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Innovation: Improvement Of Chemistry Education Students' Critical Thinking And Communication Skills Through STEM-Based REAKSI Learning Model

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Abstract:

Learning materials that are macroscopic, sub-macroscopic, and symbolic are often problematic for students. To help students understand, critical thinking and communication skills in learning are required. As such, one of the needed learning models that is able to encourage students' skills is a learning model based on the STEM approach. The related solution is the REAKSI learning model. REAKSI is an acronym for Formulation of the Problem (R), Exploration (E), Analysis (A), Classification (K), Synthetic (S), and Implementation (I). This model integrates the components of the STEM approach. The present study aims to examine the effectiveness of the REAKSI learning model to improve students' critical thinking and communication skills. The research type is a Lesson Study. The sample involved 37 chemistry students of Riau University, 20 students from the State Islamic University of Sultan Syarif Kasim Riau, and 4 students from the Islamic University of Riau through a purposive sampling technique. Data were collected through the critical thinking skill test and communication observation using the Likert Scale questionnaire. The data analysis of the REAKSI learning model based on the STEM approach effectively increases the students' critical thinking and communication skills with percentages of 90% and 89% with a high category. Critical thinking and communication skills, in addition, are related to each other with the Pearson correlation test result of 0.013 < 0.05. That effectiveness was obtained since the REAKSI learning model provided steps that led students to perpetrate their critical thinking and communication skills in learning.

Keywords: *Critical Thinking, Communication, Effectiveness, REAKSI*

INTRODUCTION

Critical thinking and communication skills are two essential skills that should be developed earlier in life to prepare students for the changing times, especially in the 21st century (Makhrus, 2018). Critical thinking skills as one of the 21st-century skills can be evolved through education. Critical thinking is a comprehensive discerning to do better reasoning (Hughes and Lavery, 2014). Mulnix (2012) argued that critical thinking consists of acquiring, developing, and processing skills to understand the conclusion within a statement. A critical thinker is able to analyse and evaluate any information (Nuryanti et al, 2018). Various education research results reveal that critical thinking is able to prepare students to think in numerous disciplines and their careers in real life (Zubaidah, 2010).

In addition, in learning, students still find it difficult to work in groups, communicate, and solve problems and have not been able to make the right decision as a solution to a problem. Communication skills are skills that students must possess to link concepts, explicate opinions, ask questions, and make questions (Wulandari, 2016). Communication skills are essential to convey new information, ideas, or knowledge in spoken and written language (Nathalia, 2019). Communication, according to Barelson and Steiner, is the

process of delivering information, ideas, feelings, abilities, and others through symbols like words, pictures, numbers, and others (Suryanto, 2015).

Chemistry lessons are expected to provide as much knowledge as possible besides stimulating students' thinking, scientific and creative behaviour, and responsibility for daily events relevant to chemistry lessons. The students' low interest in Chemistry subjects is influenced by many factors. The unlikability between macroscopic, microscopic, and symbolic makes it difficult for students to understand chemistry, thus their interest is low (Talanquer, 2011). The uninteresting and irrelevant lessons to their lives, in addition, result in an assumption that chemistry is not related and useful for their lives (Afshar & Han, 2014).

Facts discovered from several Chemistry Education Study Programs reveal that teaching and learning styles still used the recalling and understanding methods that only focused on learning memorisation during the learning process. The learning process has not yet reflected the empowerment of students' critical thinking skills. Therefore, educators should apply a teaching model that makes students engaged actively and communicative (Puspitarini & Hanif, 2019). One of the learning models is the REAKSI learning model based on STEM (*Science, Technology, Engineering, and Mathematics*) wherein the STEM approach is immensely valuable and beneficial. It is not only due to the cognitive aspect but also develops students' creativity in order to face the era (Arsy & Syamsulrizal, 2021).

