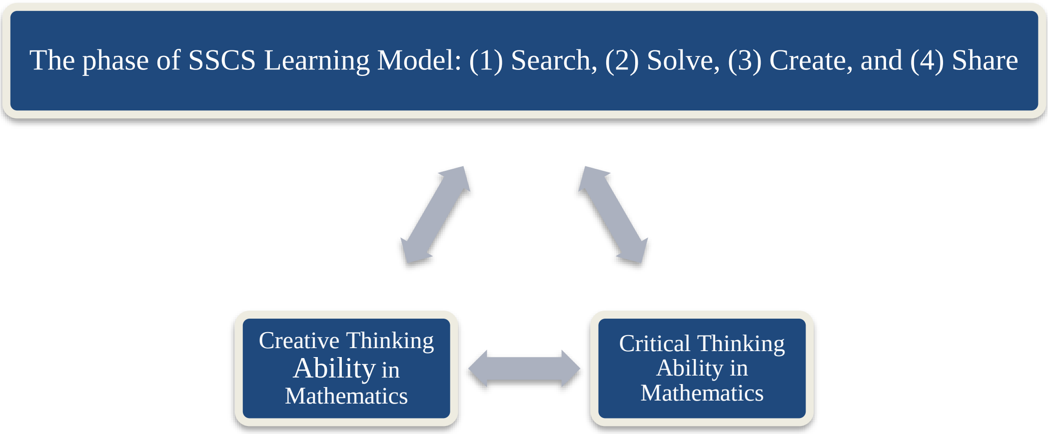

Figure 7. Design of an Experimental I Study. Adapted by Yasin & Fakhri (2020)

Based on Figure 6, the syntax of the STEM approach on students' mathematics creative and critical thinking abilities are explained in Table 2.

Tabel 2.
The STEM Approach based on the K-13 Curriculum

Syntax	**Teachers' Role**	**Students' Role**
Observe	Delivering instructional objectives in new topics and new issues.	- Observing several information using media platform. - Addressing the issues raised by informations by group.
New Idea	Encourage students to organize idea.	- Each group give an idea based-observe and interpretation of the data in light of the new issues.
Innovation	The teacher asks to describe what things must be done so that the ideas that have been generated in the previous new idea step can be applied	- Students describe the resulting ideas so that they become something new - The idea is realistic to apply - Describe the advantages of the idea with the previous idea or product
Creativity	The teacher asks students to express their ideas by drawing or making projects according to the ideas that have innovation value that have been discussed previously so that they become a picture of a science product.	- Students can apply it in the form of miniatures or sketches and drawings. The resulting drawing or sketch should be described in its entirety from various positions and as creatively as possible, especially in the part where the innovation idea is, whether it is front, side, or top view.
Society	The teacher asks students to carry out two activities, namely collecting public views on product ideas through surveys and then analyzing them.	- Students are looking for feedback about their products, whether this product can be useful and whether it can be useful for the community. - Students will present their products and the results of their analysis of product innovations to all students in front of the class.

Note: The syntax based on Indonesian K-13 Curriculum

According to Figure 7, the purpose of this study is to investigate the effect of using the SSCS learning model on students' mathematics creative and critical thinking abilities (Kuswanto, 2018) From the K-13 curriculum, these steps are explained in Table 3.

Table 3.
The SSCS Learning Model's Screenplay based on the K-13 Curriculum

Syntax	Teachers' Role	Students' Role
Search	Delivering instructional objectives and helping students in comprehending topics and resolving issues.	- Observing several difficulties that both the student and the teacher exhibit - Addressing the issues raised by challenges
Solve	Encourage students to organize and carry out problem-solving activities by identifying, gathering, and analyzing feasible alternatives.	- Grouping the group by the teachers suggestion and the teachers have separated the students into groups. - Each group evaluates and interpretation of the data gathered in light of the issues at hand.
Creat	Orienting pupils in the process of describing, designing, or creating in order for them to express the outcomes and conclusions of their investigations.	- Observing the teacher's communication and responding appropriately to the incentive conveyed - Each group meets to brainstorm answers to a variety of circumstances provided by the teacher. - Each group will present their proposed solutions.
Share	Assisting pupils in presenting their findings to their friends and clarifying any responses that remain confused during the presentation.	- Each group responds appropriately to the teacher's problem-solving instructions.

