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Developing scientific explanation of grade 11 students through socio-scientific issues learning on respiratory system

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ABSTRACT

This action research aims to develop the scientific explanation ability of grade 11 students to pass the good level up criterion using socio-scientific issues learning in biology on the topic respiratory system. The target group consisted of 17 students in grade 11 students. The research instrument were lesson plans of instrument using socio-scientific issues learning, scientific explanation test, student behavior observation, semi-structure interviews, and student journal. The data were analyzed by descriptive analysis. The results showed in the first cycle, 17 students score did not pass the good level, students received an average scientific explanation score of 3.82 out of a total of 12 points, representing 31.86%. In the second cycle, students received an average scientific explanation score of 7.47 out of a total of 12 points, representing 62.25%, 14 students score did pass the good level, 3 students score did not pass the good level. In the third cycle, students received an average scientific explanation score of 10.82 out of a total of 12 points, representing 90.20%, 17 students score did pass the good level.

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1. INTRODUCTION

Administration of high-caliber academic programs requires changes in science and technology, which in turn influence societal shifts and mean that the original purpose of scientific learning management needs to adapt to new circumstances (Kem, 2022). One of the most important skills for a country's progress is science literacy, which encourages curiosity, helps students make sense of their world, fosters critical thinking about the validity of scientific claims made by others, and equips them to make educated choices about their own health, lifestyle, and community. The Ministry of Education (2017), the importance of encouraging students to develop rational thinking, think analytically, understand questions and problems that can be investigated through research, build knowledge with quests, and ultimately make decisions and provide reasonable explanations using empirical data or verifiable evidence. Therefore, it is important to encourage students to be scientifically literate and to integrate distinct bodies of knowledge with real-world circumstances while teaching and studying science (Phoopanna & Nuangchalerm, 2022).

One of the abilities that reflects students' scientific literacy traits is the ability to scientific explanations)Organisation for Economic Co-operation and Development: OECD, 2019). Scientific explanation It is a statement used to give meaning, explanation, and claim in a scientific context, which is an explanation that reflects the observation results, experiments or other investigations that provide empirical evidence, can be linked to scientific reasoning that is consistent with evidences (Prachagool & Nuangchalerm, 2019). Giving students scientific explanations there are many benefits to learning science, such as the ability to reason and make decisions, draw conclusions, understand concepts, this promotes understanding of both content and process (McNeil & Krajcik, 2006), help students understand the nature of scientific knowledge in the way that evidence is linked, and may be changed later, encourage students to reflect on what they have learned (Ruiz-Primo et al., 2010), and focusing on students to practice explaining It encourages students to use their reasoning skills, pose a scientific question, analyze and interpret data patterns, by linking the data with the theory to create an explanation of the cause of that situation (Nawani et al., 2018). In addition, the scientific explanation reflects the processing of knowledge, application of knowledge, and communicating knowledge accurately with reasonable support from scientific evidence.

According to the inquiry of biology teachers, it was found that the school focuses on developing knowledge for students, so that students can apply knowledge to solve problems or seek answers to situations that occur rationally, and applying knowledge to life, and can use the knowledge to take the entrance examination to study at a higher level. The school also aims to develop students' ability to make decisions that reflect their impact on themselves and society, able to write, answer questions, and express one's own position with different opinions from others, there is credible evidence supporting sufficient, reasonable, consistent with scientific knowledge. However, when the researchers observed the class and had the students take a test measuring their ability to scientific explanations, it was found that most of the students lacked the ability to use evidence and reason to connect information into scientific explanation, that is, students decide to answer only a short claim.

