RESEARCH ARTICLE

Students' scientific reasoning skills through RICOSRE model in environmental changes topic

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Abstract: The low level of students' scientific reasoning skills is caused by the low-quality learning process. Action is needed to improve the learning process by applying innovative learning models, the Reading, Identification, Constructing, Solving, Reviewing, and Extending (RICOSRE) learning model. This research aims to determine the effect of RICOSRE Learning Model on Students' Scientific Reasoning Skills on the Topic of Environmental Changes of Class X MAN 1 Medan. This research uses a quasi-experiment with Non-equivalent Control Group Design. The population of this study is all class X Science and Technology MAN 1 Medan. The sample consisted of class X Science and Technology 1 with the RICOSRE learning model and X Science and Technology 2 with the conventional learning model. The results of the research show that the average pre-test and post-test data for scientific reasoning skills in the experimental class are 35.65 and 79.14, moreover in the control group are 33.94 and 67.76. Data was analyzed using an Independent Sample t-test using SPSS Version 26. Based on the t-test calculation at α = 0.05, a significance of 0.000 is obtained, which means there is an effect of the RICOSRE model on the scientific reasoning skills of students on environmental change topics.

Keywords: environmental change topic; problem learning model; RICOSRE; scientific reasoning skills

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Introduction

The development of technology and science has progressed very rapidly (Asry, 2020; Mawaddah et al., 2021).This is one of the characteristics of the 21st century which aims to produce quality human resources (Boholano, 2017; González & Castillo, 2022). This century is also referred to the century of knowledge (Angga et al., 2022; Bebasari et al., 2022). This is in line with Diyah (2018) which states that science plays a very important role in this century. The progress of the 21st century is a challenge in all areas of life including education (Joynes et al., 2019; Schoppe-Sullivan & Fagan, 2020).

Education is a means of creating generations who are skilled in their fields (Schleicher, 2018; Miftahurrohman et al., 2021). 21st-century education requires students to have various skills. One of these skills is problem-solving skills (Rahman, 2019; Hulaikah et al., 2020). Wagner categorizes problem-solving skills as one of the seven skills that must be possessed in dealing with life and the world of work. Problem-solving skills are steps taken to produce the right solution (Huang et al., 2020). Problem-solving skills require students to be able to find problems and find solutions to a problem (Riyadi & Nikmaturrohmah., 2021).

The skills of thinking in solving problems must be accompanied by good reasoning skills (Hayati, 2020; Negley, 2022). Scientific reasoning skill is also a skill that must be possessed by human resources in the 21st century, but the facts show that scientific reasoning still cannot be developed optimally in the learning process. Teachers are less able to facilitate students to apply their reasoning skills in learning in class (Adriani et al., 2015).

The low scientific reasoning skills of Indonesian students at the international level can also be seen from

the results of the 2018 Program for International Student Assessment (PISA) test for Indonesian children. In general, Indonesia's position is ranked 70 out of 78 PISA participating countries (Summaries, 2019). This is also in line with the Trends in Mathematics and Science Research (TIMSS) assessment, which is one of the international studies assessing students' mathematics and science achievements, stating that in 2015 Indonesia was ranked 45th out of 48 countries with a reasoning skill score of 390 (Vebrian et al., 2016).

The descriptions above show that learning is needed that is able to empower thinking skills in solving problems accompanied by students' scientific reasoning skills. Problem-solving can be used as a basis for learning science models in class (Maskur et al., 2020). The problem-based learning model encourages students to connect knowledge with application in solving a problem (Ulger, 2018). One learning model that is able to facilitate practicing problem-solving skills is RICOSRE (Mahanal & Zubaidah, 2017). The RICOSRE learning model has six syntaxes including Reading, Identifying Problems, Building Solutions, Solving Problems, Reviewing Solutions, and Expanding Solutions (Mahanal et al., 2019). Models that have a problem-solving syntax can be applied in schools, especially in Biology subjects (Setiawan et al., 2021).

