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Increase Critical Thinking Skills and Learning Outcomes of Students on Buffer Solution Material Using E-Modules Based on Scientific Critical Thinking (SCT)

Mahdian[1*], Risma Ariyanti[1], Iriani Bakti[1]

[1] Chemistry Education Study Program, Lambung Mangkurat University, Banjarmasin, Indonesia.

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Corresponding Author:
Mahdian
mahdian_fkip@yahoo.co.id

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Abstract: This research is Classroom Action Research (PTK) which aims to determine the increase in critical thinking skills and student learning outcomes after learning using an e-module based on Scientific Critical Thinking (SCT) on buffer solution material. The research model developed by Kemmis and Mc Taggart consists of 4 stages, namely planning, implementing actions, observing and reflecting in each cycle. The research subjects were 36 students of class XI MIPA 4 SMA Negeri 4 Banjarmasin. Data collection on critical thinking abilities and student learning outcomes was carried out using test instruments. The research results showed that the students' critical thinking skills test in cycle I was 47.18 in the moderately critical category. while in cycle II it increased to a score of 81.08 in the very critical category. In the knowledge learning outcomes test, in cycle I it was 55.56 in the poor category and in cycle II it increased by 91.11 in the good category. Student responses also showed the agree category, thus the e-module based on Scientific Critical Thinking (SCT) on buffer solution material is suitable for use in learning to improve critical thinking skills and student learning outcomes.

Keywords: Critical thinking skills; Learning outcomes; SCT based e-module

Introduction

Critical thinking skills are abilities used in 21st century learning. It is an ability used by students in formulating and identifying problems, finding cores, determining similarities and differences, extracting relevant information and data. These abilities are indispensable in science learning, one of which is in chemistry learning. This is because chemistry is considered one of the difficult subjects, which sometimes makes students unwilling to learn further chemistry (Budiariawan, 2019). One of the chemicals in question is a buffer solution, Buffer solutions learn concepts that are abstract and closely related towards everyday life. This causes students to find it difficult to understand the concept of buffer solution, resulting in low learning outcomes (Suswati, 2021).

Skill to think critically is related to the students learning outcomes. This is explained by Zulkarnain et al. (2019), that increasing the critical thinking skills of students will have an impact on high learning outcomes as well. Thus, high critical thinking skills will have an impact on high learning outcomes as well. Learning outcomes are changes in student behavior obtained after the learning process both in terms of knowledge, attitudes, and skills (Rosyid et al., 2019). Learning outcomes always a benchmark for the success of learning process. If students' learning outcomes are not in accordance with the minimum completeness criteria, then the learning carried out has not been adequate (Wiradintana, 2018). Learning outcomes in the realm of knowledge are defined as the entire learning process involving brain activity (thinking ability) (Irfan, 2019).

Studies related to critical thinking skills have been carried out stated that the ability to think critically of students in one high school of West Java is included in the very good category. Other research also indicates that on average students' critical thinking skills are in

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low category. Qualities of students' Critical Thinking Ability (KBK) is affected from several factors, including the selection for learning models by teachers who still do not lead to an improvement in critical thinking skills and the use of learning media that is still minimal in the classroom which causes low interactive students.

The results of interviews conducted with chemistry teachers at SMA Negeri 4 Banjarmasin explained that student involvement in the learning process was still low because learning activities were less interesting and still teacher-centred. This is also the reason this research was conducted. Apart from that, students' critical thinking skills are also still low, which shows that students have difficulty in providing further explanations and drawing conclusions because they do not understand the material they have studied well. Low learning outcomes are also caused by one-way interactions between teachers and students during the learning process. The lecture method that teachers often use in teaching causes students to only receive the information provided (Putri et al., 2020).

The ability to think critically can be developed through learning which requires students to conduct experiments, discoveries and problem solving activities and through discussions in small groups (Zulkarnain et al., 2019). If students do not actively participate during learning, it will affect their learning outcomes (Lathifah et al., 2019). In addition, the characteristics of chemistry learning that are difficult to understand can be overcome by creating an active learning atmosphere (Widyasari et al., 2018). This can be done by maximizing the use of media in learning chemistry.

One of the chemistry lessons that can increase the students' activity in the classroom is an e-module because this media can provide options to students in exploring learning resources that are interesting, interactive, and respond to their curiosity. E-modules also give teachers the option to answer the challenges of technological and information advances that automatically impact learning. E-modules are electronic versions of modules that can be read on a computer or smartphone and are designed using the necessary software. E-modules are learning media that contain material, limitations, and ways to evaluate that are organized and interesting (Maryam et al., 2019).