Socio-scientific issues learning has many benefits for learners, for example, it promotes science literacy in terms of the ability to apply science knowledge in everyday life (Sjoberg & Schreiner, 2005), fostering skills such as decision-making and opinions. Interpretation for valuation reliability of information and news reasoned discussion using empirical evidence (Sadler & Zeidler, 2004; Kolsto, 2006), develop an understanding of science content and scientific concepts relevant to the subjects studied (Zohar & Nemet, 2002; Sadler

& Zeidler, 2004), develop high-level thinking abilities, morality, and ethics (Nuangchalerm, 2014), and fostering the ability to scientific explanations (Mahanani et al., 2019). Due to the actual conditions that are contrary to the expected conditions above, the researchers wants to develop the students' ability to scientific explanations through socio-scientific issues learning by using an action research model.

2. METHOD

Target Group

The target group of students were selected from grade 11 students in the second semester of the academic year 2022 at a school in Mahasarakham province, Thailand. The test was conducted to measure the ability to study preliminary scientific explanation. The target group was selected based on the score of ability to scientific explanation who does not pass the good level. Therefore, the target group of this research were 17 students.

Research instruments

The research instruments for this study included lesson plan, scientific explanation test, observation form, semi-structured interviews, and student journal. As shown in the following details.

1. lesson plan: Nine lesson plans for socio-scientific issues learning received 14 hours of the respiratory system instruction. In one cycle, use three lesson plans which can be shown in Table 1.

Table 1 Socio-scientific issues lesson plans

Cycle	Lesson plans		Socio-scientific issues	Time)hours(
1	1	Gas exchange of some animals	Red tide	2
	2	Gas exchange of insects and birds	Burning corn fields	1
	3	The structure of the lungs of mammals	PM 2.5	2
2	4	Organs and structures in the human respiratory system	Biomass power plant	1
	5	Gas exchange and human gas transport	Electronic cigarette	2
	6	Human breathing control	Electronic cigarette	1
3	7	Disorders related to the human respiratory system	Electronic cigarette	2
	8	Human inhalation and exhalation	Itaewon tragedy	1
	9	The volume of air in human inhalation and exhalation	COVID-19 and sporting events	2
Total				14

From Table 1, every lesson plans passed quality inspections from 5 experts, specialist in curriculum and teaching, measurement and evaluation, and content. Lesson plans are revised according to expert advice. After that lesson plans were used for research.

2. Scientific explanation test, open-ended questions: Students took 2 final tests in each cycle, with a total of 3 cycles, the tests consisted of 3 elements: claims, evidence, and reasoning, there is a rubric score scale adapted from McNeil & Krajcik (2008). The constructed test was checked using the index of item objective congruence by five experts. The scientific explanation tests were revised according to expert advice. After that scientific explanation tests were used for research.

3. Observation form: The observation of student behavior is structured, to observe behaviors that indicate of scientific explanations of students during learning activities. The generated observations were reviewed by 5 experts, and were revised according to expert recommendations by the researchers. After that observation form was used for research.

4. Semi- structured interviews: It used for interviewing the opinions of students who do not meet the criteria set after the end of each learning activity cycle. It dvided the topics in the interview into 3 topics, identification of claim, identification of evidence and reasoning. The generated interview form was reviewed by 5 experts and was revised according to expert recommendations by the researchers. After that semi- structured interviews were used for research.

5. Student journal writing: Student's journal that reflects their thoughts after completing all lesson plan in each cycles. The researchers define an issue in the student's journal about scientific explanations, to know how to think, query method, and methods for finding answers are identified as claims, evidence and reasons.

Data collection

This research uses an action research model. The researchers conducted the research according to the concept of Kemmis & McTaggart (1988). Each cycle has 4 steps: plan, action, observe, and reflect. The researchers divided the data collection into 3 cycles as shown in Figure 1, and explained in more detail below.