The developed REAKSI learning model is based on the STEM approach component. The component of STEM familiarises students with identifying questions and problems in life, investigating natural phenomena, designing, and drawing conclusions based on the evidence regarding the acquired issues (Bybee, 2013). Learning integration using the STEM approach begins with the identification of real-life problems by using higher-order thinking and problem-solving skills to face any problems and situations (Sumartati, 2020). STEM has a real-world fit and is able to create cohesive and active learning for students in order to unify the abstract concept of every aspect of problem-solving (Torlakson, 2014). All components and characteristics of STEM are outlined in Formulation, Exploration, Analysis, Classification, Synthetise, and Implementation (REAKSI).

A relevant study conducted by Santoso & Arif (2021) integrated STEM learning with the inquiry model to increase students' critical thinking skills with a result of 51,93% before the experiment. Research conducted by Aykan & Yıldırım (2021) regarding educators' and learners' views on Lesson Study integrated with STEM reveals that Lesson Study, which is integrated with STEM in the form of planning and teaching, can produce a quality outcome. Other studies on the effect of the STEM approach on students' critical thinking skills have been conducted such as the integration of project-based learning with STEM on critical thinking (Gandi et al., 2021) and the effectiveness of the learning model of PjBL-STEM vs non-STEM on students' critical and creative thinking (Dywan & Airlanda, 2020). Another research is the implementation of project-based models which is proven to develop students' communication skills, either in verbal or non-verbal communication (Wajdi, 2017).

The integration of numerous learning models, which specifically refer to chemistry education students' critical thinking skills, has not been conducted yet. The whole learning model has initial characteristics before being integrated with the STEM approach. More intensive and structured interventions, as such, are required in order to give students a direct experience in the innovation practices

of their knowledge and skill based on their chemistry education background. REAKSI learning model, which consists of Formulation of the Problem (R), Exploration (E), Analysis (A), Clarification (K), Synthetise (S), and Implementation (I), is thereby proposed to apply in higher education through the present study based on the STEM approach on chemistry education students' critical thinking and communication skills. The formulation of research problems consists of:

1. How does the REAKSI learning model based on the STEM approach improve chemistry education students' critical and communication skills?
2. What is the correlation between chemistry education students' critical thinking and communication skills?

METHODS

Research method used in the present study is classroom action research based on lesson study, which refers to Kemmis and Mc Taggart's design, in order to achieve the research result improvement (Paizaluddin & Ermalinda, 2016). The three main research stages are plan, do, and see (Rerung et al., 2017). The research design can be described in Figure 1.

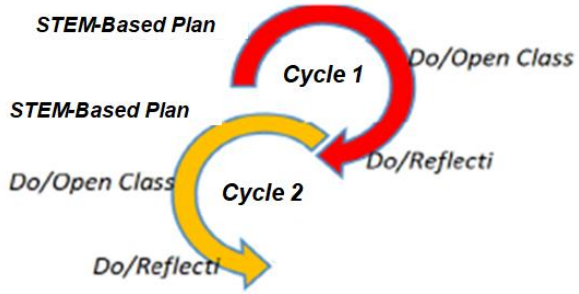

Figure 1. Research Design Using Lesson Study

This research sample is 61 students. It consists of 37 chemistry education students from Riau University with the Hydrocarbon learning material, 20 students from the State Islamic University of Sultan Syarif Kasim Riau with the Chromatography learning material, 4 from the Islamic University of Riau with the Complex Compound learning material. The researchers determine the sample class using a purposive sampling technique.

