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Empowering College Students' Problem-Solving Skills through RICOSRE

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Abstract: Problem-solving skills are advantageous when resolving complicated and multidimensional challenges. Problem-solving skills can be developed through active learning models that engage students in the learning process. One active learning model is RICOSRE. The main focus of RICOSRE is problem-solving activities in (1) reading; (2) identifying the problem; (3) constructing the solution; (4) solving the problem; (5) reviewing the solution; and (6) extending the solution. The purpose of this study was to assess the ongoing development of problem-solving skills of students with upper, middle, and lower academic abilities at the Department of Biology Education in a state university in Indonesia. This study employed a concurrent embedded mixed-methods design. The repeated-measures ANOVA was used to test the hypothesis for the quantitative data, and NVivo 12 was utilized to analyze the qualitative data. The participants' problem-solving skills were determined by their responses to items on RICOSRE-integrated worksheets. The students' responses were graded using a validated and reliable problem-solving rubric. The findings indicated that the students' problem-solving skills improved consistently in the upper, middle, and lower academic groups that were taught by implementing RICOSRE.

Keywords: problem-solving skills development; RICORSE

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1. Introduction

Problem-solving skills are multifaceted mental activities involving cognitive skills [1] and affective and behavioral characteristics [2]. An effective problem-solving process is essential for a community's survival and future success. In addition, a person's daily life cannot be separated from increasingly complex problems, so problem-solving skills are needed to solve them [3]. Problem-solving skills enable students to overcome various obstacles in the workplace and other areas of life. Individuals' ability to solve problems is tied to their reasoning skills [4]. Therefore, the development of problem-solving skills should also be associated with higher-order thinking skills that facilitate the creation of practical solutions.

Problem-solving skills are necessary for college students to overcome various issues that arise in their social lives continually. Unfortunately, multiple similar studies indicate that college students have poor problem-solving skills that need to be strengthened. For instance, students enrolled in the Elementary School Teacher Education Program at Serang Indonesia Distance Learning Higher Education through discussion method demonstrated average problem-solving skills [5]. Similarly, prospective teacher students from Hacettepe University in Turkey possess intermediate problem-solving skills [6]. The findings of Ocak [7] using the Problem-Solving Inventory also show that prospective teacher students at Afyon Kocatepe University in Turkey have average problem-solving skills. In addition, Reddy and Panacharoensawad [8] distributed ten questions that can reveal students' difficulty in solving Physics problems. The results show that many students perform poorly in solving problems.

Research indicates that specific learning models affect student performance in solving problems. Applying problem-solving instruction can improve students' ability to solve problems scientifically [9]. Students' problem-solving skills can also be enhanced by discovery learning [10]. Besides increasing motivation, problem-based learning also positively affects students' thinking [11]. Cooperative learning in biology classes helps students develop higher-order thinking and scientific practice skills [12]. However, according to Hassan et al. [13], they argue that cooperative learning (CL) and problem-based learning (PBL) can improve skills as a social constructivist method, although there is little evidence to support this claim. This statement is one of the reasons they undertook a study to increase students' problem-solving skills using a mix of CL and PBL termed cooperative problem-based learning (CPBL). Hassan et al. [13] used qualitative and quantitative research approaches to examine the semester-long development of students' problem-solving skills. As a result, additional research is needed to determine the consistency of problem-based learning in increasing students' problem-solving skills. One of the problem-solving learning models in question is RICOSRE.

The RICOSRE learning model engages students in systematic and targeted problem-solving exercises. Numerous researchers have reported on the potential of RICOSRE to improve a variety of skills. RICOSRE is more successful than enquiry at increasing high school pupils' scientific literacy [14]. Additionally, RICOSRE can close the gap between students with low academic abilities and students with strong academic abilities in terms of critical thinking skills [15]. It is reported to significantly improve learners' problem-solving skills compared to conventional learning models [16]. However, no research has been conducted to determine whether RICOSRE has the ability to improve problem-solving skills in students with high, medium, or low academic abilities. As such, the purpose of this study was to investigate the effect of the RICOSRE learning model's implementation on the development of problem-solving skills in pre-service biology teachers with higher, medium, or lower academic abilities.

1.1. Problem-Solving Skills

The term problem solving is a colloquial term that refers to solutions to challenging situations. Problem solving also involves resolving a problem by applying analytical and critical thinking, creativity, reasoning, and experience [17]. A problem-solving process entails multiple strategic steps: defining the problem, assessing it, collecting relevant data, developing different solutions, evaluating alternative solutions, selecting the best answer, and generalizing the results [18]. To summarize, problem solving is an activity that demands adequate knowledge, abilities, and cognitive methods, as well as a systematic approach to solving a problem.

Problem-solving skills are critical for college students to learn since they help them establish a way of thinking. Students will interpret the problem, collect information, determine possible solutions, assess possibilities, and propose solutions. In this study, the problem-solving process includes reading, identifying the problem, constructing the solution, solving the problem, reviewing the solution, and extending the solution by being open to feedback and various information used to solve similar problems [15].