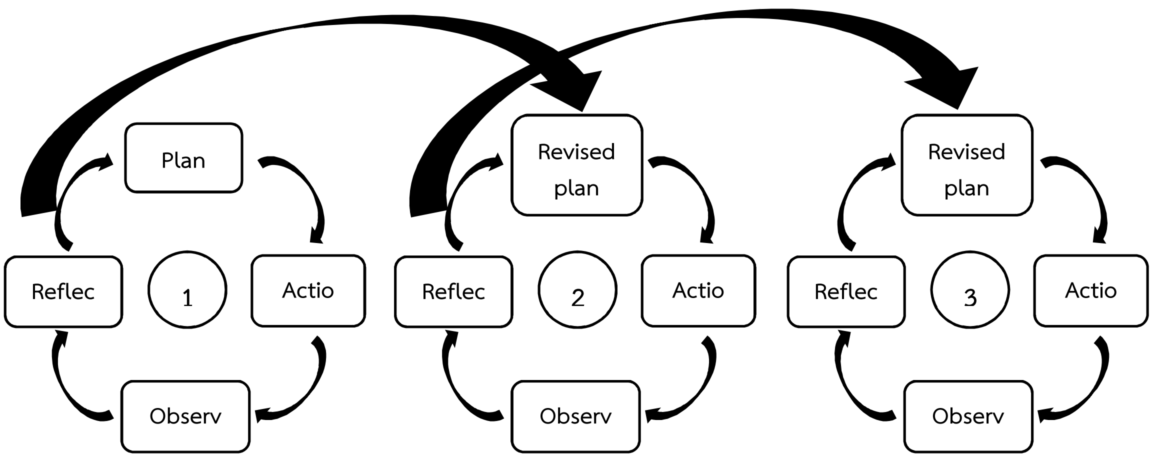

Figure 1 Cycles of action research

1. Plan: Start by exploring the problem, student context, class observation, and confirm the problem by having students a scientific explanation ability test. Then find a solution

by studying papers, and research related to the ability scientific explanations, socio-scientific Issues learning, and other research instruments related to solving such problems. Followed by the creation and development of research instruments.

2. Action: After building and improving research instruments, implementing lesson plans using socio-scientific issues for targeted students. Cycle 1 uses lesson plans 1, 2 and 3. Cycle 2 uses lesson plans 4, 5 and 6. Cycle 3 uses lesson plans 7, 8 and 9.

3. Observe: During the learning management, the researchers observed the behaviors indicating the ability to scientific explanations of the target group students, using an observation behaviors form. At the end of each lesson plans cycle, the researchers collected information on how to student scientific explanations student's journals, and collecting data on the ability to scientific explanations of students, by using a test to measure the ability to scientific explanations, amounting to 2 per cycle. Data were then collected for the ability to scientific explanations of students who did not meet the set criteria, using a semi-structured interview.

4. Reflect: Analyze the data and summarize the results from the observational behavior form, scientific explanation test, semi- structured interviews form, and student's journals, how was the research result, what's the problem. Then bring this information to plan for solving problems in the next cycle. Until the purpose of the research is achieved, the cycle is stopped.

Data analysis

Data were analyzed from the scientific explanation test. Data were analyzed by comparing students' responses with adjusted scoring criteria according to McNeil & Krajcik (2008), as in Table 2 and classified into 3 levels of individual scientific explanation ability, namely, excellent, good, and need improvement, adapted from Sampson et al. (2009), as in Table 3, to analyze and evaluate whether students pass the set criteria or not. In addition, data were analyzed from behavioral observation form, semi- structured interviews form, and student's journals. which analyzes the data by interpreting it to explain the meaning of the data, summarizing the data, and then reporting the results by describing it.