Note: The syntax based on Indonesian K-13 Curriculum

Research Procedures

The study's data collection techniques included documentation and testing. The research instrument included both a test of creative thinking ability and a test of critical thinking capacity. An initial precondition test is carried out on the findings of the students' mathematical creativity and critical thinking abilities in each treatment class before the hypothesis is evaluated in more detail.

The inclusion criteria for this study of subjects were boys and girls between the ages of 12 and 13 who have been diagnosed with first test. The test is to know that the class was normality and homogeneity. An exclusion criterion for this study might be does not have that is because this research was in social science research generally. Within these communities everyone would be eligible to participate. For the ethical aspects and permissions, we are start any study involving data collection with students', then our research and data is based on the institutional review board (IRB). Then, the data collection permitions was gave by school.

This study used a quasi-experimental posttest design. The most recent experiment included a posttest of critical and creative thinking ability, followed by a teaching experiment. Following the experiment, a posttest was administered to assess critical and creative ability as well as thinking output. The researcher assigned SSCS and STEM activities to the experimental group three days a week between August 23rd to September 27th, based on the results of posttets for critical and creative skills administered to both the experimental groups.

The technique was implemented through the use of group activities. Among the small group activities in which children can participate when they are separated by age, developmental stage, interests, and abilities are those in which they design and market a variety of products to their peers (Huda et al., 2019; Yasin et al., 2020). Numerous studies have demonstrated that small group activities with children are more efficient and effective than one-on-one training with infants and toddlers (Suherman et al., 2021)

The activities resumed after the break at approximately 90.30 a.m. Each activity was scheduled for approximately 60 to 90 minutes. Before the activities began, a vigorous play activity was conducted to help students release pent-up energy. After completing the 4-week STEM activities in the experimental II and SSCS in the experimental I groups, students' critical and creative thinking abilities were assessed, and the results were compared between the two groups. To ensure the students' comfort, the scale applications were conducted one-on-one in the teachers' room of the school. Each scale took approximately 20-25 minutes to implement. The applications were carried out in four-person small group activities utilizing the design thinking model, STEM, and SSCS. When deciding on the small groups, it was critical to strike a balance in terms of age, developmental stage, interests, and abilities. In this manner, students have been given the opportunity to achieve the same results in a variety of ways (Henriksen et al., 2016).

Instrument

The background test was adapted from the Indonesian curriculum (Kementerian Pendidikan dan Kebudayaan, 2014). The test was embedded in the developed diagnostic test body in the paper-based format. To identify students' creative thinking and critical thinking skills, 5 items were developed based on the material. The material was geometry problem-solving and the selected concepts material had been adjusted according to Indonesian education curriculum, the Curriculum 2013, especially on the upper secondary school level. Two of five selected concepts among the creative and critical thinking skills were shown in Table 4.

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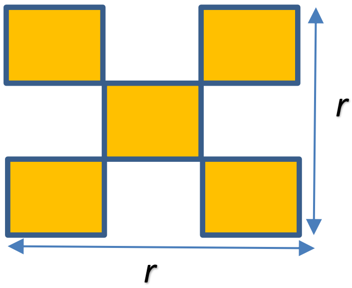
Table 4.
Sample Task in Creative and Critical Thinking

Creative Thinking	See the picture below. Express the perimeter and area of the following shapes in algebraic form! 
Critical Thinking	Create at least two questions about rectangles. Show me how you created the solution!

Note: The task is two of five sample.

Based on the test analysis, the relibiality test both of creative and critical thinking was 0.82 and 0.79, respectively. In other words, the Cronbach's Alpha were 0.80 for creative thinking and 0.86 for critical thinking. That is the test was suitable for measuring creative and critical thinking abilities.

Data Analysis

With a significant threshold of 5 percent, the Kolmogorov Smirnov normality and homogeneity tests were used using SPSS 25.0 as precondition tests before the main analyses could begin. Assume that the test results are normally distributed and that they are derived from the same or homogeneous variance areas in the population. In that case, the Multivariate Analysis of Variance (MANOVA) test can be used to test statistical hypotheses.

