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The effectiveness of implementation research-based learning model of teaching integrated with Cloud Classroom (CCR) to improving critical thinking skills in an astronomy course

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The effectiveness of implementation research-based learning model of teaching integrated with Cloud Classroom (CCR) to improving critical thinking skills in an astronomy course

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Abstract. The research aims to compares the modern class (experimental class) and traditional class with the traditional teaching style. Experiment class applies research-based learning methods integration with Cloud Classroom (CCR), and Traditional Classroom teaches with direct explanation and figure from the several textbooks of Astronomy. This research used triangulation methods. The quantitative methods were applied to analyze student achievement tests according to Critical thinking criteria. The qualitative method was applied using observation of student activity and interview for the selected student. Student achievement test followed by pretest, and post-test quasi-experimental research. The data analysis of the post-test indicated a value of sig (2-tailed) 0.002 where $p \leq 0.05$, which implied the student achievement on critical thinking skills criteria in the experimental class was better than that in the control class. The activity of students in the experimental class reached 49% as the highest activity for very active activity, 23% active, hesitate 14%, inactive 7%, and very inactive 7%. Based on this result, the implementation of research-based learning integrated with CCR is proven effective in improving student critical thinking skills Astronomy course.

1. Introduction

In this research, we apply Research-Based Learning (RBL) methods integrated with Cloud Classroom (CCR) and computer programming to improve Critical thinking skills in Astronomy courses. In-depth Astronomy learning is given at the college level. The character of the material that exists in Astronomy is different from that of the Physics material at the elementary level because in Astronomy, we learn about the macroscopic dimension. The criteria for the implementation of the preparatory or preconditioning phase is that the student must know the prerequisite material well.

The mind mapping system has many advantages in between the concept-making process is fun, because it does not rely solely on the left brain alone, and it's unique it is easy to remember and attract the eye and brain [1]. Concept maps are one way of recording subject matter that makes it easier for students to learn. The preparation of concept maps by students facilitates students' hierarchical way of thinking. Patterns that exist in the concept map created to facilitate students in preparing existing knowledge on the function of the brain systematically. The student can express freely in the learning process using mind mapping [2].

Preparation of the right concept map can direct students in improving the effectiveness of learning and serves as a support flowchart (flowchart) in making algorithm programming based on the description of the importance of concept maps in learning. So Mind Mapping can be used as one of the strategies in learning Astronomy to achieve the effectiveness of good learning. The next phase that can be done in learning Astronomy is called the Organizing phase. According to Edward, concept maps are the most effective and efficient way to enter, store, and extract data from or to the brain [1]. The learning process by using the problem-solving learning method can improve the mastery of the Physics concept [3]. In studying Astronomy requires high-level thinking skills classified as critical and analytical thinking skills. Critical thinking skills and analytical thinking skills are essentially problem-solving skills. According to Paul and Elder critical thinking is a way for a person to improve the quality of the thinking result using the technique of thinking system and generate intellectual thought in ideas that are conceived [4]. Problem-solving skills and Critical thinking, which include reasoning effectively, using systems thinking, making sound judgments and decisions, and solving problems [5]. It is clear that critical thinking, analysis, and problem-solving skills provide effective learning in decision-making and problem-solving; this phase needs to be raised in Astronomy learning activities.

This third phase is called (Thinking), which serves to maximize the potential possessed by students especially on the ability of critical thinking, analysis. The emphasis of this phase is to prove the mathematical equations and their applications on the astronomy course. The lecturer, as the facilitator, directs the students to prove their mathematical equations using the basic concept maps that have been made. The culmination of the development of analytical thinking ability can be realized by proving the formula and making of Matlab based programming algorithm [6].

The integration between exercise and visualization can make it easier for students to develop intuition [7]. Intuition is necessary to build the logic of thinking and predicting the formulation used. Singh states that the use of visualization can make learning more effective [8]. The students will get more real information from abstract information. The characteristics of the Astronomy course require a complex mathematics formulation, abstract, dynamic, and macroscopic dimension so that with the simulation and visualization of the learner will be able to develop the mental model in its cognitive aspect. This phase is called Simulating, which emphasizes the ability of students in preparing and displaying a Matlab based programming algorithm based on a flowchart that has been prepared. Nieveen and Plomp say a product is said to be qualified if it meets the criteria of validity, practicality, and effectiveness [9]. Teaching and learning activities are influenced by several factors, one of which is the learning method. Joni says the method is a relatively common way of working that is appropriate to achieve certain goals [10]. The method is a way of implementing activities in achieving the goal of learning objectives. In this study, we applied Research-Based Learning methods to integrate learning and researched the purpose of the study is to improve student achievement test as well as to improve Critical thinking student-oriented to Higher-order Thinking Skills.