1.2. RICOSRE Learning Model

The RICOSRE learning model was developed by Mahanal and Zubaidah [19]. Several experts have introduced problem-solving-based learning models such as Polya, Krulick and Rudnick, and Carson. Then, using the research and development stages of Plomp, a learning model called RICOSRE was developed by modifying the problem-solving-based learning stages of some of these experts. The RICOSRE learning model has been declared feasible; namely, it meets the requirements of a valid, practical, and effective learning model [15]. RICOSRE itself is an acronym for the following stages of education: (1) reading, (2) identifying the problem, (3) constructing the solution, (4) solving the problem, (5) reviewing the solution, and (6) extending the solution. As stated below, the

RICOSRE learning syntax has many advantages: it can help students develop their creative thinking skills through various problem-solving tasks.

Reading is the first stage in the RICOSRE learning model. Through reading, RICOSRE enables pupils to acquire higher-order thinking skills. Reading is a valuable practice for obtaining information. Reading requires active intellectual engagement to generate meaning from the text they are reading [20].

The second stage of the RICOSRE Learning model is identifying the problem. The most critical stage in problem-solving is identifying the problem [21]. Students benefit from problem identification because it allows them to identify issues systematically. A well-defined problem significantly impacts the quantity, quality, inventiveness, and type of solutions presented.

Constructing the solution is the third stage in the RICOSRE learning model. At this stage, students generate a variety of possible problem-solving alternative strategies. Some strategies such as brainstorming, surveys, discussion groups, and others could be used to develop solutions. This solution-building process necessitates an analytical mindset to address a unique and fundamental problem [9].

The fourth stage of the RICOSRE learning model is solving the problem. Students execute the plan by implementing the solution selected during the solution-construction stage [22]. The chosen solution is the solution that is considered to be the most effective. A person's problem-solving tactics reflect their thinking skills.

The fifth stage of the RICOSRE learning model is reviewing the solution. Students will communicate implemented solutions to elicit comments from other students and expand on information gleaned from problem investigations. Additionally, students must delve deeper into previously obtained solutions to determine their usefulness and accuracy [15].

The sixth stage of the RICOSRE learning model is extending the solution. Students are required to evaluate the usability of the problem-solving technique adopted after reviewing the solution. Students might consider other strategies that are more effective at resolving comparable difficulties and generalize their findings to handle similar challenges effectively in the future [15].

2. Materials and Methods

2.1. Research Design

A concurrent embedded mixed-methods design was employed in this study [23]. In this research design, quantitative and qualitative data were collected at the same time, in the same priority. Quantitative data were analyzed as primary data to determine disparities in improving students' problem-solving skills for each topic presented. Qualitative data, used in conjunction with quantitative data, demonstrated changes in students' problem-solving skills for each topic presented. The study examined six categories of Protists: Chlorophyta, Euglenophyta, Pyrrophyta, Chrysophyta, Phaeophyta, and Rhodophyta.

2.2. Study Participants

The participants in this study were students enrolled in the Protista course at the Biology Department, a state university in Malang, during the even semester of the 2020/2021 academic year. The class had 30 students, 22 of whom were female, and 8 were male.

2.3. Instructional Procedures

This research has received ethical approval from the participating university and students. The research was performed with permission from the Head of the Institute for Research and Community Service (LP2M), Universitas Negeri Malang, under the 2021 Basic Higher Education Excellence Research Scheme No. 18.3.27/UN32.14.1/LT/2021. Students' ethical approval was gained at the start of the semester by explaining the semester lecture plan's model of instruction (RICOSRE) and the learning outcomes to be measured, namely concept mastery and problem-solving skills. The research was conducted entirely online.

The participants' academic abilities were grouped based on the Grade Point Average (GPA) they achieved in the previous semester, namely high, medium, and low academic abilities.

The instructional process relates to the RICOSRE learning model's learning stages. The participants were assigned activities on student worksheets that explored the following six themes from the Protista course.

- Topic 1: Chlorophyta
- Topic 2: Euglenophyta
- Topic 3: Pyrrophyta
- Topic 4: Chrysophyta
- Topic 5: Phaeophyta
- Topic 6: Rhodophyta

The student worksheets were formatted following the RICOSRE learning stages, as indicated in Table 1.

Table 1. RICOSRE learning stages for Protista course.

RICOSRE Learning Stages	Student Activities
Reading	Students summarize an article that discusses the lesson topic (e.g., Chlorophyta). The instructor has prepared the article in advance of the lesson's start. The summary should include the article's central idea and key elements (i.e., research questions, methods, findings, and implications).
Identifying the problem	Students identify the problem(s) found in the article, then formulate it into interrogative sentences.
Constructing the solution	Students perform literature reviews to develop solutions and steps necessary to resolve the identified problem. Students propose more than one solution.
Solving the problem	Students select the answer they believe is the most suited for resolving the problem at hand. Students complete the task by fixing the problem using the solutions developed in the preceding activity.
Extending the solution	Students evaluate the suitability of the problem-solving process to the problem formulation. After analyzing the solution's accuracy, students must analyze the strategy's efficacy and compare it to alternative strategies that would be more effective in solving similar problems in the future.

2.4. Instruments and Analysis

Student responses to RICOSRE-integrated student worksheets were analyzed for data on problem-solving skills. The students' responses were graded using a rubric that adapted the Association of American Colleges and Universities' problem-solving rubric [24]. The assessment rubric's validity and reliability were empirically validated using the Rasch partial credit model, based on Fisher [25]. The obtained MNSQ infit score (0.5) is included in the good criteria, as is the obtained MNSQ outfit score (1.0). The Pearson reliability score (0.79) is included in the fair criteria, and the item reliability value (0.86) is included in the good criteria. Table 2 contains criteria for evaluating the participants' problem-solving skills.