3. Results

Testing of students' creative and critical thinking abilities in both the experimental class (the class that benefited from SSCS training) and the control class yielded the findings of this study (The class applying the TL model). This is a summary of the findings from the assessment weekly test, which are included in Table 5:

Table 5.
Weekly Assessment of the Experimental and Control Groups

Number of tasks	Teaching Methods	Weekly Test			
		week 1	week 2	week 3	week 4
1	STEM	46.60	49.72	50.66	71.70
2		50.60	49.66	52.65	70.68
3		41.75	44.88	53.65	72.85
4		52.65	52.95	53.60	73.90
5		50.77	51.65	54.65	74.60
1	SSCS	42.67	47.60	50.70	66.70
2		41.65	48.67	51.78	65.65
3		43.80	49.90	52.60	64.90
4		43.70	50.80	50.65	65.70
5		47.70	48.70	51.72	62.75

Note: The value was outcomes for experimental and control classes.

As a result, Tables 5 summarize the assessment outcomes for the control and experimental groups. Additionally, the table contains the average of the students' grades. The students obtained the highest and lowest scores for task 3 and task 4 during the first week of the trial, respectively, when the STEM learning model was used. The maximum and lowest scores for tasks 5 and 2 and task 1 and task 2 were determined during the third and fourth weeks of the study. When comparing the control group to the group that used the SSCS learning model, the largest significant result occurred in week 4. On the other hand, the minimum scores were announced during week one of the competition. Table 2 summarizes the outcomes of the control group's assessment. Between weeks 1 and 4, we calculated the maximum and minimum values for a variety of tasks. In week 1, task 5 and task 2 were used to determine the top and lowest task 1 scores. In week 4, the greatest and lowest scores for task 1 and task 5 were calculated.

The resulst of the creative thinking ability test and the resulting critical thinking abilities are following:

Table 6.
The Results of a Data Analysis on the Mathematical Creative Thinking Test Results

Value	X_{max}	X_{min}	Central Tendency Size			Size of Group Variance	
			$\bar{x}$	M_e	M_o	R	Sd
STEM	76.29	57.95	66.67	63.97	64.14	18.34	24.27
SSCS	48.25	26.40	35.94	33.77	34.65	21.84	18.41

Note: The data was statistical distributive.

According to Table 6, the STEM approach learning model's experimental class I demonstrated superior post-test mathematical creative thinking abilities over the SSCS class. This is demonstrated by the fact that the average value ($\bar{x}$) was 66.67, the mode value (M_o) was 64.14, and the range was 18.34. Considering the large range of the SSCS class, “it will produce a statistically significant variance value of 24.27 when compared to other classes". These data reveal that, when compared to the STEM and SSCS learning model, the STEM learning model has a significant difference between its highest and lowest values. According to the findings, students with low creative thinking abilities continue to struggle even when the SSCS learning approach is implemented.

Table 7.
The Results of a Data Analysis on the Mathematical Critical Thinking Test Results

Value	X_{max}	X_{min}	**Central Tendency Size**			**Size of Group Variance**	
			$\bar{x}$	M_e	M_o	**R**	**Sd**
STEM	79.23	50.00	65.28	65.38	67.31	29.23	6.86
SSCS	51.28	22.47	35.67	33.65	39.10	28.81	8.35

Note: The data was statistical distributive.

As shown in Table 7, the STEM approach learning model's experimental class I outperforms the experimental class II using the SSCS learning model in terms of post-test results for critical thinking skills. The average value demonstrates this ($\bar{x}$) of 65.28, the value that frequently appears (M_o), which is 67.31, but results in a high variance of 6.86 and a maximum range of 29.23. The conclusion is that when compared to the findings of the control class post-test, the experimental class post-test results appear fairly good.

Then a multivariate analysis will be performed to see how the learning model affects students' mathematical creative thinking skills and mathematical critical thinking skills. The null hypothesis in this study was that applying the STEM approach learning model has effect on creative mathematical thinking and mathematical critical thinking. The following table summarizes the findings of the Multivariate test:

Table 8.
Results of multivariate testing on the obtained samples

The MANOVA Hypothesis		**Value**	***F***	**Sig.**	**η²**
SSCS and STEM Learning Model	Wilks' Lambda	.060	134.75	.000	.35

Note: Compute using alpha .05.