RBL is a learning model that included authentic learning, cooperative learning, hands-on & mind learning, contextual learning, problem-solving, and inquiry discovery approach [11]. Higher-order thinking also developed by RBL implementation [12]. Higher-order thinking also contains creative thinking and Critical thinking [13]. The implementation of Research-based learning facilitates the student to explore critical thinking skills to solving several problems in an Astronomy course. Dafik explains about advantages of RBL implementation, for learners increased motivation to learn, improve the ability to do important work, and improve problems solving skills, especially when dealing with complex Problems [14]. According to the characteristic of Astronomy subject, RBL methods are suitable for implementation in teaching and learning activity. RBL encourage student more active in solving complex problems.

The main characteristic implementation of RBL is the existence of Research Group is a group of researcher and student who is working together on teaching, research and community service activities and supervising on specific research to solve the fundamental problem from simple research to complex/expert research. The following phase for implementation of RBL in Astronomy courses explains with the following phase in Figure 1. The research-Based learning method conducted by Arifin explains three main steps, namely exposure stage, experiment stage, and capstone stage [15]. The first step is the Exposure stage, student collecting information by searching literature relevant to topic research. Second steps are experiment stage student identifying and making formulation about problem-based on theoretical literature or experimental studies. In the fourth stage, they experiment on plans or ideas in providing the solution, algorithm, data measurement, and computer simulation.