Interactive e-modules contain certain learning stages that can engage students actively in their learning, one of which is the implementation of the SCT (Scientific Critical Thinking) learning model in the presentation of e-module content. SCT model is an instructional model developed particularly from the Problem Based Learning (PBL) model and the Inquiry model (Rusmansyah et al., 2019) According to Rusmansyah et al. (2019) Scientific Critical Thinking (SCT) is one of the constructivism learning styles that can be implemented in an attempt to improve the creative thinking skills, communication skills and critical thinking skills of students.

Researchers conducted research on the use of e-modules based on Scientific Critical Thinking (SCT) with the aim of enhancing students' critical thinking skills and learning outcomes. The e-modules used are valid and appropriate for use according to validation by experts and practicality tests (Riduan et al., 2021). In this study, the application of the Scientific Critical Thinking (SCT) learning model is expected to improve the critical thinking skills and learning outcomes of students. This is because in the Scientific Critical Thinking (SCT) model there are scientifical activities in problem solving that can trigger an increase in students' critical thinking skills and learning outcomes. This is aligned with research conducted by Usman et al. (2019) which shows that the application of the inquiry learning model combined with Problem Based Learning (PBL) can improve both critical thinking skills and student learning outcomes.

Method

The research was conducted in April of the 2022/2023 academic year by adjusting the even semester chemistry schedule at the school. The research was conducted at SMA Negeri 4 Banjarmasin which is located at Teluk Tiram Darat street No.16, Telawang, West Banjarmasin District, Banjarmasin City, South Kalimantan 70114. This research subject is all grade XI MIPA 4 students of SMA Negeri 4 Banjarmasin in the 2022/2023 academic year who have varying levels of ability. The object in this study is something that wants to be achieved, namely the ability to think critically and the cognitive learning outcomes of students in the chemistry subject matter of buffer solution. Learning took place in two cycles, cycle I was two meetings on April 10, 2023 and April 12, 2023, while for cycle II was one meeting on April 14, 2023. The method used in this research is the Classroom Action Research ("CAR") method with two cycles.

The implementation procedure of the CAR research can be divided into four parts, namely planning, acting, observing, and reflecting (Susilo et al., 2011). Cycle I was carried out in 2 meetings and in cycle II was carried out in 1 meeting, so for both cycles there were 3 meetings. Each meeting consisted of 2 lesson hours. Before continuing the second cycle, reflection and revision of actions were carried out for goals that had not been achieved in the first cycle. Research procedures in Figure 1 below.

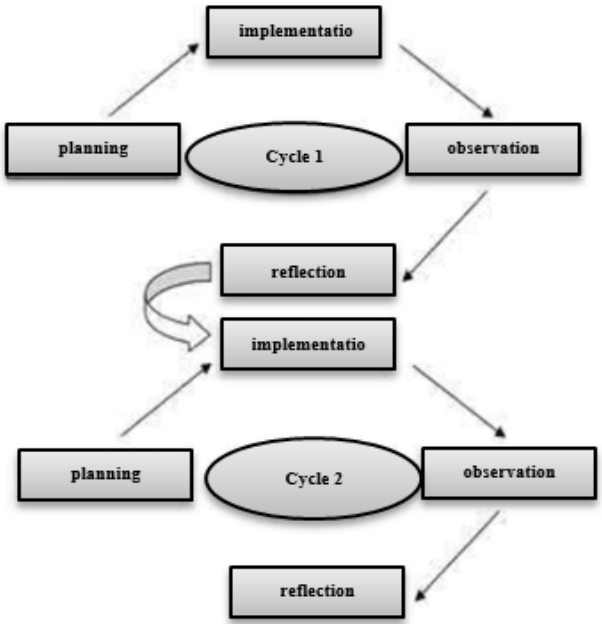

Figure 1. Research procedures

Data analysis methods that will be conducted in this study are quantitative data and qualitative data. Quantitative data consists of critical thinking skills test and knowledge learning outcomes test. While qualitative data consists of observational sheets of teacher activities, observation sheets of student activities, and questionnaires of student responses. Data collection techniques and instruments used in this study were tests and observations. Tests were used to collect critical thinking ability data and knowledge learning outcomes of students. While observation is used to obtain data on the activities of teachers, student activities, and the response of students to the learning process.