Based on Table 8, the findings of the "Wilks' Lambda Test" analysis for mathematics creative and critical thinking ability in both STEM and SSCE. The results indicate there was a statistically significant difference in creative and critical thinking ability based on a teaching model, $F(2, 123) = 134.75$, $p < .0005$; Wilk's $\Lambda = 0.060$, partial $\eta^2 = .35$. Consequently, H_o(The STEM has effect on creative and critical thinking) was accepted as a result of this demonstration, the use of the STEM approach learning model has been shown to have an impact than SSCS on mathematical creativity and critical thinking skills.

4. Discussion

The findings of this study have been determined to be consistent with the research hypothesis. Due to the fact that STEM-based education utilizes information technology, students' creative and critical thinking abilities are enhanced. In this context, information technology refers to the use of computers that have achieved notable feats (D'silva, 2007). To guide students through the problem-solving process, technology should be used in conjunction with a combination of mathematical thinking patterns and techniques that generate new ideas.

STEM education can heighten students' sensitivity to real-world problems and prepare them to provide a variety of justifiable answers or solutions for a variety of phenomena that occur in their daily lives and are related to their ability to think metaphorically. Due to the scarcity of resources available for information retrieval. As a result of their STEM education, students' creative and critical thinking abilities have improved.

According to the post-test results, the experimental class's capacity to think creatively and critically, the results indicate that there is a relationship between the ability to think creatively and critically. As demonstrated by the fact that pupils' high scores on creative thinking tests correlate with high scores on critical thinking tests. Regarding the results of the analysis above, STEM learning can stimulate the thinking process to develop thinking abilities and is beneficial for honing students' ideas or thoughts in creative and critical thinking following treatment in each sample class. Students' influence and interest demonstrated a positive attitude toward mathematics education. Learning can drive students to think critically and imaginatively about challenges, facilitate active learning through experimental learning, and enable students to create responses that are not unique to the problems presented.

In contrast, the purpose of incorporating prism and pyramid information into the learning process in the control class is to direct students' attention to previously studied material. Students are just required to listen to the researcher and take notes on what they say. The control class's learning activities have been going well; it can be noticed that some students are actively asking questions while the researcher delivers the content. However, several pupils did not pay attention, conversed, dozed off, or copied the results of their classmates' assignments. After the learning material is completed, the class operates similarly to an experimental class in that the researcher administers post-test questions to ascertain the students' creative and critical thinking abilities.

The findings reveal that STEM has the edge over SSCS and that STEM fosters student innovation. Additionally, the study's second week revealed the greatest disparities between the samples. The research findings are congruent with those of the majority of previous studies in this field. Suherman et al. (2021) and Han et al. (2016) discovered that STEM greatly enhances students' creativity as well as critical thinking skills. Additionally, the learning method had a beneficial effect on pupils' learning ability. While, Zulnaidi et al (2021) discovered that when students learned SSCS, their self-efficacy increased and problem-solving skills. Additionally, participants indicated that this strategy is significantly more effective and more reflective of real-world settings than standard educational methods. According to the steps for developing critical and creative thinking through STEM approach learning (Acar et al., 2018), there are stages of idea generation and creativity. These stages include analyzing the teacher's questions and gathering information from classmates before discussing and solving the problems presented in the lesson plan. It is possible to improve critical and creative thinking by going through the process of generating new ideas and being creative without the use of media in case of SSCS learning. STEM refers to the stage of media use that provides students with new learning experiences as a result of their critical and creative thinking being improved (Holmlund et al., 2018). Numerous studies have proved STEM beneficial effect on creative and critical thinking (Hanfy et al., 2022; Utami et al., 2021). In other words, some studies have shown that STEM also supports students' cognitive because in STEM learning, students are also encouraged to be actively involved in groups to solve a problem and they are required to think critically (Retnowati & Subanti, 2020). Moreover, suggest that the activities done in learning are oriented to ensure students' active participation to stimulate their creative and critical thinking skills (Bulu & Tanggur, 2021). Corrigan et al. (2021) state that such practical realities also necessitate that teachers consider pedagogical approaches and behaviors, such as standing back with a clear pedagogical purpose, using questions to prompt student thought, and actively valuing student ideas, as essential aspects of teaching practice for fostering student critical and creative thinking.