2.5. Data Collection and Analysis

2.5.1. Quantitative Approach

Data on the quantitative approach were obtained by measuring students' answers to the test using a Problem-Solving Skill rubric. Additionally, data for upper, middle, and lower academic abilities were gathered from each stage of the RICOSRE learning model. This study hypothesizes that the RICOSRE learning model affects students' problem-solving skills. ANOVA was used to test hypotheses about the development of problem-solving

skills in students with high, medium, and low academic abilities from topic one to topic six. The analysis employed a 5% level of significance and used SPSS 26 for *Windows*. In quantitative research, hypothesis testing was followed by effect size testing to ascertain the significance of differences between groups in terms of variables. The effect size value was obtained from the partial eta square coefficient.

Table 2. Problem-solving skills assessment rubric.

Activity	Exceptional (4)	Adequate (3)	Emerging (2)	Not Present (1)
Reading	The summary is accurate (containing the article's main idea), well organized, coherent, and well written. The summary contains the article's main points (i.e., the research questions, methods, results, and implications) and is written in the students' own words.	The summary is quite accurate despite some minor errors in uncovering the article's main idea and key points (i.e., the research questions, methods, results, and implications). The summary may be written in the students' own words or directly adopted from the article.	The summary is less accurate. It does not contain the articles' main idea or key points (i.e., the research questions, methods, results, and implications).	The summary is very limited. It does not contain the main idea and key points of the articles.
Identifying the problem	Students demonstrate the ability to write concise and perceptive problem statements that include sufficient contextual evidence.	Students demonstrate the ability to construct problem statements with relevant contextual evidence. The problem statements are quite detailed.	Students begin to demonstrate the ability to generate problem statements based on contextual facts, although the problem statements are brief.	Students demonstrate limited ability to identify problem statements or related contextual factors.
Constructing the solution	Students propose more than one solution/hypothesis, indicating a deep understanding of the problem.	Students propose one solution/hypothesis, indicating an understanding of the problem.	Students propose one solution/hypothesis that is not appropriate for solving the problem.	Students propose one solution/hypothesis that is difficult to assess because it is irrelevant to the problem statement.
Solving the problem	Students apply smart or innovative strategies or approaches to solve problems or develop reasonable solutions.	Students use an efficient or effective strategy/approach to solve the problem accurately or develop good solutions.	Students apply an appropriate strategy or approach to solve problems or create solutions.	Students apply strategies or approaches to solve problems or develop solutions.
Reviewing and extending the solution	Review of the problem-solving results is defined with specific and thorough consideration of the need for further work.	A review of the problem-solving results is defined with some consideration of the need for further work.	A review of the problem-solving results is defined with little consideration of the need for further work.	Review of the problem-solving results is superficially defined without considering the need for further work.

Modified from: the Association of American Colleges and Universities' rubric, 2017.

2.5.2. Qualitative Approach

The observational data were analyzed qualitatively, and the results of student problem solving were coded. Thirty students from a public university in Malang specializing in biology participated in the qualitative analysis. The qualitative data were analyzed in two stages. First, the group that improved the most from topic one to six at each problem-solving stage was identified. Second, the changes in the problem-solving components completed by students who earned the highest scores on the first, third, and sixth topics that referred to the problem-solving skills assessment rubric using NVIVO12 were coded. The participants' identities were concealed during the data analysis stage to preserve their privacy.

3. Results

Statistical analysis using repeated-measures ANOVA revealed that the *p*-value was less than α (0.05), which was considered significant (Table 3). This result indicates a considerable improvement in students' problem-solving skills from the upper, middle, and lower academic groups on topics one to six following RICOSRE implementation.

Table 3. Repeated measures ANOVA on the participants' problem-solving skills.

Source	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Problem-solving Skills	16.939	0.127	4.694	0.000	44.89	105.7	141.17	0.258

The lower academic abilities group reported the most significant increase in problem-solving skills (141.17%), followed by the medium ability group (105.7%) and the upper academic group (44.89%) (Table 3). These results demonstrate that the RICOSRE learning model can enhance students' problem-solving skills from various academic backgrounds, particularly those with lower academic standing (Figure 1).

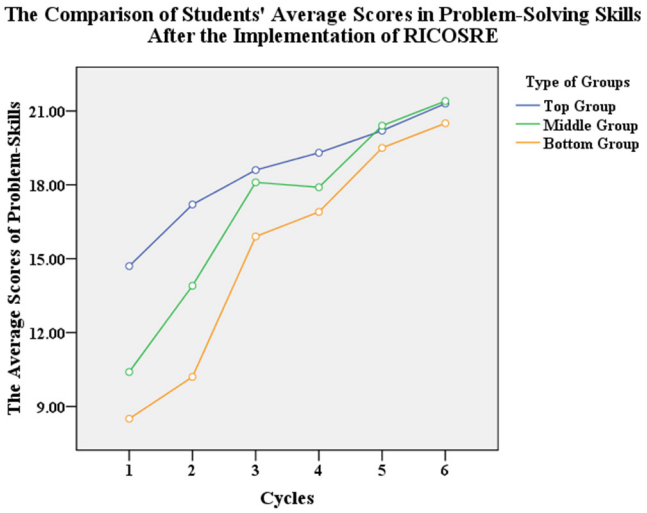

Figure 1. The comparison of students' problem-solving mean scores following RICOSRE implementation.