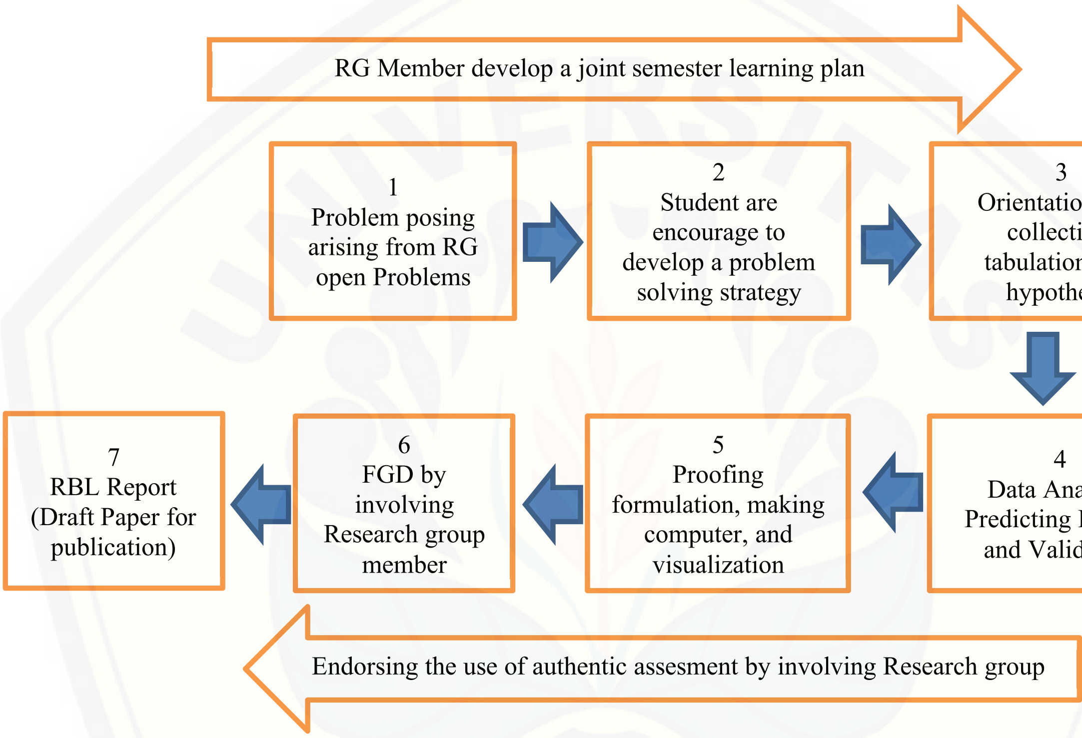


Figure 1. The stages of implementation RBL in the Quantum Mechanics course

Critical thinking is a kind of thinking skills oriented to Critical thinking and creative thinking related to Higher order thinking skills. There are five indicators indicate Critical thinking ability, which is an understanding problem well, changing problem into mathematics symbol, creating a strategy to solve the problem, concluding, and explaining the obtained conclusion. The last capability is creating a strategy in the highest level of higher-order thinking skills. Table 1 explains about four indicators and sub-indicator of Critical thinking skills, and Table 1 explains the indicator of Critical thinking skills in Astronomy. Ennis shared six basic elements of critical thinking through approaching FRISCO (Focus, Reason, Inference, Situation, Clarity, and Overview). The first step of critical thinking, according to Ennis are:

1. Focus
Introducing some situations, we must understand what to discuss, main point, issue, what to ask or what to say. To hold it, we must focus on it because if we do not, we will waste time. Ennis define it as"the focus is ordinarily the conclusion."

2. Reasons
Supporting the conclusion, we must have supporting reasons and decide the acceptable reasons. This is accomplished before we value the argument.

3. Inference
Assessing the inference is different in assessing reason. We must assess the acceptable and sufficient to make a decision. Yet, inference gets ambiguity, more than one meaning, as Ennis said:" Sometimes the word inference is used to mean conclusion so that the conclusion of an argument would then be an inference."
4. Situation
When thinking focuses on trust and takes a decision, it needs to supporting situation that includes involving other people, another side. The environment is in it, both the physical and social environment. It is not only thinking activity but also the meaning of what to hold and to assess by the thinker.

5. Clarity
The most important thing in our writing and speech is clarity of what we said. We must understand what to say, and the other people understand what we say. By delivering a clear and explicit message, we will avoid ambiguity. And clarity is the most important element in FRISCO
6. Overview
In the overview, the thinker verifies about what to think

Table 1. Indicator of student's critical thinking skills.

Critical Thinking Skills	Indicator	Sub-Indicator
Giving a simple explanation	Formulate problems and answer simple questions	Gathering information about Blackhole from relevant literature and answer simple questions.
Basic decision making	Apply a formula or procedure	Analyzing the concept of Blackhole Formation and
	Analyze information based on data, ideas or concepts	Analyzing the concept of Blackhole Formulation
Conclusion	Make a conclusion from generalizing the data	Proofing The Blackhole Formulation
Giving further explanation	Synthesize ideas into a unified whole	Making an algorithm for computer simulation

In this study, the learning process in experimental use cloud classroom (CCR) to helping student interaction beyond real class and also for interactive formative assessment in the control class learning method using traditional methods.

2. Methods
This research is in education research quasi-experimental research. The purpose of research to compare and analyze the implementation of traditional learning with learning using the RBL model. The design of research using mixed methods, including qualitative and quantitative methods. Quantitative methods are used to analyze student work in solving some problems regarding the astronomy course integrated with the RBL learning model. Qualitative methods are used to analyze data from the results of interviews

conducted on students to find out their opinions about RBL. The independent variable of this study is the RBL learning model. The dependent variable is student learning outcomes related to critical thinking skills. After student does the task, interviews were conducted with the experimental class to find out their opinions about the research-based learning model. The research design uses two classes by purposive random sampling and examined using a pre-test and post-test using the following design.

Table 2. Design of research using mix methods.