Although Yasin & Fakhri (2020) presents the application of SSCS during learning can develop in pupils the ability to be oneself (self-regulating) and to compete independently. It should be emphasized that the study also provides a favorable assessment of the procedure under examination in the STEM learning. It is critical to remember that creativity is an abstract term that is impossible to quantify objectively at this point of research. Thus, Sternberg (2019) describes creativity as a novel, surprising, and alluring event. However, this statement is incomplete, as creativity is a subjective concept in this circumstance. When conducting our research, we repeatedly tried to cognitive processing creativity by drawing upon the vast amount of cognitive experience that the teachers who investigated the compositions possessed. Extensive contractual research into exceptionally creative people, particularly in mathematics, has revealed the limitations of psychometric scaling methodologies in analyzing this phenomenon. This study used "a peer review process to examine the final manifestations of creativity, in this case, generated artistic minds (Barrett & Limb, 2019).

5. Limitation and Future Research

There are a number of limitations to the teaching model implemented in this study. Not all scientific concepts studied in Indonesia were utilized to develop the products. Therefore, additional research is required to identify new creative and critical thinking concepts for situations where students find it difficult to comprehend and demonstrate creative and critical thinking. The fact that the participants were drawn from a small population in the province of Lampung and attended only public schools may be a limitation of this study. Some of the results in the educational context could not be generalized, it was realized. In-depth exploration of how creative and critical thinking become aspects to be assessment criteria and how to influence of other factors would be very helpful. Further research might compare, for example, intervention class with other material and other affective factor in same strategies in the STEM classroom.

6. Conclusion

The study's framework included comparing students' creativity and critical thinking levels concerning their learning technique (STEM and SSCS). The analysis and discussion in this study indicate that the adoption of the STEM approach learning model affects students' mathematics creative and critical thinking abilities. It should be emphasized that the objectivity of the results obtained in this example was somewhat warped, as prisms and pyramids as stimuli may only be evaluated using a limited number of objective criteria. In light of the ambiguous nature of uniqueness as an assessment criterion, the only justification for this research methods is the teachers' own personal perspective and awareness of the subject matter.

Future models of the lesson will delve deeper into creativity and critical thinking concepts. It is expected, in particular, that objective criteria will be discovered that will indicate the level of originality of the work indirectly, and that these criteria will be validated. Also planned is an increase in the sample size and the number of participants to produce a more accurate result.

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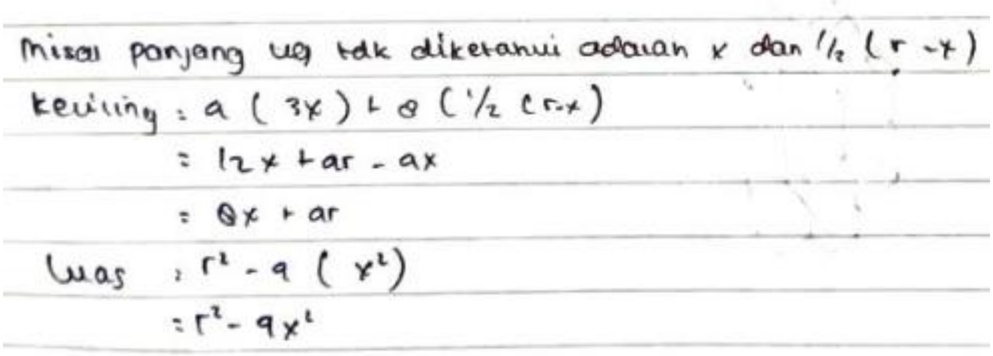
Appedix

