



Improving Students' Critical Thinking Through the Learning Strategy "Students as Researchers": Research Based Learning

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Abstract: Critical thinking is an intellectual process in making ideas and concepts logically and allows students to analyze their thinking in making choices and drawing appropriate conclusions. However, in fact, in the observations made by lecturers on students, it is still difficult to understand and complete the tasks given by the lecturers, students' critical thinking skills are still low. This study aims to improve critical thinking skills through the "student as researchers" strategy. This study uses quantitative analysis with a one group pretest posttest design. The sample in this study were Biology Education students in semester 3 (three) class A who took the Learning Media course. Data were obtained from critical thinking questionnaires and observation sheets. The data were analyzed through significance test and Gain Normalization. The research data shows that students' critical thinking abilities have increased by 0.70 in the high category after participating in learning with the "Student as Researcher" strategy. The indicator for compiling "able to express ideas/ideas" is an indicator that has the highest increase compared to other critical thinking indicators, which is 0.79 in the high category. It can be concluded that the "student as researchers" strategy can improve students' critical thinking skills.

Keywords: Critical thinking; Research based learning; Students as researchers

Introduction

Critical Thinking is a bridge to help individuals find answers to the problems they face. Critical thinking is also one of the important skills in facing the 21st Century, so it is important that this skill is trained and developed (Changwong et al., 2018). Critical thinking skills need special attention, because according to Alvionita et al. (2020), critical thinking is a high-level thinking ability that has the potential to increase one's analytical power which is closely related to intellectual abilities and helps students achieve success. Critical thinking skills have been identified as essential and important life skills or life skills Changwong et al. (2018). Some descriptions of critical thinking skills are the ability to interpret, inference, analyze, and evaluate, as well as synthesis which is closely related to analytical

and reflection and involves questioning, testing activities (Firdaus et al., 2015). For this reason, it is important to develop, train and improve critical thinking skills for prospective teacher students, because according to Alvionita et al. (2020) and Ririen et al. (2023) critical thinking skills are not an automatic inheritance from every student but can be trained through guided practice. Focusing on student teacher candidates means that we help prepare two generations at once because prospective teachers are the liaison and transferor of knowledge and skills back to prospective students.

Critical thinking can be used as a means to solve problems, make decisions, seek answers, enrich meaning, and fulfill one's curiosity (Alvionita et al., 2020). According to Kurnianto et al. (2019), critical thinking is an intellectual process in making ideas and concepts logically and allows students to analyze their

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thinking in making choices and drawing conclusions appropriately. However, the fact is that in the observations made by lecturers on students, it is still difficult to understand and complete the tasks given by the lecturers, this is evident from the inability of students to obtain maximum grades and from student answers that are still at the level of thinking, knowledge and understanding. Based on the results of interviews, information was obtained that students were still accustomed to completing assignments by copying or just copying and pasting from existing information sources without first analyzing the questions or assignments given, so students' analytical skills were still very low. Students said they found it difficult to find a new idea to construct existing concepts into a series of solutions to existing problems.

Seeing this phenomenon, it encourages lecturers to innovate in carrying out the learning process. In order to improve good critical thinking skills, the learning process must be packaged in such a way that students are actively involved in the learning process because critical thinking has become a very popular term in education. Critical thinking can be stimulated through learning that emphasizes the importance of learning through a process to gain experience (Setyowati et al., 2020). Critical thinking allows someone to make breakthroughs, verify facts, and think outside the box that can directly affect students' potential by applying information effectively so that students can decide and find the right solution to the problems they face (Hafni et al., 2019). According to Mahardini et al. (2018) and Susiani et al. (2018) research-based learning is one of the learning strategies that can be carried out and is effective in improving students' critical thinking skills where students become researchers ("student as researchers"). Further, Susiani et al. (2018) suggests that research-based learning is learning that can construct understanding, past learning, learning that involves social interaction, and meaningful learning achieved through experience, so that a strong relationship is formed between learning, learning experiences, and new discoveries through research activities. Research-based learning encourages students to actively participate and solve problems logically, systematically, and accurately.