Result and Discussion

Result

Classroom action research on the material of buffer solutions using application of e-modules based on the Scientific Critical Thinking (SCT) model was carried out in 2 cycles which were seen from the success of teacher actions, student activities, critical thinking ability test results, learning outcomes tests and student responses. Cycle I consisted of two meetings. While cycle II is consist of one meeting. This research is based on the existence of problems in the form of low critical thinking skills and students' self-efficacy in learning (Hasbie et al., 2023). The results of the investigation are in the forms of critical thinking ability test results and student learning outcomes. In addition, teacher activity and student activity data were also obtained.

Teacher and Student Activity

The observation sheet in this study was used to collect data related to the plan that had been made in accordance with the lesson plan. The data generated from the teacher's learning activity observation and student activity. Increasing teacher activity during the learning process by using SCT-based e-modules on buffer solution material is an objective of class action research. Effectiveness here is also related to the teacher's ability to plan learning, the learning process, and the teacher's ability to use learning media (Lubis et al., 2020).

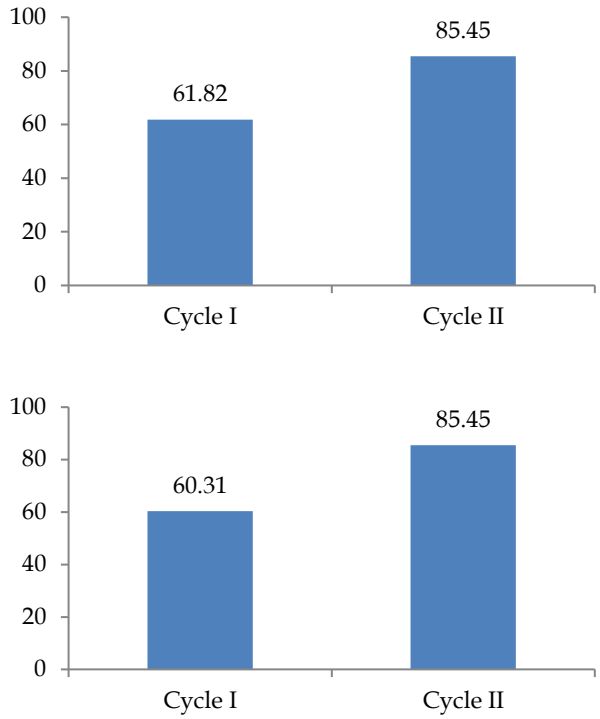

Figure 2. Teacher and Student Activity

Teacher activity is very important to analyze so that the learning process can run optimally. Teachers must make the learning process active and fun so that students are motivated to follow the learning process. In addition, student activity is needed in an optimal learning process. Curiosity, cooperation, activeness, and discipline are some of the activities needed to improve students' critical thinking skills and learning outcomes. The results of the teacher and student activity observations are displayed in Figure 1 below. Based on Figure 1 above, it shows that both the teacher's activity and students' activity improved from cycle I to cycle II. The teacher activity increased from 161.82% in cycle I to 85.45% in cycle II, while the student activity increased by 60.31% from cycle I to 85.45% in cycle II.

The results of the critical thinking skills test and learning outcomes

According to the learning activities carried out, researchers also obtained the following critical thinking skills results critical thinking skills, learning outcomes as well as students' responses to the buffer solution material presented in Tables 1, 2 and 3 below.

Table 1. Critical Thinking Test Results

KBK value	Frequency of students			
	Cycle I		Cycle II	
81 – 100	-	Very critical	24	Very critical
61 – 80	2	Critical	11	Critical
41 – 60	25	Quite critical	1	Quite critical
21 – 40	6	Less critical	-	Less critical
0 – 20	3	Uncritical	-	Uncritical
Average	47.18	Quite critical	81.06	Very critical

Based on this table, it shows us that the critical thinking skills test results of cycle I are still classified as quite critical with an average score of 47.18, this is because there are still many students who have a score in their critical category. However, during cycle II it increased to 81.06 with a very critical category. While the distribution of statistics by category, in cycle I most students were in the quite practical category as many as 25 students, and in cycle II there were many in the very practical category as many as 24 students.