Biology learning is a lesson that tends to be rote learning (Suryanti et al., 2019). It is the reason why students find it difficult to understand biology lessons because studying biology is not by memorizing all aspects of the material, but by understanding the concepts contained in it (Yusup, 2018). Besides that, learning biology is not only about concepts or theories, but students also learn to observe various natural phenomena in life so that they can formulate problems, provide solutions, and solve these problems (Simatupang & Ionita, 2020; Saxe et al., 2021). A biology topic that is suitable to be applied to problem-solving-based learning models is the topic of environmental change (Tivani & Paidi, 2016). Environmental change is a topic that is full of environmental problems that must be resolved. Students who learn about environmental change topics can obtain information and learn about problems contained in the surrounding environment (Markowitz et al., 2018; Suryanda et al., 2018).

One alternative learning model that can improve students' scientific reasoning skills is the RICOSRE learning model. Scientific reasoning skills are needed to solve a problem. The RICOSRE learning model is able to facilitate students training in solving problems (Mahanal et al., 2019). By applying the RICOSRE model, students are expected to be able to improve their scientific reasoning skills through problem-based learning.

This research aims to determine the effect of using the RICOSRE learning model on students' scientific reasoning abilities at senior high school on the topic of environmental change. The benefits of this research are input and consideration for biology learning in schools by applying appropriate learning models to environmental change material to achieve learning objectives. It is then hoped that it can become a source of information and additional reference for teachers regarding the latest problem-solving learning models that are able to improve students' scientific reasoning abilities.

Method

This research uses a quasi-experimental method, the research design used is Nonequivalent Control Group Design (Table 1) (Bulus, 2021). The target population in this research was class X students at MAN 1 Medan. The sample in the study was selected using Purposive Sampling techniques. In conducting this research the sample is divided into two groups, namely the experimental group and the control group. The experimental group (X Science and Technology 1) is treated using the RICOSRE learning model and the control group (X Science and Technology 2) is treated using the conventional learning model.

Table 1. Non-equivalent Control Group Design

Class	Pretest	Treatment	Posttest
E	O_1	X_1	O_2
K	O_3	X_2	O_4

The description of the table is E = experiment class, K = control class, O_1 = initial test in the experimental group, O_2 = final test in the experimental group, O_3 = initial test in the control group, O_4 = final test in the control group, X_1 = treatment using the RICOSRE learning model, X_2 = treatment using conventional learning models.

Scientific reasoning abilities in this research are measured using the Modified Lawson's Classroom Test of Scientific Reasoning (MLCTSR) (Novia & Riandi, 2017). The scientific reasoning ability test used in this research includes 6 reasoning patterns that will be developed, namely conservation reasoning, proportional reasoning, control variable reasoning, probability reasoning, correlation reasoning, and hypothetical-deductive reasoning developed from Lawson's scientific reasoning pattern. The instrument used was 10 questions to fill in according to Lawson's Classroom Test of Scientific Reasoning (LCTSR) indicators with a score of 1-4 referred to Handayani et al., (2020). The content of the test includes material regarding environmental changes taught during the research. Each question represents an indicator of

scientific reasoning. Hypothesis testing uses an independent t-test with the help of Statistical Product and Service Solution (SPSS) version 26.

Results and Discussion

Based on the value of scientific reasoning skills, the average pretest score for students' scientific reasoning skills in the experimental class is 35.65 with a standard deviation of 7.79, the highest score is 47.5 and the lowest score is 12.5. The average pretest score for the control class is 33.94 with a standard deviation of 6.05, the highest score is 47.5 and the lowest score is 20.0. The average scores of the two samples are not significantly different, indicating that the initial reasoning abilities of students in both classes are the same (can be seen in Table 2).

Table 2. Results of Scientific Reasoning Skills of Experimental Group and Control Group Students

Class	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experiment Class	38	12.50	47.50	35.6579	7.79129
Posttest Experiment Class	38	67.50	92.50	79.1447	6.95731
Pretest Control Class	38	20.00	47.50	33.9474	6.05804
Posttest Control Class	38	52.50	82.50	67.7632	9.18631

After carrying out the learning activities, the average posttest score in the experimental class is 79.14 with a standard deviation of 6.95, the highest score is 92.5 and the lowest score is 67.5. Meanwhile, the average score in the control class is 67.76 with a standard deviation of 9.18, the highest score is 82.5 and the lowest score is 52.5. Both classes, both the experimental class and the control class, experienced an increase in the average value of scientific reasoning skills. However, the increase in the average value of scientific reasoning skills in the experimental class is higher than in the control class. Data on increasing students' scientific reasoning abilities in the experimental class and control class can be seen in Figure 1 below.