Several studies that discuss research-based learning, including research conducted by Tungkasamit (2019), found that research-based learning improves research skills and student achievement and the level of student satisfaction with research-based learning systems is in the high category. Research conducted by Susiani et al. (2018), found that the implementation of research-based learning can develop critical thinking skills and improve the quality of learning as well as make positive changes in the intellectual and emotional aspects of students. Furthermore, it is reinforced by the

results of research conducted by Mahardini et al. (2018), namely the implementation of research-based learning is an effective approach in improving critical thinking skills and student learning outcomes, research-based learning is the center of a learning model that integrates research into the learning process. The learning process combines research experiences to students in the learning process in finding new knowledge so that meaningful learning will be realized. Several previous studies examined research-based learning at the high school level, there are still very few studies that focus on the tertiary level with the subject of student teacher candidates. Indeed, student teacher candidates are the forerunners of human beings who will distribute knowledge, skills, and attitudes to their students in the future. Furthermore, several previous studies have not discussed the effects of research-based learning on students' critical thinking skills in terms of Marzano's frame of mind. Marzano suggested that critical thinking ability is one of the dimensions of the habit of thinking (Habits of Mind) and has several aspects that become indicators of critical thinking ability.

Based on the above review and as a manifestation of the Vision of the University of Riau in general and the FKIP's mission specifically related to the implementation of research-oriented education and teaching, the researchers are interested in conducting research with the title "Improving Student Critical Thinking through Learning Strategy "student as researchers": Research based Learning! " This research also prepares the golden generation to be able to compete in facing challenges in the 21st Century with the provision of critical thinking skills that will be developed. This study aims to improve students' critical thinking skills through the "student as researchers" learning strategy.

Method

This study uses quantitative data analysis. The research design used was One-Group-Pretest-Posttest, this design was used to compare the pretest and posttest in the experimental group. The test was carried out twice, namely before the class was given treatment (pretest) and after the class was treated (posttest). The treatment in this research is to apply the lecture strategy "student as researchers". The source of data in this study is the primary source, namely students. According to (Sugiyono, 2018), primary data is data collected by researchers directly from the first source or the place where the object of research is carried out. The population in this study were all students of Biology education at the University of Riau. The sample in this research is Biology Education student in semester 3

(three) class A who takes the Learning Media course. The sampling technique is through purposive sampling. The following is the research design:

Table 1. Research Design

Group	Pretest	Treatment	Posttest
E	O ₁	X _{SAR}	O ₂
Description			
E	: Experiment Group		
O ₁	: Pretest		
X _{SAR}	: Learning Strategy "student as researchers"		
O ₂	: Posttest		

The research data were obtained from (1) Modified Critical Thinking Questionnaire from Marzano, the questionnaire was given before and after lectures using the "student as researchers" strategy, the questionnaire aims to describe students' Critical Thinking abilities before and after the implementation of the lecture strategy "student as researchers", (2) The observation sheet aims to describe the implementation of the "student as researchers" lecture process by emphasizing the description of students' Critical Thinking indicators. Observation sheets are used during the lecture process using the "student as researchers" strategy. Through the observation sheet, it will be seen how the development of students' Critical Thinking abilities. Before the instrument is used in the study, validation is carried out on expert judgment. After that a trial was conducted, the ordinal data obtained from the questionnaire was first converted into interval data through MSI.