Table 2. Learning Outcomes Test Results

The value of learning outcomes	Frequency of students					
	Cycle I			Cycle II		
92 – 100	-	Excellent	A	20	Excellent	A
83 – 91	2	Good	B	10	Good	B
75 – 82	7	Enough	C	6	Enough	C
< 75	29	Less	D	-	Less	D
Average	55.56	Less	D	91.11	Good	B

Based on Table 2, above shows a very significant improvement in the learning outcomes of students from Cycle I to Cycle II, which is 55.56 in the category of less to 91.11 in the category of good. This is because during cycle I, the distribution for students when viewed based on the category of learning outcomes was as many as 29 students were in the poor category or scores below 75. This is different from cycle II, students are widely spread in the very good category, namely as many as 20 students.

Based on the Table 3, indicates that students gave a good response to the Scientific Critical Thinking (SCT) model applied. This is indicated by the results of the learner response questionnaire which states that they agree with the use of the Scientific Critical Thinking (SCT) model in learning chemistry.

Table 3. Students Respon

Score	Category	Frequency of students
10-17	Strongly disagree	-
18-25	Disagree	-
26-33	Not Sure	2
34-41	Agree	15
42-50	Totally agree	19
Average		41.61
Category		Agree

Discussion

Researchers apply SCT-based e-modules as an effort to improve the critical thinking skills and learning outcomes of students on buffer solution material. The research results obtained after the researchers went to the field at SMA Negeri 4 Banjarmasin, then the researchers presented the data that had been obtained in the form of a written report. The overall data results obtained from observation, evaluation, and questionnaire data have been presented and summarized after being processed and processed according to the stages carried out. The analysis was carried out on teacher and student activities, the results of the ability to think critically and learning outcomes as well as the analysis of student responses which are explained as follows. Several other studies have also discussed Scientific Critical Thinking (SCT), namely Rahman (2021), Yuanita et al. (2018), and Sihombing et al. (2021).

Teacher and Students Activities

According to the observation data on teacher actions, the percentage of the learning process of teacher activities in cycle I was obtained with a score of 61.82% and in cycle II the average data was 85.45%. From these data it could be concluded that there had been a significant improvement in the learning process of teacher activity from cycle I to cycle II. The improvement in the process is because the teacher feels that it increases the activities that occur in the classroom, so that students are able to receive learning well and easily.

The first meeting in cycle I, the learning process was still not running optimally. At the first meeting in cycle I there were still several aspects that had not been achieved, such as there were still many students who were less focused in paying attention to learning in class, students were less active in group discussions. Some students are also still lazy to ask the teacher about material that is not understood so that the classroom conditions are less lively. In addition, students lack confidence in reading the results of discussions in front of their classmates and concluding the learning outcomes. During group formation, students were also still unruly and crowded, even so the teacher still tried

to condition the class back to calm. In the second meeting of cycle I, the teacher began to slightly improve the teaching methods that were lacking in the first meeting of cycle I, by following the suggestions of the three observers. The suggestions given by the observers were to further stabilize the teaching method and be able to position themselves as teachers in the classroom. Because there were still many students who did not pay attention to the equalized explanation. In addition, the teacher was asked to be more varied in teaching positions such as going around to be more controlled to reduce noisy students.

According to Dewi et al. (2017), good learning must be designed appropriately so that it reaches the realm of students' attitudes, creates curiosity, then proceeds to solve problems that arise using appropriate learning models so as to produce products in the form of facts, principles, theories and laws that are appropriate and can be applied or implemented in everyday life. Cycle II was more able to build students' learning motivation which had an impact on students' critical thinking skills and learning outcomes. In cycle II, classroom conditions were more stable than in cycle I. Students were more focused during the material delivery process and were able to discuss even with a little encouragement by the teacher. Students who began to be interested in the learning process influenced the progress of teacher activities in implementing learning. It can be seen from the percentage of teacher activity, it can be concluded that the teaching and learning process carried out by the teacher is increasing with the increase in meetings conducted. This shows that the teacher's ability to manage the class is very good. The increase is because teachers always make improvements to actions that help increase motivation in learning which affects students' critical thinking skills and learning outcomes.