Research data is the test results of students' critical thinking skills and observation of their communication skills. The improvement of critical thinking skills was acquired through the tests conducted in each cycle with the instrument of essay questions. The indicators of critical thinking essay items are to provide simple explanations, build basic skills, conclude, provide further explanations, and develop strategies and tactics (Ennis 2011). The indicators of communication skills consist of verbal communication, dialogue, selecting information, understanding the meaning of media and effective communication (Greenstein, 2012). After collecting data, the analysis of quantitative-descriptive research is to describe the data based on the facts and circumstances. The conclusive analysis is to convert the data of 21st-century skill tests, which can be described with the effectiveness of Table Indicator 1 as follows:

Table 1. Indicator of the REAKSI Learning Model Effectiveness (Widoyoko, 2012)

% Students' Test Result of 21st-Century Skills (p)	Effectiveness
$0 \leq p < 41$	Very Low
$41 \leq p < 56$	Low
$56 \leq p < 66$	Medium
$66 \leq p < 80$	High
$80 \leq p < 100$	Very High

In terms of determining the correlation between chemistry education students' critical thinking and communication skills, the Pearson Correlation test with Software SPSS v23 is used with a significance level of 5%.

RESULTS AND DISCUSSION

1. Improvement of Students' Critical Thinking and Communication Skills Using STEM-Based REAKSI Learning Model

Before applying Cycle 1, the Plan stage should be conducted. The activities that should be carried out in the Plan stage are to discuss the REAKSI learning model based on STEM with the teaching team, prepare devices and material mastery, and provide in-depth material linkages based on real-life problems. Designing the project plan is to be innovative for the students in the learning process. After completing the planning stage, the do stage is subsequently carried out using the REAKSI learning model. This stage is conducted to assess the effectiveness of the learning model, the improvement of students' skills, and further learning strategies. The findings of the cycle I indicated that implementing the REAKSI learning model provided new challenges for students wherein students' critical thinking and communication skills were increased well.

Data on chemistry education students' critical thinking and communication skills were acquired through evaluation test results of critical thinking skills at the end of the cycle. Evaluation was carried out at every meeting using the REAKSI learning model based on STEM. The evaluation test result of critical thinking skills can be seen in Table 2.

Table 2. Percentage of Critical Thinking Skills in Cycle 1

No	Indicators	Percentage		
		Sample 1	Sample 2	Sample 3
1	Provide Simple Explanations	80%	80%	78%
2	Build Basic Skills	82%	82%	74%
3	Conclude	81%	80%	75%
4	Provide Further Explanations	82%	80%	75%

5	Develop Strategies and Tactics	80%	77%	77%

Table 2 reveals that the percentage of chemistry education students' critical thinking skills is quite good with an overall percentage of 80%. It is due to the analysis stage and clarification in the REAKSI learning model directing students to think in-depth and critically to analyse a phenomenon or issue. The problem-solving stage can be applied to students whereby student groups build knowledge through being cooperative in their social environment to learn and solve a problem or produce a product (Burns et al., 2014).

The analysis stage in the REAKSI learning model encouraged students to find out the root of why the problems occurred. In this stage, students were trained to be communicative and critical thinkers. This is relevant inasmuch as the analysis stage results in students being active and creative in increasing their thinking skills in solving problems in the learning process, thus it can make students curiosity to discover the solutions (Asthira & Margunayasa, 2016).

As regards the analysis stage, students reinforced the results of the material exploration they have done. In Sample 1, students analysed the problems of primary, secondary, tertiary, and quaternary carbon atoms. Based on Sample 2, students analysed the analysis on paper Chromatography on Chromatography learning material. Students analysed reactions that occurred in Complex Compounds in sample 3.

The clarification stage of the REAKSI learning model aims to establish the relationship between issues and numerous alternative solutions. This urges creativity, communication, collaboration, and critical thinking of students. It is strengthened by (Hesse et al (2015b) statement in their research that planning for problem-solving should be based on joint problem representation and provide the basis for a well-organised and coordinated solution. It is added that students must have the ability to identify the identity of shared knowledge, identify others' perspectives collaboratively, and build a shared vision of problems and activities (Dillenbourg & Traum, 2006; Zengin, 2023).