The data were analyzed quantitatively to determine the level of validity and reliability of the instrument. The data obtained were first tested for prerequisite analysis, namely the normality test. The data normality test was conducted to determine whether the data obtained from the population were normally distributed or not. Furthermore, the significance test was carried out, the data were analyzed through the SPSS program. The data obtained from the students' critical thinking questionnaire data at the beginning (pretest) and at the end (posttest) will be used to find the N-gain value. The N-gain value serves to find out how much improvement in students' critical thinking after following the learning strategy with the "student as researchers" lecture. To get the N-gain value, the following formula will be used:

$$N - Gain = \left(\frac{\text{posttest score} - \text{pretest score}}{\text{Maximum score} - \text{minimum score}} \right) \quad (1)$$

The N-gain/gain index obtained (pretest and posttest) shows the category of increasing students' critical thinking. These categories can be seen in Table 2.

Table 2. N-gain Score Categorization

Score	Category
0.70-1.00	High
0.31-0.69	Medium
0-0.30	Low

Class observation data listed on the observation sheet during lectures with the "student as researchers" strategy were analyzed by calculating the percentage. Based on these data, it is known that the critical thinking achievement of students who are trained every time is learning by using the "student as researchers" lecture strategy. Table 3 presents the criteria for the percentage of values obtained.

Table 3. Categorization of Results Percentage Observation Sheet

Score (%)	Category
86 - 100	Very good
76 - 85	Good
60 - 75	Enough
55-59	Less
≤ 54	Very Less

Result and Discussion

Improvement of Critical Thinking Indicators on Learning Strategy "Student as Researchers"

Marzano divided critical thinking ability into several indicators, namely (1) accurate and seeking accuracy, (2) clearly seeking clarity, (3) being open, (4) able to provide ideas, (5) is sensitive and knows the abilities of his friends. The value of increasing critical thinking abilities before being tested for significance is first carried out with a prerequisite test, namely the normality test. Furthermore, the data is processed through a significance test and the results of the Sig value are obtained. (2-tailed) < 1/2α (0.005) which is 0.000, it shows that there is a significant difference between the average critical thinking questionnaire scores before and after the implementation of lectures with the "Students as Researcher" strategy. The average initial score, final score and N-gain for each critical thinking indicator are presented in Figure 1.

The data in Figure 1 shows that through the learning strategy "student as researchers" can improve students' critical thinking skills as seen from the N-Gain value data, which is 0.70. In the learning system using the "student as researchers" learning strategy, students are trained to be able to conduct research on the development of a simple biology learning media product through the development stage consist of Analysis, Design, Development, Implementation, and Evaluation. The details of student activities in implementing learning with the "student as researchers"

learning strategy are: (1) Analysis, students conduct a needs analysis on the development of simple learning media through interviews and observations of teachers in the education unit. (2) Design, students make product designs in the form of simple learning media needed to overcome existing problems based on the results of the needs analysis that has been carried out, (3) Development, students develop simple learning media products (prototypes) according to the designs that have been designed, then expert validation of the media was carried out, (4) Implementation, students made learning videos by implementing simple media designs in learning, (5) Evaluation, students evaluated simple learning media that had been made.

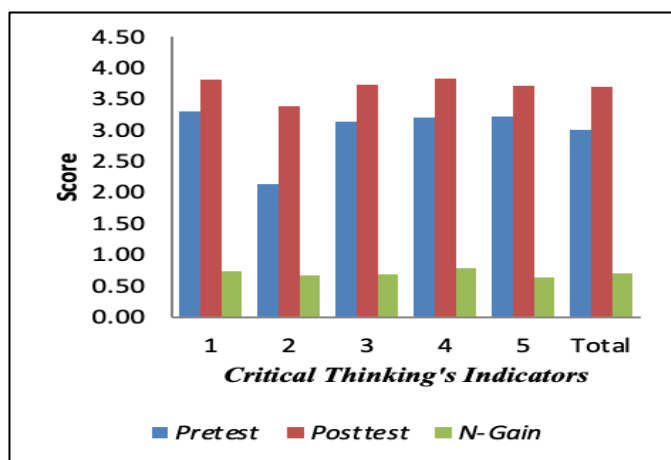


Figure 1. Graph of the Average Initial Score, Final Score, and N-Gain Critical Thinking

Note: (1) accurate and seeking accuracy, (2) clearly seeking clarity, (3) being open, (4) able to provide ideas, (5) being sensitive and aware of the abilities of his friends.