Increasing student learning outcomes can also be achieved due to effective learning using interesting and fun learning methods and models (Dakhi, 2020). The increase in learning outcomes is also balanced with increased motivation, this is because students feel refreshed in teaching and learning activities, so they try to focus their attention during learning (Syaparuddin, 2020). According to the observation of student activities, the average percentage of the learning process of student activities in cycle I was obtained with a score of 60.31% and in cycle II the average data was 85.45%. From these data it can be observed that there has been a substantial improvement in the learning process of student activities from cycle I to cycle II. The increase in the process is because students feel interested in participating in the learning process. In cycle I students still looked passive in participating in learning. Students are still in the introduction stage of the material presented and the learning model used. In addition, students still lack discussion with their group mates. In cycle II, there was a significant increase in student activity. Students are able to discuss and are able to convey the results of their discussions in turn. Students also showed curiosity in the learning process as seen from starting to dare to ask questions during the process of delivering material by the teaching teacher.

Critical Thinking Skills, Learning Outcomes and Student Responses

The analysis of data on students' critical thinking skills is obtained from essay questions done by students in each cycle which have been summarized and presented in the form of numbers. According to the results of the study, the percentage score of critical thinking skills was obtained by learning using SCT-based e-modules on buffer solution material in cycle I and cycle II. From the data obtained, students' critical thinking skills are still classified as quite critical during the learning process in cycle I, where the the number of students who meet the criteria is quite critical there are 25 people, critical criteria 2 people, less critical criteria 6 people, and uncritical criteria 3 people. This is because the learning process that occurs is not yet too conducive and many students are still passive to ask the teacher and do not discuss with their peers.

Based on the opinion of Ramdani et al. (2020) and Sulistyowarni et al. (2019), critical thinking skills are something that must be trained in students so that students' critical thinking skills are very important in ensuring the success of learning. Critical thinking ability is a thinking process ability that allows someone to evaluate or investigate the evidence, assumptions and logic underlying other people's ideas (Putra, 2015). Therefore, critical thinking skills can be formed from now on in children at junior and senior secondary levels.

Then during the second cycle learning process, students' critical thinking skills increased, which met the completeness criteria (KKM) as many as 24 people with very critical criteria, 11 people with critical criteria, and 1 person with fairly critical criteria. Thus, the average data of critical thinking skills in cycle II was 81.06% with a very critical category. In cycle II, students were more willing to discuss with their peers in one group. Interaction with the teacher also looked more effective, many students began to ask and answer the questions the teacher gave. Students have also begun to express their opinions to solve problems given by the teacher with peers in the group. Most students are also more motivated to pay attention to the instructions given by the teacher, so that understanding the material is more readily understood by students. So it can be concluded that the application of SCT-based e-modules on buffer

solution material can improve students' critical thinking skills.

The analysis of student learning outcomes data is generated from multiple choice questions that have been done by students who have been summarized and presented in the form of numbers. According to the results of the study, the percentage score of learning outcomes using SCT-based e-modules on buffer solution material in cycle I and cycle II was obtained. From the data obtained, the students' learning outcomes have increased. In cycle I, the average data of students' learning outcomes was 55.56% with a poor category (D), where as many as 29 people scored 75 (incomplete) and only 9 students answered completely. This proves that the completeness value in cycle I is still very low. This is caused by low student activity such as paying less attention to the teacher who teaches in front and less participation in group discussions so that the SCT-based e-module is less optimal which affects the construction of student material understanding. Teacher activities also affected the low learning outcomes in cycle I, namely the lack of teaching variations which caused students to become bored and pay less attention in the learning process.

According to Hanina et al. (2021), teacher learning variations are expected to use various kinds of learning strategies and media, learning strategies are action plans (series of activities) including the use of methods and the use of various resources or strengths in learning. This learning variation is also related to meaningful learning for students, which is the hope of all parties. This hope is as described by Hasibuan et al. (2022) who stated that future teachers are desired by many parties as planners, innovators, motivators, capable, and developers.

The data results obtained that the components of the questions that still get low learning outcomes are on indicators of competency achievement identifying the components of the buffer solution, calculating the pH or pOH of a buffer solution, and analyze the buffer solution mechanism in maintaining its pH against the additions of a little acid or a little base or dilution. The low level of understanding completeness on these indicators was due to the first cycle lesson plan only being carried out with the discussion and question and answer method, making it difficult for students to understand the concepts learned because students did not see directly, whereas learning at the second meeting which was carried out with practicum, discussion, and question and answer methods helped students a little in understanding the concepts learned, but because there were too many subchapters of material discussed, it made students difficult and lacked time in working on the questions in the first cycle, causing many students to be incomplete, causing many students to be incomplete.