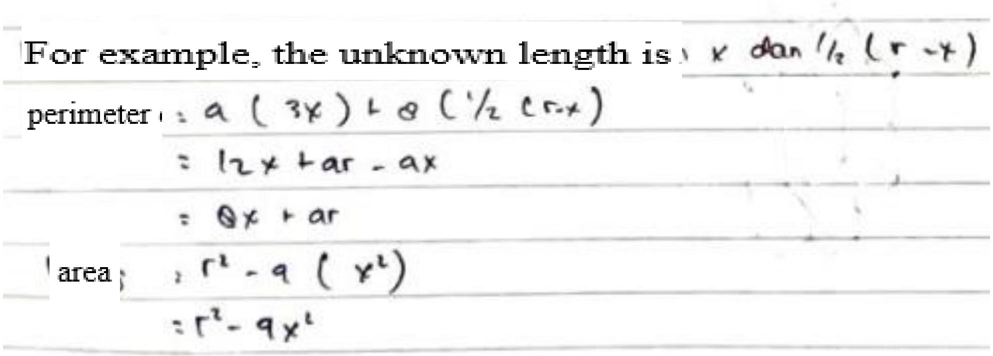
STEM Class

1. Example answer from students' in STEM Classroom for question no.1

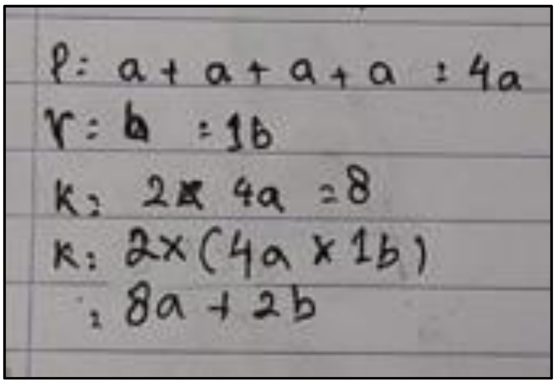
Indonesian version


misal panjang yg tdk diketahui adalah x dan 1/2 (r - x)
keliling : a (3x) + 8 (1/2 (r-x))
: 12x + ar - ax
: 8x + ar
luas : r² - 9 (x²)
: r² - 9x²

English version

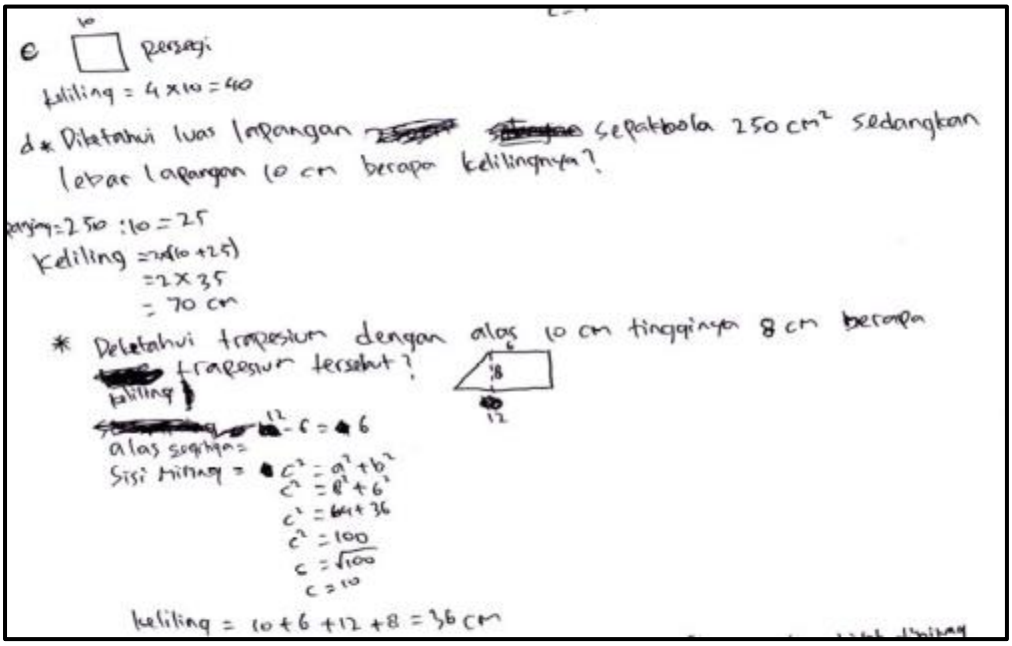

For example, the unknown length is x dan 1/2 (r - x)
perimeter : a (3x) + 8 (1/2 (r-x))
: 12x + ar - ax
: 8x + ar
area : r² - 9 (x²)
: r² - 9x²

2. Example answer from students' in SSCS Classroom for question no.1


P : a + a + a + a : 4a
r : b : 1b
K : 2x 4a : 8
K : 2x (4a x 1b)
: 8a + 2b

DOI: http://dx.doi.org/10.6018/red.507701

3. Example answer from students' in STEM Classroom for question no.2



4. Example answer from students' in SSCS Classroom for question no.2