The "student as researchers" lecture strategy is a learning strategy that facilitates students to be able to conduct investigations and become actors or actors in a study. This learning makes students act as researchers who explore and investigate independently existing problems and then develop a product to overcome existing problems. These activities will build their critical thinking skills, as stated by Mutakinati et al. (2018) and Saputri et al. (2020) through scientific investigations can encourage students to face life's challenges to adapt in solving problems so that they can practice critical thinking skills. Research-based learning is a strategy that integrates research in learning to build knowledge, develop scientific attitudes, critical thinking skills in finding solutions. Critical thinking refers to the ability to analyze information, determine the relevance of the information collected and then interpreted to solve problems. It requires the highest level of thinking involving a process of analysis, evaluation, and

reflection. Critical thinking and communication skills must be possessed by students for their future. This is also supported by the opinion Yulhendri et al. (2018) that research-based learning is a learning system that uses problem-solving, direct learning, inquiry and discovery approaches, referring to the constructivist philosophy aimed at creating a learning process that leads to activity analysis, synthesis, and evaluation, as well as improving the ability of students and lecturers in terms of assimilation and application of knowledge.

Based on the results of research conducted by Mutakinati et al. (2018), that project-based learning can organize systematic practice, build realistic criticism of their thoughts so as to improve their critical thinking skills. In the process of developing learning media that is carried out during lectures using the "student as researchers" strategy, students are also trained to develop their own projects through scientific stages to produce learning media products that can help students understand the concept of the material. During the completion of the project, students can criticize their own thinking, try various methods and combine several methods in making a good product so that the product becomes a solution to the existing problem. Based on these habits, it means that they are trained to always seek accuracy in developing ideas.

Each stage of the "Students as Researches" lecture strategy can train students' critical thinking skills. Through the needs analysis stage (Analysis) by interviewing teachers in the education unit, students are trained in finding problems, after that students design a product in the form of learning media to overcome these learning problems, students also of course collect various sources of information in developing good learning media, then analyze the facts that exist during the implementation or test the media that has been designed. According to Lamsihar et al. (2020) that critical thinking skills are trained through 1) Finding problems, 2) Finding solutions to problems, 3) Finding and collecting information, 4) Analyzing data and facts, 5) Drawing conclusions. Students should be involved in the learning process in which theory and practice emerge and are interconnected. Students also need courses that are theoretically oriented and require skills such as observation, interviewing and interpretation in developing their critical thinking skills.

Based on Figure 1 on the research data, it shows that the indicator "able to provide ideas" is an indicator that has the highest N-gain value, which is 0.79 in the high category. The stages in the "student as researchers" lecture strategy provide opportunities for students to come up with and provide ideas. In the product design step (Design), students construct their thoughts to develop solutions for product design ideas in answering the problems that exist in the educational unit that they

previously found from the needs analysis stage (analysis). Each student will have their own product design ideas, this will train students to independently develop their thoughts and ideas in order to solve a certain condition or problem. In line with Tungkasamit's research (2019), in research-based learning, students conduct research on the problems they encounter and they try to solve those problems. Research-based learning also allows students to come up with ideas and think rationally in order to find solutions to existing problems.