Table 2 Scientific explanation scoring criteria adapted from McNeil & Krajcik (2008)

Component	Level		
	0	1	2
Claim: Statement that is a preliminary answer to a question related to the situation	Do not write claims or making false claims related to the situation	Make a valid claim related to the situation, but the claim is incomplete, add other irrelevant claims	Make all claims related to the situation accurate and complete, do not add other claims that are not relevant
Evidence: Scientific data that supports the claim. where the information must be	Do not write evidence to support the claim, or provide unrelated evidence	Write evidence to support the claim made in relation to the situation, but it is	Provide relevant and sufficient evidence to support the assertion of the

Component	Level		
	0	1	2
relevant, and sufficient to support the claims of the situation	to support the circumstances' claims	not enough, not writing to provide some evidence related to that situation	situation, that is, present all evidence relevant to the situation
Reasoning: Showing a connection between a claim and evidence by showing why the information was used as evidence, using adequate scientific principles	There is no justification or justification that does not show a link between the evidence and the claim	There is a written argument showing the link between the evidence and the claim, with reference to scientific principles but not enough	The reasoning is correct and complete, show the link between the evidence and the claim, with sufficient reference to scientific principles

Table 3 Criteria for interpreting scores for ability to scientific explanation adapted from Sampson et al. (2009)

Score ranges	Ability level
9-12	Excellent
5-8	Good
0-4	Need to be improved

3. RESULT

The results of the analysis of the ability to scientific explanations of the target group students both before learning activities, and after learning activities in each cycle. The data analysis results are shown in Table 4.

Table 4 The scientific explanations score between before and after learning activities in each cycle

Cycle	Score component (N=17)				Pass the good level
	Claim (4)	Evidence (4)	Reasoning (4)	Total (12)	
Before	1.59 (39.71)	0.94 (23.53)	0.29 (7.35)	2.82 (23.53)	0 (0.00)
Cycle 1	2.59 (64.71)	0.94 (23.53)	0.29 (7.35)	3.82 (31.86)	0 (0.00)
Cycle 2	3.53 (88.24)	2.24 (55.88)	1.71 (42.65)	7.47 (62.25)	14 (82.35)
Cycle 3	4.00 (100)	3.65 (91.18)	3.18 (79.41)	10.82 (90.20)	17 (100)

From Table 4, it shows that before organizing a learning activity using socio-scientific issues, the researchers surveyed 17 students whose scores on the ability to scientific explanations did not pass the good level up criterion. Subsequently, the researchers organized learning activities using socio-scientific issues for a total of 3 cycles, resulting in all 17 students developing in scientific explanations pass the good level up criterion. As the following details.

Cycle 1: It was found that all 17 target groups had not yet passed the good level up criterion. When considering the total score for all components of the scientific explanations, the students had the mean score for the ability to scientific explanations equal to 3.82 points out of a full score of 12, representing 31.86 percent. While considering the scores on each side, the total score was 4 full points, it was found that the students began to develop in identifying claims. This can be seen from the students' claim scores with the mean score of 2.59 points, representing 64.71 percent, which is higher than before the learning activities. but the mean evidence identification score and reasoning had the mean scores that were not different from those before the learning activities (Figure 2), this shows that in cycle 1, students have not yet developed in the identification of evidence, and reasoning.

Cycle 2: It was found that 14 students in the target group passed the good level up criterion, representing 82.35 percent, but there are 3 students who have not yet passed the good level up criterion, representing 17.65 percent. When considering the total score for all components of the scientific explanations, students had the mean total score of ability to scientific explanations equal to 7.47 points out of 12 full scores, representing 62.25 percent. While considering the scores for each aspect, a total of 4 full points, it was found that the claim identification score, identification of evidence, and reasoning had the mean score of 3.53, 2.24 and 1.71 points respectively, representing 88.24, 55.88 and 42.65 percent respectively, which shows that in cycle 2, students begin to develop all three components of the scientific explanations as shown in Figure 2.

Cycle 3: It was found that 17 students in the target group passed the good level up criterion, representing 100 percent, which is considered to have achieved the objectives of the research set, the researchers therefore stopped organizing learning activities using socio-scientific issues at the end of the third cycle. When considering the total score for all components of the scientific explanations, the students had the mean score of ability to scientific explanation equal to 10.82 points out of 12 full scores, representing 90.20 percent. While considering the scores for each aspect, a total of 4 full points, it was found that the claim identification score, identification of evidence, and reasoning with mean scores equal to 4.00, 3.65 and 3.18 points, respectively, representing 100, 91.18 and 79.41 percent, this shows that in cycle 3, the students' mean scores in all components of the scientific explanation increased significantly from cycle 2. As shown in Figure 2.