The statistical analysis of pairwise comparison revealed that the *p*-value was less than α (0.05), which was considered significant, with the following details: (a) Topic 1 to 2 was calculated as 0.000 to three decimal places using SPSS; (b) Topic 2 to 3 was calculated as 0.000 to three decimal places using SPSS; (c) Topic 3 to 4 was calculated as 0.001 to three decimal places using SPSS; (d) Topic 4 to 5 was calculated as 0.000 to three decimal places using SPSS; and (e) Topic 5 to 6 was calculated as 0.000 to three decimal places using SPSS (Table 4). Those results demonstrate that the increase in each topic was related to the rise in the previous topic.

The following sections detail students' problem-solving skills with upper, middle, and lower academic abilities at each stage of the RICOSRE learning model, from topic one to topic six.

3.1. Students' Reading Ability

The *p*-value for data on the participants' reading ability was 0.440 ($p > 0.05$), indicating no significance. The highest increase in reading ability, from topic one to topic six, was obtained by the moderate academic group (68.18%), followed by the lower academic group (52.7%) and the upper academic group (35.7%) (Table 5).

Table 4. Pairwise Comparison of the Participants' Problem-Solving Skills Following the Implementation of RICOSRE.

(I) Topic	(J) Topic	Mean Difference (I–J)	Std. Error	Sig. [a]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
2	1	2.567	0.850	0.000	0.823	4.311
3	2	3.767	0.659	0.000	2.414	5.119
4	3	0.500	0.257	0.001	−0.028	1.028
5	4	2.000	0.276	0.000	1.433	2.567
6	5	1.033	0.270	0.000	0.480	1.587

Table 5. Repeated measures ANOVA of the reading stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Reading	3.150	0.050	1.008	0.440	35.7	68.18	52.7	0.069

This result demonstrates no difference in students' reading ability development across academic groups on topics one through six. Although not considerably, students in the upper, middle, and lower academic groups improved their reading abilities on each topic (Figure 2).

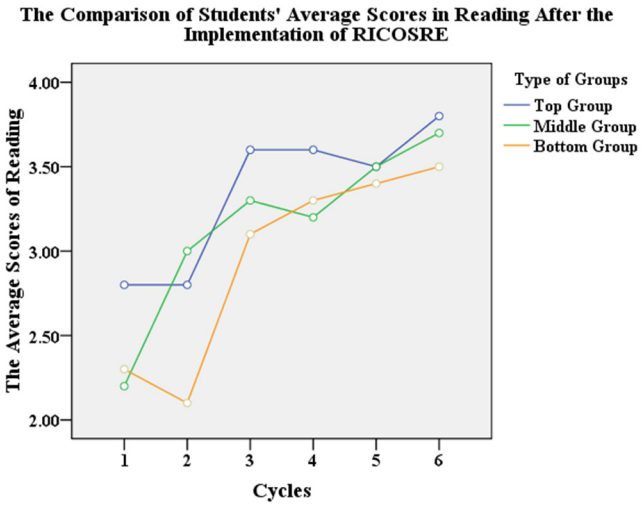

Figure 2. The comparison of students' mean scores of reading after the implementation of RICOSRE.

On the first topic, the students with middle academic ability demonstrated limited reading comprehension and were unable to include the article's main idea into a summary. On the third topic, the students progressed in reading by understanding the article's main idea but still included opinions in their writing. The most significant gain in reading comprehension was observed in the sixth topic, where students could arrange and coherently summarize the article's important points accurately. The students' reading ability improvement can be seen from their responses to the student worksheets, described as follows.

Topic 1—Reservoir is a large body of water home to various small fish and microscopic organisms known as phytoplankton. This research examined the diverse Chlorophyta species found in the Sumber Air Jaya Reservoir, Bululawang District . . . . The data indicated that the most frequent species were *Ulotrix sp*. (Participant 1).

Topic 3—Red tide episodes, most commonly referred to as Harmful Algal Bloom events. This phenomenon is because of the high nutrient levels and the calm waters, which

promote the formation of *Dinoflagellates* . . . . All of these unfavorable consequences are a result of the existence of harmful *Dinoflagellates*. The findings indicated that the seven different forms of *Dinoflagellates* identified in this study are . . . . (Participant 1).

Topic 6—Red algae are a type of macroalgae that can be found attached to other species. There is relatively little information about red algae in Indonesia's mangrove ecosystems . . . . This study aims to ascertain the species diversity and features of red algae found in mangrove roots. According to the study's findings, there were 11 species of red algae, precisely four species of the genus . . . . (Participant 1).

3.2. Student's Ability to Identify the Problem

Data on the students' ability to identify the problem showed a p-value of 0.017 ($p < 0.05$), indicating significance. The highest increase in problem identification ability from topic one to topic six was reported by the lower academic group (117.6%), followed by the middle academic group (90%) and the upper academic group (44%) (Table 6).

Table 6. Repeated measures ANOVA of the identifying the problem stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Identifying the Problem	2.906	0.053	48.0	0.017	44	90	117.6	0.341

This result demonstrates that students' ability to identify problems varied significantly among academic groups from topic one to topic six. Students with varying levels of academic aptitude significantly increased their ability to identify the problem associated with each topic (Figure 3).