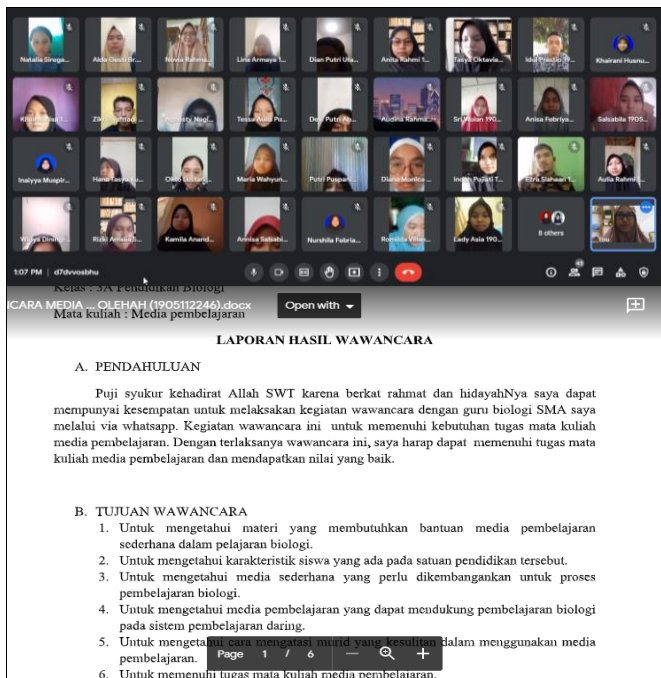


Figure 2. Students carry out needs analysis activities

In the implementation of learning in the “student as researchers” lecture strategy, students communicate the design of the learning media products they made, while other students and lecturers will provide feedback in the form of input ideas for developing better learning media products. Exchanging ideas and communicating with each other will train students' habits to add reference ideas and come up with ideas in developing product designs. According to Tungkasamit (2019), a research-based learning approach is an approach about developing a product from students that involves the pedagogical thinking process as the main educational goal by involving several thinking concepts such as critical thinking, didactic thinking and pedagogical thinking. The idea is to integrate theoretical aspects with practice during studies. To describe a finding and fill a gap between researchers, it can be done through consistent communication, presentation or mediation strategies with other friends and lecturers in order to find quality ideas.

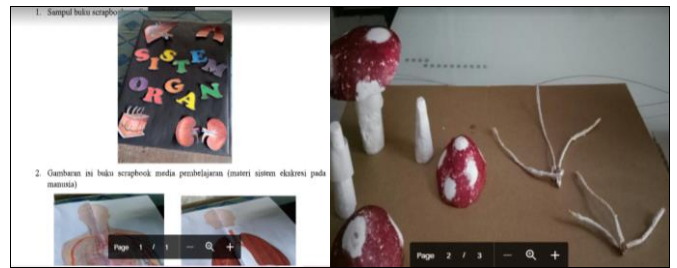


Figure 3. The results of the development of student work

An interesting thing was stated by Rahim (2019), that students are able to make an active contribution to the research-based learning process by building their own knowledge by combining new information and experience with the knowledge structure that already exists in their minds. Many students show critical thinking skills with indicators of expressing ideas/ideas through asking questions, arguing during discussions, listening to group friends during discussions, and digging up more information through articles on the internet. The product development stage (development) also trains students in finding ideas. This stage is the product validation stage carried out by media experts and material experts. The collaborative thinking of experts will stimulate students to improve and provide new ideas that support the achievement of learning media product goals in terms of improving educational problems.

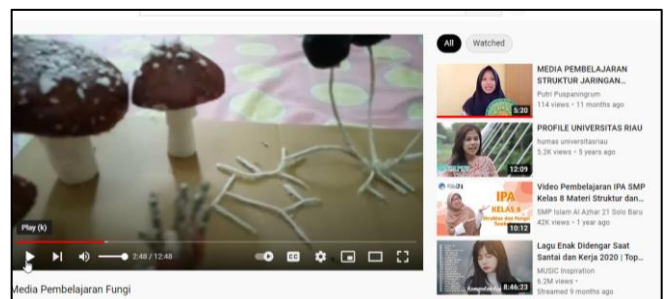


Figure 4. Implementation through making learning videos that are uploaded on each student's YouTube channel