Group	Pre-test	Treatment	Post-test
Control Class n=40 Student	O_1	-	O_2
Experiment Class n=40 Student	O_3	X	O_4

O_1 & O_3 = both groups were examined using pre-test in order to find out their Critical thinking skills, which was expected to be at the same level.
O_2 = the post-test result of the control class.
O_4 = the post-test result of experiment class (Sugiono, 2017)

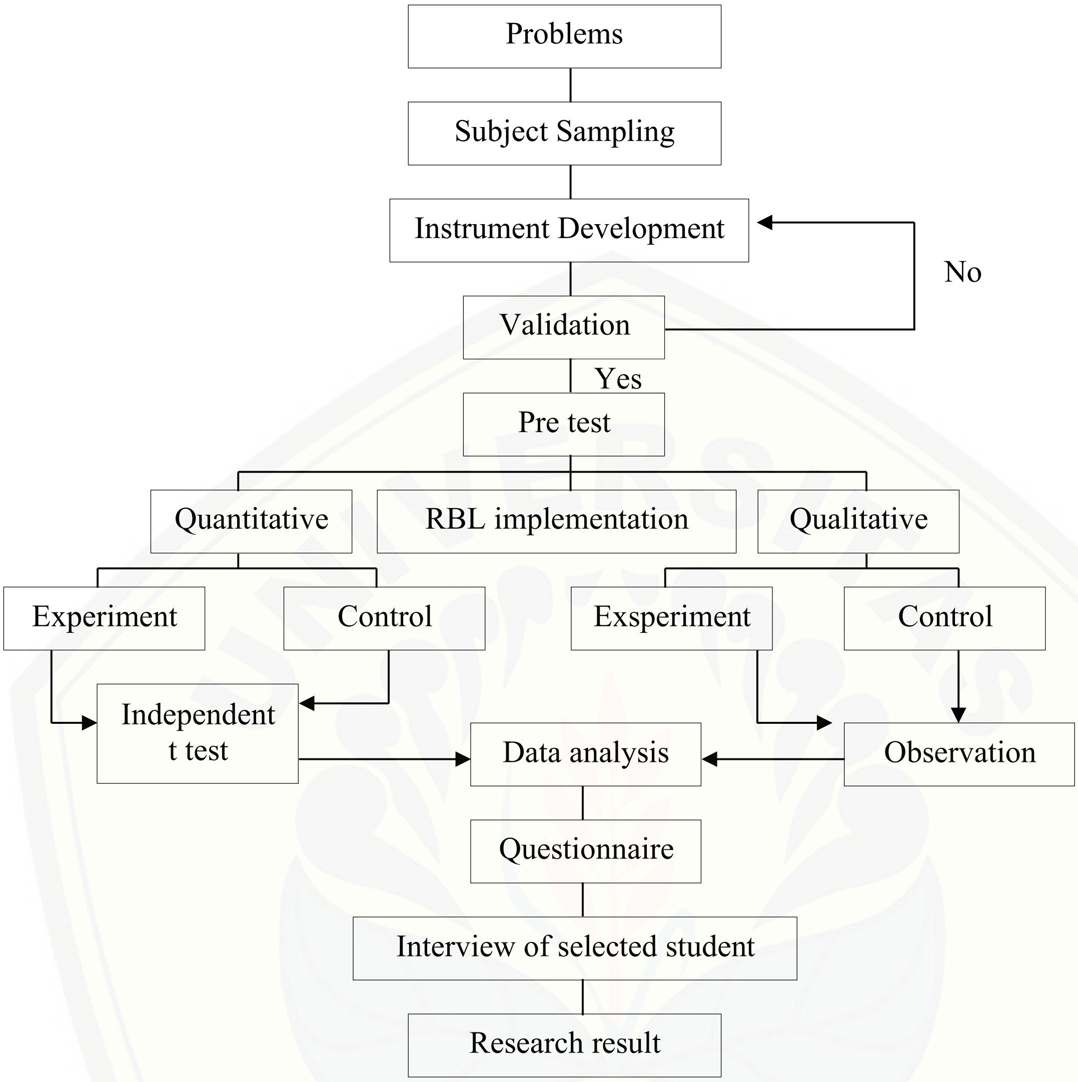


Figure 2. The model of triangulation in mix method [16].

2.1. Population

In this study, the population used was first semester students from the department of Mathematics education at the University of Jember. Next, class selection uses cluster sampling to randomly select two classes. The total number of students in this study was 40 students, with ages ranging from 19-21 years. There were 40 students in the experimental class consisting of 17 male and 23 female. In the control class, there were 40 students composed of 12 males and 28 females. Data is taken from August to November 2019. To retrieve data, there are several instruments provided. These instruments are tasks, interviews, questionnaires, and observation sheets. Instruments in the form of the task are used to finding out the extent of students in understanding the concept of the superposition wave function. The observation sheet is used to determine the level of student activity. Interviews and questionnaires are used to determine students' opinions regarding research-based learning models.