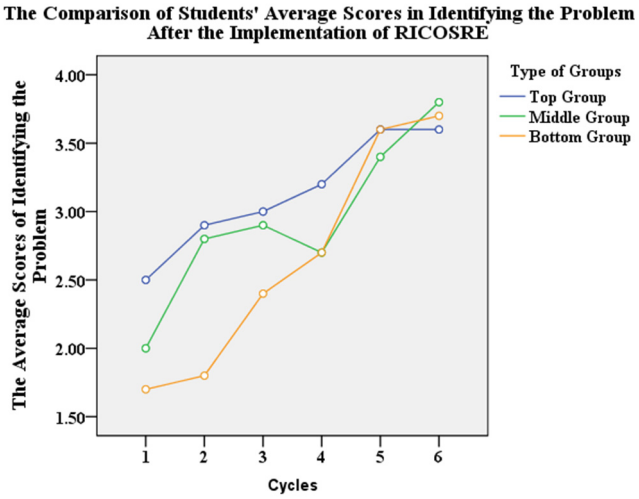

Figure 3. The comparison of students' mean scores of identifying the problem following the implementation of RICOSRE.

On the first topic, the students with lower academic abilities demonstrated a limited ability to identify contextual problem statements. On the third topic, the students could construct a problem statement with evidence, although the problem statement remains brief. The students performed to their best ability in identifying problems of the sixth topic. They built concise and insightful problem statements during this stage, accompanied by relevant contextual evidence. This result is indicated by the students' ideas in the student worksheets.

Topic 1—What should be done to clear the Kelingi River from domestic waste, including organic, inorganic, and liquid waste? (Participant 2).

Topic 3—What is the harmful impact of tourism development on the coastline waters in Padang, West Sumatra? What should be done to increase public awareness of Benthic Dinoflagellates' presence and danger? (Participant 2).

Topic 6—What is the red algae (Rhodophyta) composition that can be utilized as a skincare product? How effective is red algae (Rhodophyta) on the skin? (Participant 2).

3.3. Student's Ability to Construct the Solution

The *p*-value for the students' ability to construct the solution was 0.031 ($p < 0.05$), indicating significance. The highest increase in solution construction ability from topic one to topic six was reported by the lower academic group (209.9%), followed by the middle academic group (106.5%) and the upper academic group (58.3%) (Table 7).

Table 7. Repeated measures ANOVA of constructing the solution stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Constructing the Solution	2.711	0.058	48.0	0.031	58.3	106.5	209.9	0.381

This result demonstrates that the increase in the solution construction ability reported by the upper, middle, and lower academic groups varied significantly from topic one to topic six. The participants' ability to construct the solution improved considerably on each topic (Figure 4).

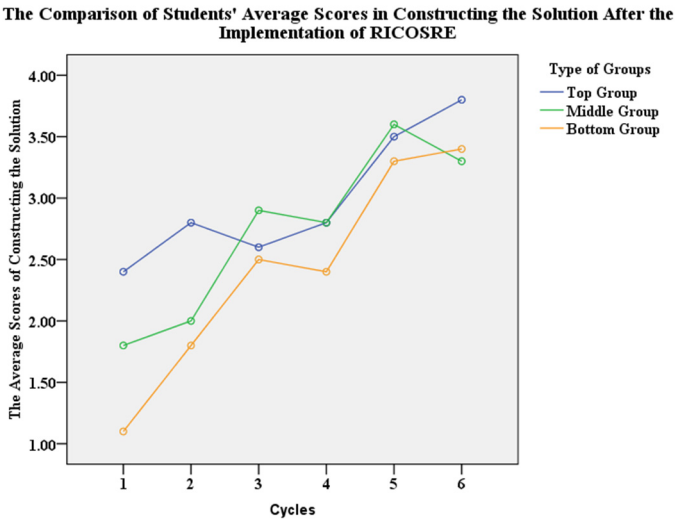

Figure 4. The comparison of students' mean scores of constructing a solution following the implementation of RICOSRE.

The highest increase in the ability to construct solutions was obtained by the lower academic abilities, as evidenced by the development of skills demonstrated by the students in constructing solutions for each topic. The students could not create a solution for the first problem, where the proposed answers were ambiguous and difficult to evaluate. The students could develop solutions on the third topic but could not demonstrate a depth of comprehension. However, the sixth topic proved the students' optimal capacity to create answers and a thorough comprehension of the problem at hand. This phenomenon is represented by the students' answers written in the student worksheets.

Topic 1—Given the nature of the Chlorophyta organism, which is capable of photosynthesizing and producing enormous amounts of oxygen, the utilization of these organisms will be centered on the creation of oxygen. (Participant 3).

Topic 3—The first step is identifying the *Dinoflagellates* species that create the poison. Then, further steps include monitoring and limiting *Dinoflagellates* growth and reducing activity around Weh Island's waters. (Participant 3).

Topic 6—Temporary remedies include as follows. (1) Conducting phytochemical analyses on red algae extracts to investigate their content. (2) Before determining the effect of red algae on experimental animals, testing is conducted on extracts of chemicals believed to affect the experimental animals. (Participant 3).

3.4. Student's Ability to Solve the Problem

The data on the students' capacity to answer the problem had a *p*-value of 0.069 ($p > 0.05$), indicating that it was not statistically significant. The lower academic abilities group obtained the highest increase in problem-solving ability from topic one to topic six (208.3%), followed by the middle academic abilities group (137.5%) and the upper academic abilities group (50%) (Table 8).