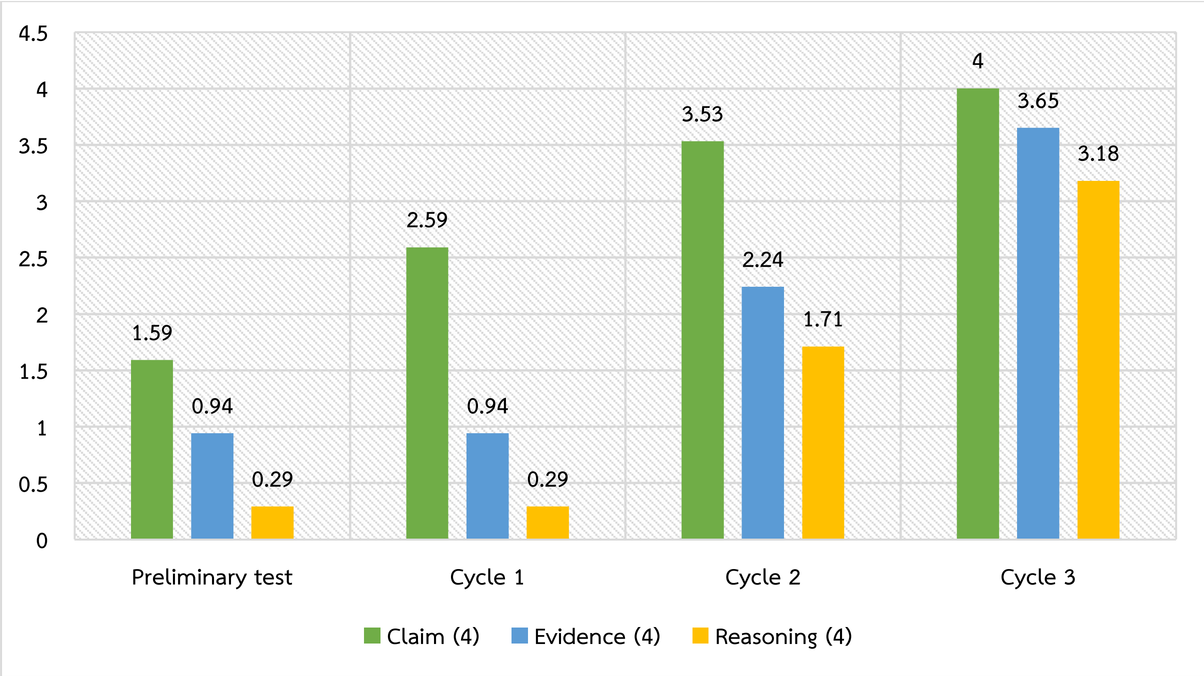

Figure 2 Mean score of scientific explanation

4. DISCUSSION

Development in each action cycle

Cycle 1 : From the analysis of the research results, it was found that students had the mean score for the ability to scientific explanations equal to 3.82 points. When considering individual scores, it was found that there were no students in the target group who had score passed the good level up criterion. However, even if the target group of students still does not have score pass the good level up criterion, it does not mean that Innovative socio-scientific issues learning is not effective in developing students' ability to scientific explanations. If considering the time spent on learning activities in cycle 1, the researchers spent only 5 hours, which in order to develop the ability of students to scientific explanations, it takes some time to learn and practice. Therefore, students can develop at a higher level, consistent with the research of Wanloh & Nuangchalerm (2022), which requires 6 hours and 14 hours of learning activities to be developed to enable students to develop scientific explanations. In addition, the reason why the target group of students did not pass the good level up criterion, may be due to socio-scientific issues that the researchers raised were too diverse in the content to be studied, and it's also a matter that is far from the students. As a result, students are unable to analyze the issues in order to connect them to the subject to be studied. The students were not interested in reading the socio-scientific issues in the paper because there were too many texts. Students use their ideas to write evidence and reasoning. Students also understand the word the “scientific principles” were inaccurate, even though before the start of the learning activities, the researchers had explained the meaning, component, characteristics and importance of the scientific explanation, along with giving examples of scientific explanations to students. Therefore, the researchers brought the problems in cycle 1 to improve and develop in cycle 2.