2.2. Instrument

The instruments used in this study were task, observation sheets, interviews, and questionnaires. Interviews and questionnaires were only given to the experimental class, which consisted of several question items. The observation sheet uses a Likert scale *Very Active (Score 5), Active (Score 4), Hesitate (Score 3), Inactive (Score 2), Very Inactive (Score 1)*. The instrument sheet was validated by the expert of physics education.

2.3. Task

"Black Hole"

The death of a high-mass star with a mass exceeding about 8 M_{sun} is an extremely violent process in which the star's outer layers are blown off in a supernova explosion, leaving the extremely dense core behind. If the mass of that remnant core is greater than about 3 M_{sun}, there's no force in the Universe that can prevent gravity from causing the material of the core to collapse into a singularity. As the remnant core shrinks, its mass remains the same, but its volume approaches zero. And since density is equal to mass/volume, the numerator of the fraction remains the same, but the denominator approaches zero. Thus the density approaches infinity. Most people have heard the term "event horizon" of a black hole. The event horizon is the point of no return, which is why Shep Doeleman of MIT calls it "an exit door from the Universe." Nothing that approaches a black hole closer than this distance can ever escape from the gravitational force of the black hole. Even light cannot escape, which is why the object is called "black." In this section, you will learn how to calculate the size of the event horizon or "Schwarzschild radius" of a black hole. As you work through this section, keep in mind that the event horizon is a mathematically defined distance from the center of the black hole. It describes an imaginary spherical surface surrounding the central singularity, not a real physical surface. The event horizon itself cannot be seen, and if you were falling into a black hole, you may not know when you crossed the event horizon. But once inside, you would have no hope of ever getting out. It's important to realize that when astronomers refer to the "size" of a black hole, they are referring not to the zero volume that the mass physically occupies, but rather to the size of the Schwarzschild radius (*Rsc*). That radius is nonzero and can be determined by finding the distance at which the *vesc* equals the speed of light. As you can see in the next section, this results in the following equation:

$$R_{sc} = \frac{2\,G\,m}{c^2}$$

Although not a physical surface, the size of the event horizon is mathematically defined by the equation above, where *Rs* is shorthand for Schwarzschild radius, *G* is the universal gravitational constant, *m* is the mass comprising the singularity, and *c* is the constant speed of light. The size of the event horizon depends on exactly one physical property of the black hole. Can you name it? If not, take a look at the parameters on the right side of Eq. 6.6. Notice that they're all constants, with one exception: the variable (*m*) that represents the mass of the black hole. Mass is the one and only physical property of a black hole that determines its event horizon. In this sense, black holes are actually simpler to analyze than other astronomical objects.

Figure 3. Simulation birth of black hole

Student Tasks
1. Explain several concepts in Science and Mathematics for Blackhole.
2. Draw mind map to get a formulation of Blackhole
3. Proof the formulation of the Schwarzschild radius (*Rsc*).
4. Make M-File, and simulate the calculation using different of m (planet mass)

2.4. Data Collection and Analysis

Pretest and post-test are implemented to control class and experimental class. In this research, we apply a mix method analysis, including qualitative data and quantitative data. The quantitative data analyzed with independent sample t-test and qualitative data were analyzed by interview and observation based on ordinal data. Both of the results of the test (pre-test and post-test) use to analyze the improvement of Critical thinking skills in tunneling effect subjects. The information from data, i.e., frequency, mean, std deviation, and sig (2-tailed) used to describe statistical inferential data. Statistical results related to the impact of implementation RBL method using CCR. The significant value was confirmed by the difference at 5% (0.05).

3. Result

The analysis of student achievement test (pretest and posttest) under the implementation of RBL is using an independent sample t-test. The result of the pre-test score from control compares with experiment class is a normal distribution, which means the class is homogenous. Further analysis is explained by statistic software (SPSS). The result of the Pre-test score indicates significant between the control class and experiment class, as seen in Table 3.

Table 3. The table display pre-test result and mean value control class and experiment class.