Table 8. Repeated measures ANOVA of solving the problem stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Solving the Problem	2.961	0.038	48.0	0.069	50	137.5	208.3	0.283

This result demonstrates no difference in the skill improvement of the academic abilities groups from topic one to topic six. The capacity of students in the upper, middle, and lower academic abilities groups to solve problems rose, but not dramatically, across all topics (Figure 5).

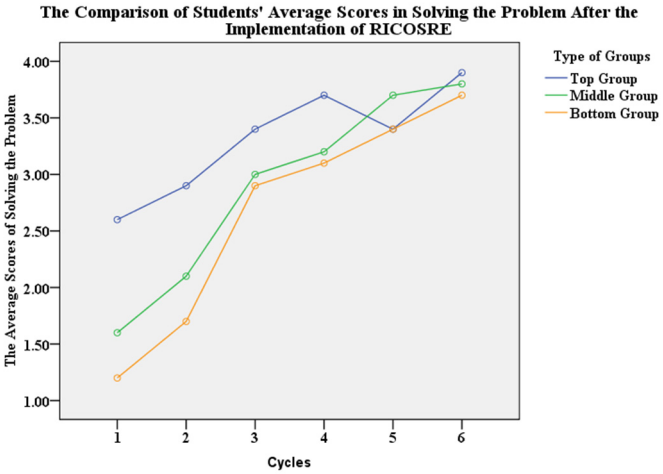

Figure 5. The comparison of students' mean scores of solving the problem following the implementation of RICOSRE.

Students in the lower academic abilities group displayed considerable progress in their problem-solving skills across the topics. For example, students could only develop solutions on the first topic. Still, they could legitimate their solutions and use specific problem-solving procedures on the third topic. On the sixth topic, the students demonstrated their superior problem-solving skills by utilizing a variety of tactics and unique approaches to resolving problems and providing valid and accurate solutions. This finding is confirmed by the student worksheets' list of student responses, as presented below.

Topic 1—Water pollution caused by rubbish or careless individuals can degrade the quality of the water. One of the efforts to conserve waters is by the use of bioremediation.

Bioremediation uses microorganisms that have been grown on specific pollutants to reduce the pollutant contents in water. (Participant 4).

Topic 3—Dinoflagellates or Pyrrophyta are frequently responsible for bioluminescence or red tides. Many fish perish when a red tide occurs due to clogged gills or a lack of oxygen. The methods necessary to overcome this phenomena are surveillance and direct observation of toxicity in areas . . . . (Participant 4).

Topic 6—Rhodophyta is a precious resource, but the Pangandaran area has not nurtured it, resulting in a lack of interest and knowledge about Rhodophyta . . . . Rhodophyta can be used to make gelatin in the industrial field, such as food and beverage, cosmetics . . . . Rhodophyta is helpful in biotechnology as a medium for bacteria, fungus, yeast . . . . Rhodophyta is also beneficial in the health sector as a source of polysaccharides and fiber (Participant 4).

3.5. Student's Ability to Review the Solution

The *p*-value for the students' capacity to review the solution was 0.014 ($p < 0.05$). The highest increase in students' ability to review the problem-solving results, from topic one to topic six, was observed in the lower academic group (181.8%), followed by the medium academic group (142.8%) and the upper academic group (40.9%) (Table 9).

Table 9. Repeated measures ANOVA of reviewing the solution stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Reviewing the Solution	2.606	0.035	46.0	0.014	40.9%	142.8%	181.8%	0.349

This result demonstrates disparities in the students' ability to review the solution across academic groupings and topics. Students from the higher, middle, and lower academic groups showed a considerable gain in reviewing the solution on each topic (Figure 6).

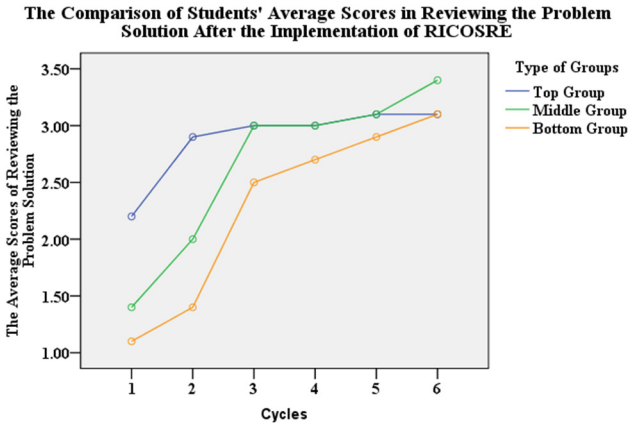

Figure 6. The comparison of students' mean scores of reviewing the solution following the implementation of RICOSRE.

Students from the lower academic abilities group showed significant progress on each topic. On the first topic, the students could only review the problem-solving results superficially. In contrast, they could add some considerations to reviewing the problem-solving results on the third topic. These students demonstrated the most optimal performance in reviewing the solution on the sixth topic, where they wrote down specific and thorough considerations when examining the results of problem-solving. This finding was revealed from the student worksheets submitted by the students.

Topic 1—Chlorophyta can survive because they have food reserves stored in their bodies and do not always seek sustenance. (Participant 5).

Topic 3—Based on the challenges and solutions presented, it is possible to begin controlling *Dinoflagellates* toxicity by maintaining a clean surrounding environment and improving waste disposal and sanitation. (Participant 5).