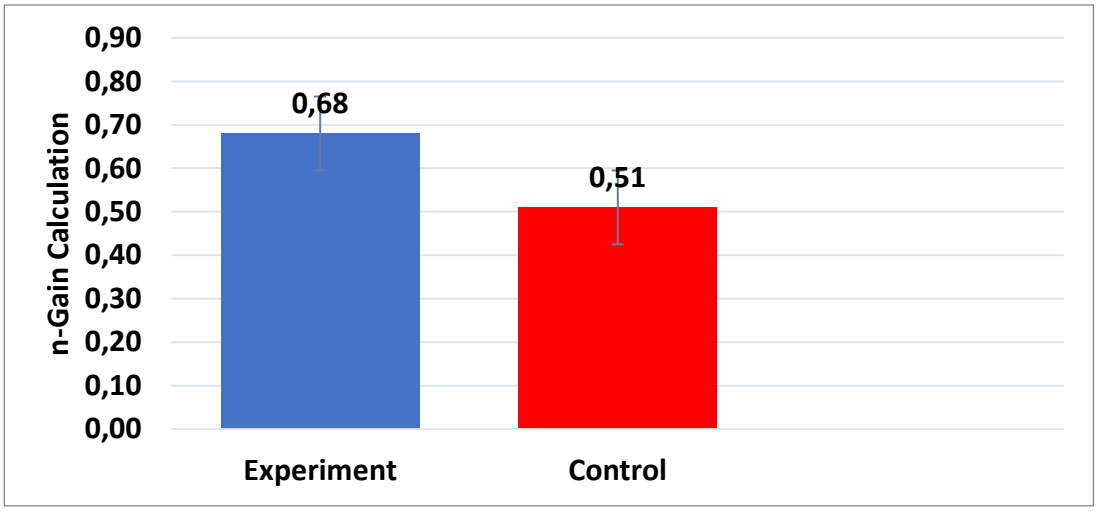

Figure 1. Diagram of Increasing the Scientific Reasoning Skills of Experimental and Control Class

The diagram in Figure 1 shows that there is a difference in the increase in students' scientific reasoning abilities in the experimental class and the control class. The experimental class that applied the RICOSRE model experienced an increase of 0.68 which was included in the medium category. Meanwhile, the control class has an average n-gain value of 0.51 and is included in the medium category. The experimental class experienced an increase of 68% which was categorized as quite effective, while the control class experienced an increase of 51% which was categorized as less effective. Based on the results of the n-gain score test, shows that the use of the RICOSRE model is more effective in improving students' scientific reasoning abilities than the use of conventional learning models.

The research results obtained showed that there are differences in the average posttest scores for students' scientific reasoning abilities in the experimental class and the control class. The experimental class showed an average posttest score of 79.14 while the control class was 67.76. The difference in average posttest scores in the RICOSRE classes is better compared to conventional classes. The results obtained are closely related to the learning activities implemented.

Learning with the RICOSRE model involves students actively understanding the concepts and principles

of the material because the characteristics of this learning are centered on solving problems carried out by students. This is supported by (Mahanal et al., 2019) who stated that the RICOSRE model of learning facilitates students to play a bigger role in the learning process. By applying the learning model, students are encouraged to think actively (Mulnix, 2012) and as a result, students participate enthusiastically in discussions and evaluation of learning activities. The ability to solve problems is in line with the ability to carry out scientific reasoning.

The differences in the results of students' scientific reasoning abilities are also caused by classes that use the RICOSRE model which is able to improve students' scientific reasoning abilities. In the process of applying theory, students understand the material better and develop problem solutions that can influence students' scientific reasoning abilities. This is in line with Mahanal & Zubaidah (2017) statement which states that the RICOSRE model is a problem-solving-based learning model that prioritizes thinking about problems, so it is effective in promoting students' higher-level thinking skills. One of the higher-order thinking skills is scientific reasoning ability.

Learning with the RICOSRE model begins with the activity of reading excerpts from articles on problems that occur related to environmental change as an introduction so that students get an idea of the material to be studied. After being given a discourse in the form of an article excerpt, students are formed into groups and given worksheets containing leading questions that can hone students' scientific reasoning skills because giving problems in students' worksheets trains students' thinking abilities.