Figure 1 on the research data also shows that the indicator "accurate and looking for accuracy" has an N-gain value which is in the high category with a value of 0.73. Through the lecture strategy “student as researchers” students analyze and try research evidence, understand and implicate it critically, and are able to present research results or research arguments appropriately and accurately. Students are accustomed to formulating problems, reviewing literature, making their own hypotheses, analyzing data, and concluding the results of processed data. Indicators of analysis, evaluation, induction and accuracy have been trained on students during the development of learning media in their research stage. In line with the opinion of

Suyatman et al. (2021), Thonney et al. (2019) and Mahardini et al. (2018), that each step of a research-based learning strategy empowers several aspects of analytical thinking skills that facilitate students' ability to seek the accuracy of research results. The stages of discussion, presentation, interview, exploring various information, and validating learning media products are ways to find data accuracy.

In the needs analysis stage (Analysis), students conduct interviews, observations and analyze the real situation of an educational unit in learning biology materials related to the needs of learning media. The results of the needs analysis that have been carried out by students are their basis in designing and developing simple instructional media product designs that are appropriate, suitable and accurate to overcome the problems they have previously studied. Accuracy and seeking accuracy are described through the stages of needs analysis, student experience contextually in finding sources of evidence will confirm students' ability to search for relevant data accuracy, so that students not only develop learning media but also provide appropriate solutions to problems in learning biology. In addition, each stage that is carried out will always be through discussion with the lecturer so that students are also facilitated to always seek accuracy in the stages of research carried out. According to Hashim et al. (2018) and Daryanes et al. (2023) guiding students to think independently, and seeking deeper information in exploration and discussion is very important. Students are directed to analyze and manage various processes in the survey and observation during actualization and exploration activities by exploring an existing problem, then the information obtained will become a tool to confirm the accuracy of the existing data. So it can be said that it is important for students to explore problems by going directly to real situations and by analyzing situations and needs.

The Results of Observations During Lecture Activities "Student as Researchers"

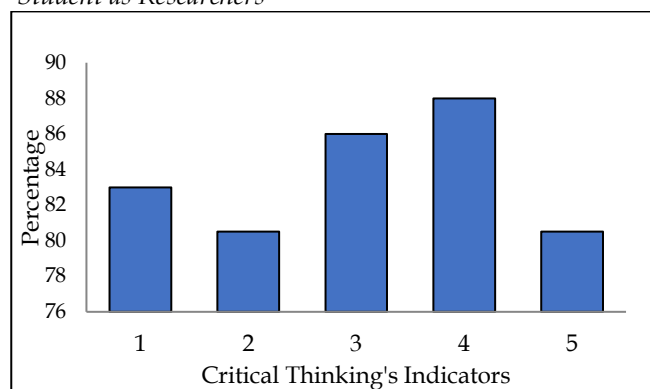


Figure 5. Results of observations during the learning of "student as researchers"

Note: (1) accurate and seeking accuracy, (2) clearly seeking clarity, (3) being open, (4) able to provide ideas, (5) being sensitive and aware of the abilities of his friends.

Based on Figure 5 the observation results show that the critical thinking ability on each indicator is in the good and very good categories. The results of observations are also in line with and support the results of students' critical thinking questionnaires after attending lectures with the "student as researchers" strategy. During the observation, it was seen that students' critical thinking skills increased through the process of analysis, synthesis, sharing and communication, creating, and evaluating a learning media product through the stages in the "student as researchers" lecture strategy which provided student experience as researchers. According to Usmeldi et al. (2017), each step of the research-based learning model empowers several aspects of analytical thinking skills in finding and classifying several aspects because, in this case research-based learning provides opportunities for students to conduct research from the point of view of solving problems and communicating them. To foster student independence, improve critical thinking skills, creative and good communication skills. The stages of students reporting and presenting the results of developing their learning media products can also train their organizational skills so that the critical thinking indicator, namely "sensitive to the ability of friends" can be developed. As stated by Yulhendri et al. (2018) and Daryanes et al. (2020), the superior research-based learning model not only develops the ability to find and communicate knowledge but is also able to integrate ethical and moral decisions both individually and collectively for private and public. Research-based learning has a "social learning" component to develop self-confidence, empathy and social solidarity among friends.