Topic 6—Red algae can supply a significant amount of food for fish and other water creatures. *Chondrus crispus* (Irish moss) and numerous genera Porphyra are also used as food by humans. *Chondrus crispus* and *Gigortina mamylose* produce carrageenan, useful for tanners, creams, and hair washes. (Participant 5).

3.6. Student's Ability to Extend the Solution

Data on the students' ability to expand the solution obtained a *p*-value of 0.014 ($p < 0.05$), indicating significance (Table 10). This result proves a difference in the students' ability to extend the solution across the academic groups and topics. The students experienced a significant increase in extending the solution on each topic (Figure 7).

Table 10. Repeated measures ANOVA of extending the solution stage.

Stage	Mean	SD	F	Sig.	Increase (%)			Partial Eta Squared
					Top Group	Medium Group	Bottom Group	
Extending the Solution	2.606	0.035	46.0	0.014	40.9%	142.8%	181.8%	0.349

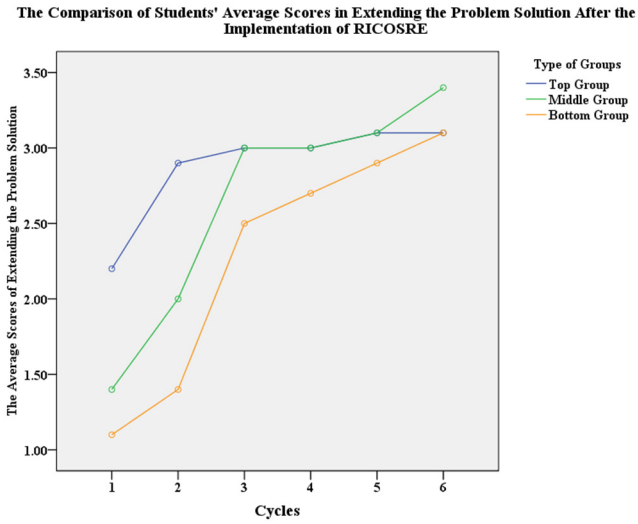

Figure 7. The comparison of students' mean scores of extending the solution following the implementation of RICOSRE.

The highest increase in students' ability to extend the solution, from topic one to topic six, was found in the lower academic group (181.8%), followed by the medium academic group (142.8%) and the upper academic group (40.9%) (Table 10).

This result proves a difference in the students' ability to extend the solution across the academic groups and topics. The students experienced a significant increase in extending the solution on each topic (Figure 7).

The students' lower academic abilities group demonstrated significant progress in gradually extending the solution on each topic. The students did not include further needs considerations in expanding the solution on the first topic. Still, they experienced a slight development on the third topic by having further needs considerations to extend the solution. On the sixth topic, students scored optimally when extending the solution by wholly and carefully evaluating additional needs. This finding is confirmed by the student's responses to the student worksheets.

Topic 1—Chlorophyta can reproduce itself by sexual reproduction infusion of male and female sex cells and undergo conjugation. Chlorophyta can also reproduce asexually by fragmentation, binary fission, and zoospore generation. (Participant 6).

Topic 3—Ecosystem preservation is also necessary to keep *Dinoflagellates* from becoming a time bomb for humans. Additionally, carbon charcoal can be used to detoxify poisons other than those found in Dinoflagellates, as long as the dose is administered correctly. (Participant 6).

Topic 6—Red algae, such as *Gelidium* and *Agardhiella*, are farmed for their ability to produce gelatin. Researchers utilize it as a bacterial culture medium and solid phase in gel electrophoresis, as a food thickening, textile glue, laxative, and dessert. Phycoerythrin is the most abundant pigment responsible for the reddish hue of this algae's thallus. It is bright red at middle depths but slightly greenish at very shallow depths. (Participant 6).

4. Discussion

Problem-solving skills are widely recognized as critical in times of rapid change. This phenomenon is because in the knowledge era, problems are unpredictable, unstructured, and cannot be solved with simple remedies alone [26]. A competent problem solver will employ particular tactics to arrive at a successful solution. RICOSRE learning is a means for students to become real problem solvers by reading, identifying the problem, constructing a solution, solving the problem, reviewing the solution, and extending the solution to gain feedback [15].

The findings of this study reveal that students in the upper, middle, and lower academic abilities groups had a considerable improvement in problem-solving skills between topics one until six. These findings demonstrate that the RICOSRE learning model can consistently assist students from diverse academic abilities backgrounds to resolve problems when integrated into asynchronized learning. Numerous studies have established a positive correlation between problem-solving abilities and other higher-order thinking skills, such as critical thinking [27] and creative thinking [28]. The RICOSRE learning model has been proven to promote critical and creative thinking, science process skills [29], and scientific literacy in the classroom [14].

The statistical analyses in this study indicate that the RICOSRE learning model can improve students' problem-solving skills from the higher, middle, and lower academic groups. The lowest academic group achieved a tremendous increase in problem-solving abilities (141.17%). Specific improvements in the problem-solving skills of the upper, middle, and lower academic groups were observed at each stage of RICOSRE. However, upon additional research, it was shown that certain implementations of the RICOSRE stages were less than optimal, resulting in a non-significant increase in the participants' problem-solving ability.