There are six stages of implementing the Reading, Identification, Constructing, Solving, Reviewing, and Extending model in learning. The first syntax is reading. Reading is not only about expressing what is in the text but includes the process of constructing meaning (Akın et al., 2015). Reading also involves coordinating affective and cognitive components such as observing, focusing, having perception, memorizing, building relationships, analyzing, and interpreting (Cer & Sahin, 2016).

The second stage is identifying the problem. At this stage, students use information from reading activities to identify the problem of the given phenomenon. The problem solver, in this case, the students are required to identify an unclear and unstructured problem. At this stage, students' problem-solving skills are empowered because students are focused on solving the problems they find (Widiantie & Lismaya, 2017). Identifying the problem is a stage that warrants further theoretical search to produce a potential model for solving the problem. The problems that have been identified are then formulated in the form of questions.

The third stage is constructing solutions, at this stage students are trained to build solutions to problems that have been formulated in the previous stage. Constructing solutions students apply the skills and knowledge they have to solve problems (Tanujaya et al., 2017). The skills and knowledge required to solve problems are in line with reasoning abilities. Constructing solutions involves the process of filtering and combining information and ideas to build effective solutions. Through the analytical process, students determine the best and most feasible plan to solve the problem (Treffinger & Isaksen, 2013).

The fourth stage is solving the problem or using predetermined solutions to solve problems. Students in this activity implement solutions to problems determined in the previous stage. The problem-solving strategy represents one's thinking skills (Temel, 2014). Problems that can be solved at this stage help students understand the material they are studying.

The fifth stage is reviewing the problem-solving. The activity carried out at this stage is that students communicate the results of implementing solutions to problems that have been discussed with their group of friends by presenting the results of their discussions in front of the class. At this stage, there is also the activity of exchanging ideas to find ideas or solutions to the same problem. Activities at this stage can encourage students to think fluently, come up with ideas, and find new ways to solve problems so that at this stage they can also encourage students' creative thinking skills. The results of activities or activities in the fifth syntax can be utilized by students in the sixth syntax, namely extending the problem-solving.

After students communicate the results of their implementation and check the correctness of the solution, students are given other similar problems to solve. Extending the solution where students analyze how effective and efficient the strategy is and analyze the probability of applying the solution to similar problems (Bayazit, 2013). In this sixth syntax activity, students are asked several questions or other problems related to the material being studied. Extending problem-solving involves students thinking about solutions to solve problems, calculating possible suitable solutions, and making decisions from many solutions.

Problem-solving-based learning such as Reading, Identification, Constructing, Solving, Reviewing, and Extending prioritizes thinking about problems, so it is effective in promoting students' higher-order thinking skills which include students' scientific reasoning abilities. Different things happened in the application of conventional learning in the control class. In control classes, students are always facilitated and directed. The teacher presents the concepts before the investigation so that the investigation activities carried out by students are only activities that have been discussed previously, as a result, students are less able to develop.

Table 3. Summary of Data Hypothesis Test Results

Class	N	Mean	T	Sig.(2-tailed)	A	Conclusion
Experiment	38	79.14	6.08	0.000	0.05	H_0 rejected
Control	38	67.76				H_a accepted

The results of the hypothesis test in Table 3 show that there is a significant difference between the post-test scores for the experimental class and the control class with a significance value of 0.000 < 0.05. So it can be concluded that Ha is accepted which states that there is an influence of the RICOSRE learning model on students' scientific reasoning abilities. Based on the N-gain test, the experimental class which used the RICORSE model experienced an increase of 68%, while the control class experienced an increase of 51%. This shows that the RICORSE learning model has a greater influence than using conventional methods.

Conclusion

Based on the research results, it can be concluded that there is an influence of the RICOSRE on students' scientific reasoning skills on the topic of environmental change. The application of this learning model can be used as an alternative model for scientific reasoning skills because the syntax of the RICOSRE learning model requires students to be able to reason and solve problems.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

H. Hasruddin: data analysis; methodology, writing original draft preparation and reviewing. **R. N. Aulia:** data analysis, writing original draft preparation, editing/reviewing.

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