The solution provided when students were at the clarification stage was to discern primary, secondary, tertiary, and quaternary carbon atoms through molymod or plasticine. Sample 2 illustrated chromatography to calculate the RF value of a sample. Sample 3 designed a reaction box of complex compounds. The problem-solving solution is addressed to students whereby student groups build knowledge through working together in the social environment to learn and solve a problem or create a product (Burns et al., 2014).

The improvement of chemistry education students' critical thinking occurred since the analysis and clarification stages in the REAKSI learning model based on STEM could direct students to have skills in deciphering data, recognising patterns, prioritise components, and developing systematic strategies to solve problems (Cahdriyana et al., 2019).

Chalim et al (2019) stated that implementing STEM-based learning provides an opportunity for students to explore their knowledge in society, thus it enables students to exchange ideas and help each other to solve the issues. Another relevant study mentions that the STEM-integrated learning model is also able to increase critical thinking skills (Lai, 2018; Mutakinati et al., 2018; Soros et al., 2017). Learning based on STEM is used to integrate the knowledge learnt with problems found in daily life as well as is able to relate the mathematics concept theoretically and based on information technology with the contextual issues found in real life (Widana & Septiari, 2021).

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In addition to critical thinking skills, the assessment is carried out for students' communication skills. Data on communication skills were obtained from the observation results carried out in every meeting using the REAKSI learning model based on STEM. The observation results of students' communication skills from each sample can be seen in Table 3.

Table 3. Percentage of Communication Skills in Cycle I

No	Indicators	rcentage		
		Sample 1	Sample 2	Sample 3
1	Use Various Verbal Communication	82%	78%	80%
2	Actively Engage in Building Dialogue	77%	80%	76%
3	Select and Understand Appropriate Information by Reading	80%	78%	75%
4	Discern Meaning and Information of a Picture and Video	81%	81%	80%
5	Communicate Clearly and Effectively	78%	80%	76%

Table 3 indicates that the percentage of chemistry education students' communication skills is quite good with an overall percentage of 78%. This is due to the learning stage of the Theme Formulation and Exploration in the REAKSI learning model making students communicate well with their lecturers and fellow friends.

Early stage of the REAKSI learning model is to formulate a theme that directs students to define the problems they found. It is in line with (Supeno, Nur & Susantini, 2016) research that students who were engaged cognitively to explicate an upcoming problem could be engaged actively in the next learning process. Exploration stage, in the syntax of the REAKSI learning model, taught students to delve deeper with various relevant sources. It is relevant with Barthelemy et al (2015) statement that learning, basically, is an educator's attempt to enable students to experience learning activities to explore knowledge. Another relevant theory stated by Trianto (2010) implies that the features of innovative learning begin with giving problems, existing problems have real-life contexts, learning in groups, formulating problems actively, identifying knowledge gaps, and finding case-based material and reporting it to discover the solution.

At the end of Cycle I, students were served an evaluation test to measure their critical thinking skills in the learning process they have performed. After finishing the Cycle 1 stage, the reflection was done to get suggestions and improvements. The numerous suggestions in Cycle 1 are described as follows:

1. Evaluation test of critical thinking needs a lot of time at the end of the lesson
2. Several students have not been optimal in communication
3. Lecture is still frequently lecture-centered.

After performing reflection, the Cycle 2 process began. Plan stage in Cycle 2 is conducted to prepare Cycle 2 learning better than Cycle 1. The REAKSI learning model was optimised so that students are able to communicate well and are not centred solely on the lecturer. During the implementation of the REAKSI learning model based on STEM at the end of the process or Do stage, an evaluation test was carried out on students' critical thinking skills. the test result of critical thinking skills in Cycle 2 can be seen in Table 4 as follows:

Table 4. Percentage of Critical Thinking Skills in Cycle 2

No	Indicators	rcentage		
		Sample 1	Sample 2	Sample 3
1	Provide Simple Explanations	94%	96%	86%
2	Build Basic Skills	88%	90%	82%
3	Conclude	95%	89%	82%
4	Provide Further Explanations	94%	94%	80%
5	Develop Strategies and Tactics	92%	95%	82%