Cycle 2 : When improving the development of learning activities using socio-scientific issues learning from cycle 1, it was found that the students' mean scores for the ability to scientific explanations were 7.47 points. When considering individual scores, there were 14 students whose scores pass the good level up criterion, this shows that students are improving in creating better scientific explanations. This is because the researchers has improved and developed learning activities, by selecting socio-scientific issues that are close to the context in everyday life of students, and that can be perceived from various media. Keep asking questions to encourage students to think critically, articles are adjusted to be more concise, and find video clips about socio-scientific issues to insert in the article to encourage students to study the article. In addition, the researchers also improves and develops learning activities, by having students jointly criticize the scientific explanations that the researchers uses as an example to compare the good and bad scientific explanations, to allow students to classify and tell how the example scientific explanations has strengths and reading points. It will make students practice activities in order to obtain evidence that can be used to relate to scientific knowledge. Nuangchalerm (2014), said that socio-scientific issues that can be seen in everyday life, and that can be perceived from various media to help develop students' thinking, make decisions based on scientific knowledge, and have awareness of the social context. The teacher lets the students read the article and understand the problem situation that the teacher has selected. Problems that occur in real life and society close to students, make students analyze the situation, and be able to analyze situations, problems, issues, and facts in situations. And using questions to get students to think analytically will help students have the ability to discern to find the subsections of different content and what they consist of, and can see the relationship of related parts. The use of questions that lead to learners' learning must be questions that spark students' thinking, and questions must relate to the problem and be relevant to the student's daily life (Elsteest, 2001). This is consistent with the research of Babokaite (2009), which found that the use of multimedia media was interesting, and appropriate length to arouse the interest of students It can promote scientific explanation and student learning. Organizing activities for students to criticize examples of good and bad scientific explanations are compared, help students gain a better understanding of the components of scientific explanations.

However, there were still 3 students whose scores for scientific explanations did not pass the good level up criterion. This is because the students still do not quite understand the content in the unit on the subject of the respiratory system that they have studied in the class, each of which deals with socio-scientific issues. This makes students unsure of what keywords to use when searching for evidence, and making sure that the information contained in the article will be consistent with the subject studied or not, it also hinders the use of content as a scientific basis to link claims and evidence.

Cycle 3 : When the researchers improved and developed socio-scientific issues learning from cycle 2, it was found that students had the mean score of 10.82 points for the ability to scientific explanations. When considering individual scores, it was found that There are 17 target group students, all of whom have pass the good level up criterion. This may be due to the development of learning activities, by encouraging students to exchange knowledge and express their own opinions with friends within the group even more, to provide students with an understanding of content that guides them in searching for information in order to obtain evidence to support their claims and obtain evidence that is consistent with socio-scientific issues, and content studied. Then use knowledge and understanding of the content to reason to connect between claims and evidence. This is consistent with the research of Sulistina et al. (2021); Wanloh & Nuangchalerm (2022), which found that the students will have the ability to scientific explanations. Students must show behavior that students have to talk, communicate, exchange knowledge with friends within the group. The scientific explanation does not only require intellectual abilities, but communication skills are also required. This is consistent with the research of Nucharoen & Dahsah (2023), who studied that, if students understand the content, students will be able to use their content knowledge to explain simple scientific phenomena in contexts that are familiar or directly relevant to their daily lives. And it is also consistent with the research of Badeo & Duque (2022), who found that, teaching science using socio-scientific issues learning can have a positive impact on students' learning of the subject matter, and have better reasoning.