In the second cycle, the lesson plan has been improved by the teaching teacher at the stage of guiding group work and learning so that it can improve students' understanding of the concepts being studied. In the second cycle lesson plan, students are invited to see around them which is the role and function of buffer solution in daily life, so that students can see the real role and function of buffer solution which can build students' understanding in discussion. In addition, in the second cycle lesson plan, there was a review of the previous indicators that had not been achieved.

Therefore, learning outcomes in the learning process of cycle II have increased which meet the criteria for completeness, namely there are 36 students or all students experience completeness with a percentage of 100%. Thus, it could be summarized that the application of SCT-based e-modules on buffer solution material has been successfully applied to improve student learning outcomes. This happened because of the increased actions taken by teachers and students that made the learning process with the application of SCT-based e-modules more optimal. The involvement of students with other students or students with the teaching teacher can build their own knowledge with learning activities such as being active in discussions, active in asking and answering questions, or focusing on the delivery of the teaching teacher will have a a positive effect on improving student learning outcomes. The application of SCT-based e-modules on buffer solution material is further sharpened in cycle II by creating active, innovative, and enterprising learning that will make the process of learning in the classroom more lively.

The increase in the application of e-modules based on Scientific Critical Thinking (SCT) is influenced by several things, one of which is activities carried out by educators and students, such as scientific activities which can be a factor in increasing students' scientific literacy. Educators play a continuous role in improving the activities that occur in class, so that students are able to receive learning well and easily. The results show that improving learning outcomes in SCT-based e-modules starts from the role of educators who carry out corrective actions in the learning process so that it has an impact on student activities at the next meeting.

This condition can be proven by improvements in the application of SCT-based e-modules to buffer solution materials which were further sharpened in Cycle II. In Cycle II, after undergoing improvements, results were obtained which by creating active, innovative and creative learning would make the learning process in the classroom more lively. Questions from students are also able to provide things that encourage students' thinking abilities, followed by the

ability to interact and convey the results of discussions in front of the class in turn.

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The various conditions above show that the implementation of learning in cycle II has been successful in improving critical thinking skills and overall student learning outcomes. Overall, the average percentage of all indicators in cycle II has reached the very critical category. The critical thinking ability test was 81.06 indicating the very critical category, then there was an increase in the student learning outcomes test to 91.11 with category B which means good. Therefore, overall the indicators of success in this research have been successful, which is of course influenced by the implementation of e-modules, the role of educators, and classroom conditions which of course must be active and innovative.

Factors for improving learning outcomes according to Marlina et al. (2021) state that the factors that can influence student learning outcomes are internal factors (interest, talent, motivation and way of learning) and external factors (school environment and family environment). These two factors can be balanced with the role of the students themselves, the role of educators and families. Apart from that, the existence of activities and supporting infrastructure that can arouse student interest and motivation is also needed to improve student learning outcomes.

Several advantages of this SCT-based e-module make it easier for students to access it in the current 5.0 revolution era. Hayati et al. (2021) also stated that SCT also plays a role in increasing students' self-efficacy and students' positive responses in learning. In accordance with Saputra (2019), the research carried out also concerns the responses of teachers and students to the implementation of active, innovative based learning in learning. A positive response is characterized by an increase in learning so that it influences learning outcomes (Ahmadurifai, 2020).

The results of this study prove that e-module-based SCT on buffer solution material can be applied and help learning in the classroom. Judging from the data obtained is 41.61 with the agreed category. The benefits of SCT-based e-modules to improve critical thinking skills and student learning outcomes by working together in groups, solving problems, and helping to improve understanding of buffer solution material. Therefore, SCT-based e-modules on buffer solution material can help students in the learning process.

Conclusion

From the research it was concluded that the use of e-modules based on Scientific Critical Thinking (SCT) in buffer solution material could improve critical thinking skills and student learning outcomes as evidenced in cycle II which experienced an increase in the critical thinking ability test to 81.06 in the very critical category and test results student learning was 91.11 with category B which means good. The results of student responses after using the Scientific Critical Thinking (SCT) based e-module on buffer solution material in class.

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Authors Contributions

Conceptualization: R, M, I; Methodology: R, M, I; Validation: K, P, R, P, J; Formal analysis: M, B, R, S; Investigation: R; Writing research: R; Editing research data: R; See the research manuscript and agree: M, B, S.

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Conflicts of Interest

All authors have read and agreed to the published version of the manuscript, and there is no conflicts of interest.

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