The observation results show that the indicator "able to provide ideas" has an achievement rate of 88% in the very good category. In class discussion activities and presentations, it was seen that all students played an active role in conveying ideas for the design of their learning media products and providing input ideas for other friends' learning media products. Lecturers always provide opportunities and opportunities for all students to participate in giving ideas to their friends so that the resulting product development becomes better. In this "student as researchers" lecture strategy, students independently find problems through needs analysis activities, students solve and find solutions to their problems through the stages of the scientific method that provide research experience so that students are pure in creating an appropriate learning media product from

their ideas alone. Lecturers do not carry out conventional learning that restricts and forces students to develop products according to the direction of the lecturer, but students utilize their critical thinking skills in generating ideas for learning media products to be developed.

According to Ridlo et al. (2021) and Daryanes et al. (2023), students present their research results and explain the research topic thoroughly and discuss so that the material is used as the basis for students to report their work. The presentation serves as a springboard for further and in-depth discussion, in practice the researcher communicates his values, ideas and experiences through the discussion process. Seen the analysis and ideas of each researcher in finding solutions to problems, which include a relevant strategy and analytical reasoning, critical thinking skills and persuasive communication.

The results of observations during lectures with the lecture strategy "student as researchers" show that students are always open-minded as can be seen from the achievement of the critical thinking indicator "open-minded" by 86% and is also in the very good category. Students always collect various information related to the development of simple learning media products, they modify, analyze and create innovative product designs. In addition, students also always follow up input from friends and lecturers on the design of their learning media. Many of the students initially used only pictures, but after class discussions, listening to input from lecturers and looking for various reference sources, the design of student learning media products became more innovative. Students develop simple media products other than as teaching media as well as quiz media so as to create interesting learning.

Based on interviews, students also always look for information through YouTube, the internet, and scientific articles in developing creative learning media, this shows the achievement of the "open-minded" indicator. It can be seen based on the results of observations during lectures using the "student as researchers" strategy that students' critical thinking abilities have increased every meeting. This is in line with the opinion of Narahaubun et al. (2020) and Daryanes (2021), in research-based learning there is an independent information search stage that helps students practice as critical thinkers to find out and utilize information to form logical thinking. In addition, students are also free to convey and accept arguments. Students are trained to be open-minded by using learning resources from anywhere, not limited to teachers and books, but more than that flexibility of thinking can be obtained through the web and the internet, videos and pictures of information sources. Students synthesize independent learning resources and

the results of their friends' readings so as to allow the exchange of information between each other.

Conclusion

Overall, students' critical thinking abilities increased by 0.70 in the high category after participating in learning with the "Student as Researcher" lecture strategy. The indicator for compiling "able to express ideas" is an indicator that has the highest increase compared to other critical thinking indicators, which is 0.79 in the high category. Based on the results of observations, students' critical thinking skills continue to increase at each meeting. Other research that can be done is to look at the lecture strategy "student as researchers" in training other abilities or if other researchers want to do research with the same theme they can modify the stages in the research-based learning process.

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Author Contributions

Conceptualization, Febblina Daryanes; methodology, Deci Ririen and Khusnul Fikri; software, Khusnul Fikri; validation, Irda sayuti; formal analysis, Febblina Daryanes; investigation, Febblina Daryanes and Deci Ririen; data curation, Khusnul Fikri; writing-original draft preparation, Deci Ririen; writing-review and editing, Febblina Daryanes; visualization, Khusnul Fikri; funding acquisition, Irda Sayuti.

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Conflicts of Interest

The authors declare no conflict of interest.

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