	Class	N	Mean	Std. Deviation	Std. Error Mean
Pre-test	Control	40	41.25	12.74755	2.01556
result	Experiment	40	44.35	11.35567	1.79549

The significance value serves as the basic information to analyze and get a decision from the data result. The significant value is set at 5 % or 0.05. The average achievement test in the control class is 41.25, with a Standart deviation of 12.74755, and the average achievement test in the experimental class is 44.35, with a standard deviation of 11.35567. The different mean of a control class and experimental class is not significant.

Table 4. The comparison of pre-test results and mean value control class and experiment class.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pre-test result	Equal variances assumed	1.446	.233	-1.148	78	.254	-3.10000	2.69931	-8.473	2.27392

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances not assumed			-1.148	76.980	.254	-3.10000	2.69931	-8.475	2.27504

The display of analysis from SPPS software shown in Table 4 about the pretest from the experimental class and control class. The result of the t-test indicates the value od significant (2-tailed) 0.254 with criteria of significant value is 0.05. According to the criteria of homogeneity, statistic means the two classes (control class and experiment class) are homogenous because of the value of sig (2-tailed) bigger than 0.05.

The result of the post-test also analyzed by using SPSS software. Table 5. displays a comparison between post-test results from the control class and experiment class. The mean from the control class reaches 69.9500 with standard deviation value 14.52487, while the mean of experiment class reaches 77.9500 with a Standart Deviation value 6.09308. The information from Table 6 shows that there is a significant value between two classes indicated with the value of t in Levene's Test score -3.212 according to the value of $p < 0.005$

Table 5. The table display post-test result and mean value control class and experiment class.

	Class	N	Mean	Std. Deviation	Std. Error Mean
Post-test result	Control	40	69.9500	14.52487	2.29658
	Experiment	40	77.9500	6.09308	.96340

Table 6. The comparison of pre-test results and mean value control class and experiment class.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Post-test result	Equal variances assumed	7.639	.007	-3.212	78	.002	-8.00000	2.49047	-12.958	-3.04186
	Equal			-3.212	52.314	.002	-8.00000	2.49047	-12.996	-3.00322

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
variances not assumed									

The information from Table 6. also shows the result of the independent sample t-test indicates a significant value of 0.002 ($p \leq 0.05$). Thus, it is a significant value. The findings conclude that two classes have differences in terms of student multiple representations and creative thinking skills tests after the implementation of the RBL model of teaching. Figure 6 and Figure 7 express student profile multiple representation skills in the control class and experiment class.

The student activity in experimental class observed by 11 observers using Likert scale student activity spread into five categories very active (score 5), active (score 4), hesitate (score 3), inactive (score 2), and very inactive (score 1). The total result of observation student activity shown in the Figure 4 below.