Reading is the initial step of RICOSRE learning. According to studies, reading activity integrated with teaching materials has a beneficial influence on student learning outcomes and enhances student performance [30]. Basaran [31] asserts a correlation between reading fluency and learners' comprehension of a topic. Students who excelled at reading also excelled at problem-solving. Good readers know which strategy to use when reading the text, whereas bad readers have problems understanding it, so they cannot solve a problem [32]. Ulu [33] discovered that reading ability affects students' understanding of a topic, indirectly affecting students' problem-solving skills. Reading comprehension is critical for problem-solving because it enables students to comprehend an issue, pick necessary information, transform knowledge into alternative answers, and arrive at solutions [34,35].

The second stage of RICOSRE is identifying the problem. The statistical analysis findings of students' ability to identify problems showed a considerable increase. Students from the lower academic group increased their capacity to identify problems by the most significant margin. The first step in problem solving is identifying the problem by contextualizing it. Students might engage in critical thinking processes as a result of problem identification. Evaluating and processing data can yield an accurate depiction

of the situation. Students who are adept in identifying problems demonstrate a greater comprehension of the problems [36,37].

The third stage of the RICOSRE problem-solving process is solution construction. The lower academic group achieved the most significant improvement in their capacity to build solutions. Students from this academic category initially performed poorly in solution construction, with their solutions remaining challenging to evaluate. However, after implementing RICOSRE in the classroom, their capacity to create solutions improved significantly. According to Wang and Chiew [1], solution construction is a critical cognitive process that results in creative solutions. Yu et al. [38] discovered that students who can construct solutions could associate knowledge from various sources. Constructing solutions has consequences for developing higher-order thinking literacies [39], affecting the quality and uniqueness of solutions to various real-world issues.

Solving the problem is the fourth stage of RICOSRE. Students' ability to solve problems on each topic, showing a non-significant gain. The group with the lowest academic ability showed remarkable improvement in problem-solving skills. At first glance, the students in the group appeared to be incapable of addressing problems by devising solutions in the absence of strategies. However, after implementing RICOSRE, the students could employ novel tactics and methodologies to create legitimate and correct solutions. The problem-solving stage is critical in developing students' ability to solve difficulties [40]. Solving a problem entails a cognitive process that transforms a given circumstance into purposeful and methodical. Problem-solving is associated with applying cognitive abilities to select from various solutions when confronted with complex problems in daily life [41,42].

The fifth stage of the RICOSRE learning model is reviewing the solution. The statistical analysis of students' ability to review the solution showed a considerable increase. Students from the lower academic group increased their capacity to review the solution by the most significant margin. Reviewing the solution is the stage during which learners examine their assertions. Learners are encouraged to create their original statement during this stage. Through communication, they can be given feedback and supplement information about their problem investigations [43]. Foster et al. [44] discovered that students use problem-solving reviews to hone concepts and judge the accuracy and usefulness of strategies employed to solve the problems.

Extending the solution is the sixth stage in the RICOSRE learning model. The statistical analysis of students' ability to extend the solution increased considerably. Students from the lower academic group increased their capacity to extend the solution by the most significant margin. Students in this group made quick progress in extending the solution, moving from not considering additional needs to deliberately and thoroughly considering other needs to expand the solution. Extending the solution is a multi-stage process in which the good and negative features of various solutions are weighed and merged to determine the overall solution [45]. Elvira et al. [36] discovered the real problem solvers would evaluate potential solutions twice as often as beginners when examining a case. Celik et al. [46] found that students assess the adequacy of a solution by reviewing the effectiveness of the chosen problem-solving technique. Students do this to anticipate and tackle similar problems more efficiently.

The findings of this study demonstrate that students enrolled in the Protista course could consistently enhance their problem-solving skills using the RICOSRE learning model. Students with varying academic levels improved problem-solving skills across different topics. However, a closer examination revealed that only students in specific academic groupings reported a considerable increase. For example, the moderate academic group reported the most significant improvement in reading skills, whereas the lower academic group reported the highest increase in identifying the problem. According to the findings of this study, it is recommended to employ the RICOSRE learning model in Biology classes to help students develop their problem-solving skills, as each individual needs these skills to deal with complex and multidimensional challenges.

5. Conclusions

The findings of this study suggest that integrated RICOSRE learning can consistently increase students' problem-solving skills from a variety of academic backgrounds. Consistent progress is possible by optimizing each RICOSRE stage. The reading stage helps students develop their reading comprehension and encourages them to comprehend difficulties and select pertinent information. Students can determine the steps necessary to accomplish a goal by identifying the problem stage. Constructing the solution stage motivates pupils to produce high-quality work. Solving a problem promotes the creation of appropriate solutions for the problem's resolution objectives. Reviewing the solution teaches students to evaluate the problem-solving outcomes to gauge the solution's efficacy. Extending the solution teaches students to evaluate the solution's suitability for advanced needs, preparing them to solve difficulties on an ongoing basis.

Implementing the RICOSRE learning model trains students to become consistent problem solvers. The learning experience gained by the students in this study demonstrates how the RICOSRE learning model can prepare students to become competent problem solvers. We hope that the RICOSRE learning model can be used outside biology classrooms. Additionally, this study demonstrates how teachers can effectively apply asynchronized learning to help students gain the necessary abilities to function in society. This study was only conducted on 30 students enrolled in the Protista course with no control class involved. Therefore, future research could concentrate on developing quasi-experimental studies that employ a control class that is stricter in class screening. More in-depth studies can be conducted to determine the influence of RICOSRE on the higher-order thinking skills of junior and senior high school students.

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