Component of scientific explanation of the 3 cycles

From the results of data analysis for all 3 cycles, it was found that students had the highest mean scores for claim identification. This may be because claims are the simplest elements, because it is a confirmation or preliminary answer to a question. The researchers uses questions for each group of students to collectively analyze, and discussing issues selected by the researchers to present through interesting media, to allow students to identify a claim based on available information on socio-scientific issues, and social considerations that exist in the minds of students. This is consistent with the research of Sadler & Zeidler (2004), socio-scientific issues learning, which bring interesting issues that are close to students as a base for organizing learning activities, and having students discuss the issues together will encourage them to build their arguments. This is consistent with the research of Suhandi et al. (2018), found that the use of provocative questions together with the use of situations from video clips resulted in students' ability to scientific explanations in terms of claims, climb.

In terms of identifying evidence, it was found that students' mean scores were second to those in identifying claims. This may be due to the fact that socio-scientific issues learning, there is a teaching process that promotes the identification of students' evidence, whereby students search for information. Find evidence using socio-scientific issues that are interesting and close to students as a base for searching. Students understand the content of the unit on the subject of the respiratory system according to the topics studied in the class, make sure students know which keywords to use when searching for evidence to support their claim, and make sure that the information contained in the article is consistent with the subject matter or not. Consistent with the research of Sandoval and Millwood (2005), that found that, evidence-based skills are a rare skill, in which the students will develop the skills to use evidence, students must have understanding socio-scientific issues and an understanding of the content of the evidence relevant to the socio-scientific issues is also required. Activities that encourage students to collect information or evidence, it is an activity in the form of facts about various situational issues, that will encourage students to collect evidence. Therefore, organizing learning activities that allow students to search and collect data, helps encourage students to identify evidences (Khajornkhae & Nuangchalerm, 2021).

In terms of reasoning, it was found that it was the component that the students received the lowest average score. Although the learning activities have a step that encourages students to reason. This may be due to the fact that some students who are the target groups do not participate in expressing opinions, discussing, and exchanging knowledge with their peers as they should. Causing students to not quite understand the content studied in the class. As a result, students scored less. Reasoning is the component in which students score the least in scientific explanation, and it's the hardest thing for students, which if students have knowledge or correct scientific concepts, it encourages students to reason to make connections between claims and evidences (Nuangchalerm, 2009; Lieber & Graulich, 2022).

From the research results, the researchers have discovered that socio-scientific issues learning can develop the ability to scientific explanations of the target group. This is because it is a learning arrangement where students learn through encountering socio-scientific issues that students are interested in, and it is an issue that students are aware of in their daily life through various media. Students are interested in studying and analyzing the issue in order to identify as a claim. As well as linking issues with the content studied as well. In making decision to assert a claim, students have identified the considerations of society to support their claims with morality and ethics. Students have been doing activities together as a group, talking, expressing their opinions, arguing, and discussing issues, and exchange, learn together. The researchers gives students the opportunity to use technology to search for information, independently collects information from various sources. It gives students the ability to choose evidence that is credible and sufficient to support their claims. The researchers also focused on biological knowledge, by having students do worksheets so that students understand the content that must be studied, this encourages students to use their knowledge to make connections between claims and evidence. There is an activity sheet for students to practice scientific explanations. In addition, the scientific explanation strategy is used to allow students to classify and identify the strengths and weaknesses of the explanatory examples (Herman et al. 2019; Mahanani et al, 2019(.

4. CONCLUSION

This study helps students improve their capacity to explain scientific concepts in a way that meets the good level-up criteria. The first cycle's findings revealed that 17 students did not meet the good standard; in the second cycle, students obtained an average score; 14 students achieved a good level of performance, while 3 students did not. On average, 17 students in the third cycle achieved a satisfactory level of performance.

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