Table 4 describes the percentage of chemistry education students' critical thinking increased by 92%. This result is relevant to the (Gandi et al., 2021) statement that learning integration based on STEM can increase students' critical thinking skills. In addition, (Li, 2016) states that creative thinking is an essential critical thinking skill to identify an issue in order to get a comprehensive solution. Critical thinking skills, as such, are crucial in spreading student skills to maximise learning objectives (Tehrani & Razali, 2018). Communication skills also increased better than in Cycle 1. The observation result of communication skills in Cycle 2 can be described in Table 5 as follows:

Table 5. Percentage of Communication Skills in Cycle 2

No	Indikator komunikasi	rsentase		
		Sampel 1	Sampel 2	Sampel 3
1	Use Various Verbal Communication	95%	93%	89%
2	Actively Engage in Building Dialogue	92%	90%	84%
3	Select and Understand Appropriate Information by Reading	89%	86%	80%
4	Discern Meaning and Information of a Picture and Video	90%	89%	87%
5	Communicate Clearly and Effectively	90%	84%	80%

Table 5 implies that the percentage of chemistry education students' communication skills experiences an increasing percentage of 89% in Cycle 2. This is relevant to research conducted by Aini & Aini (2023) regarding the implementation of STEM-integrated learning on students' communication skills

in the Genetic learning material in a very good result with 81.55%. This is due to each group being directed to conduct discussions during exploration which could encourage maximum student communication.

2. The correlation Between Critical Thinking and Communication Skills of Chemistry Education Students

The research result of the Pearson Correlation test regarding the correlation between the variables of critical thinking and communication skills of chemistry education students can be seen in Table 6 below.

Table 6. Correlation of Critical Thinking and Communication Skills

		Communication	Critical Thinking
Communication	Pearson Correlation	1	.293*
	Sig. (2-tailed)		.013
	N	71	71
Critical Thinking	Pearson Correlation	.293*	1
	Sig. (2-tailed)	.013	
	N	71	71

*. Correlation is significant at the 0.05 level (2-tailed).

Based on Table 6 above, the significance is 0.013 < 0,05. It implies that there is a relationship or correlation between students' critical thinking and their communication skills. This research result is also relevant to (Noor & Ranti, 2019) research that there is a correlation between students' critical thinking skills and mathematical communication skills. This correlation occurred since one's critical thinking skills in analysing material, making decisions, and drawing conclusions determine their ability to communicate. A person who has trouble communicating cannot analyse the learning material properly. Conversely, students who are able to think critically will be skilled in combining every argument or unifying ideas (Greenstein, 2012). Critical thinking and communication skills that students have in learning will encourage them to express ideas, discuss, and exchange ideas about issues or cases served by the teacher. When students communicate in the class, their critical thinking will work. A proper strategy, of course, needs to be applied to stimulate students' communication skills (Mursidah et al., 2019).

CONCLUSION

According to the research result, the REAKSI learning model based on the STEM approach could increase students' critical thinking. The evaluation test result of critical thinking skills reveals that the Cycle 1 result was 80 and the Cycle 2 result was 92 with a high category. These findings are acquired since the REAKSI learning model based on STEM has the analysis and clarification stages that could facilitate students in delving deeper and finding solutions to the problems. The increase was also seen in the students' communication skills with 78% in Cycle 1 and 89% in Cycle 2. These improvements are obtained since the REAKSI learning model based on STEM has the Theme Formulation and Exploration stages that encourage students' communication while being given discussion. Critical thinking and communication skills also have a positive correlation with the significance result of the Pearson Correlation test 0,013<0,05.

All components of the STEM approach are integrated into the syntax of the REAKSI learning model, which was immensely synonymous with the 21st-century skill actors.

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