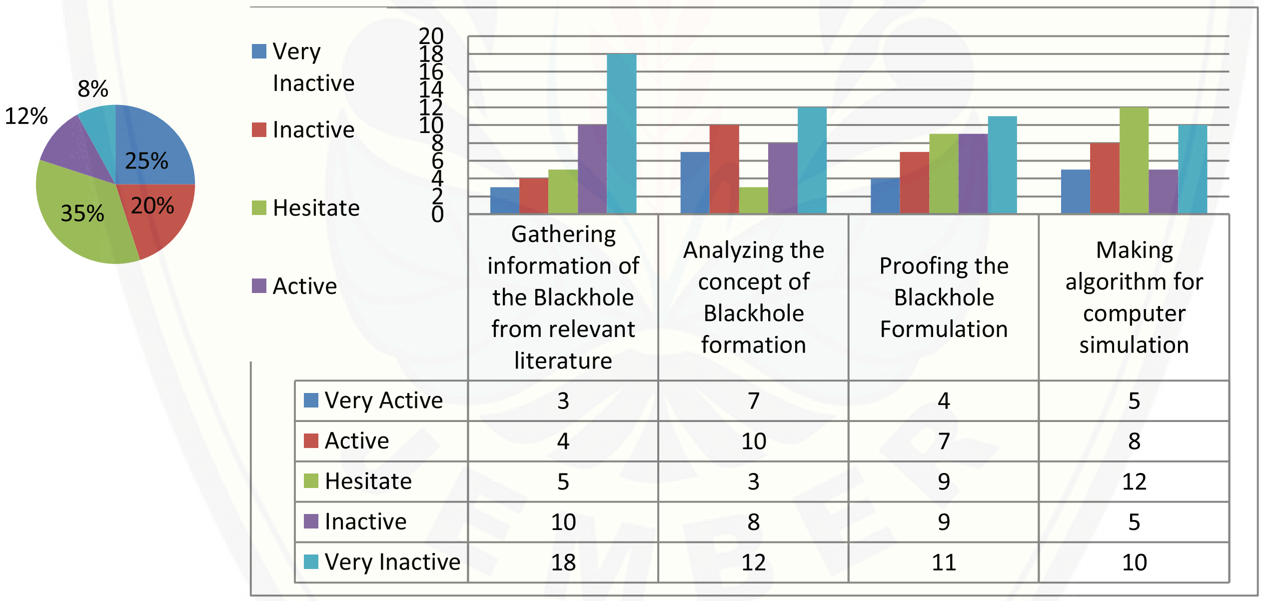
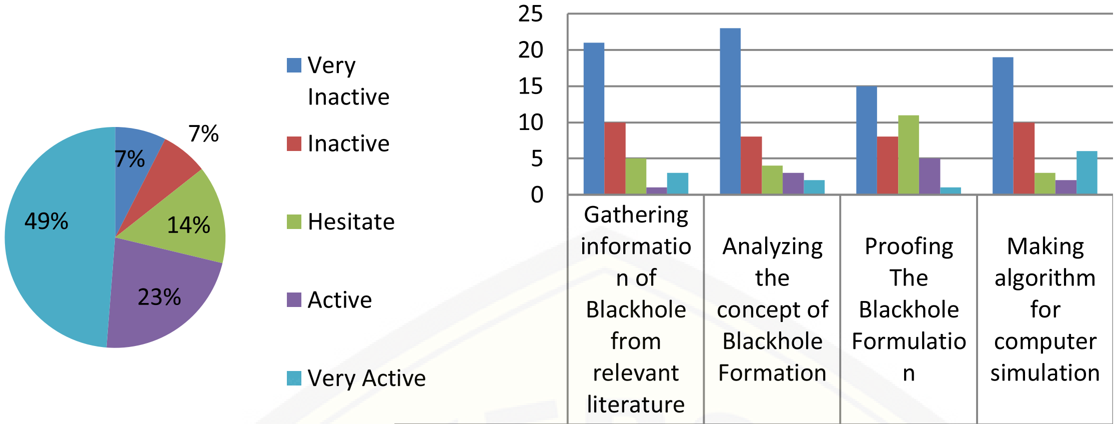


Figure 4. The student activity during the implementation of the traditional model of teaching in control class.

The student activity in control class under implementation of traditional model of teaching show in Figure 4. The data show most of the student activity is in hesitate (35%), especially in making algorithms for computer simulation with Matlab. The assessment is control class are using traditional assessment with paper-based test. In the experimental class, the student activity reaches 49% in very active criteria, 23% active criteria, 14% hesitate, 7% inactive, and 7% very inactive.



	Gathering information of Blackhole from relevant literature	Analyzing the concept of Blackhole Formation	Proofing The Blackhole Formulation	Making algorithm for computer simulation
Very Active	21	23	15	19
Active	10	8	8	10
Hesitate	5	4	11	3
Inactive	1	3	5	2
Very Inactive	3	2	1	6

Figure 5. The student activity during the implementation of the RBL Method in the experimental class.

4. Discussion

This research explores the effectiveness of the implementation Research-Based Learning model in improving critical thinking skills in the astronomy course, especially in the simulation of Blackhole. The finding of this study indicates that students in the experimental class had a positive effect on the impact of the implementation of RBL models. The result of this result in line with Ridlo (2019) about the implementation of the RBL model in mathematical modeling combination of wave functions in improving higher-order thinking skills related to critical thinking skills. The implementation of RBL making the student more critically and creative than student teach with traditional methods (Suntusia, 2019). The implementation of RBL improves knowledge, competence, cognitive skills, and information technology skills (Sota and Peltzer (2017)).

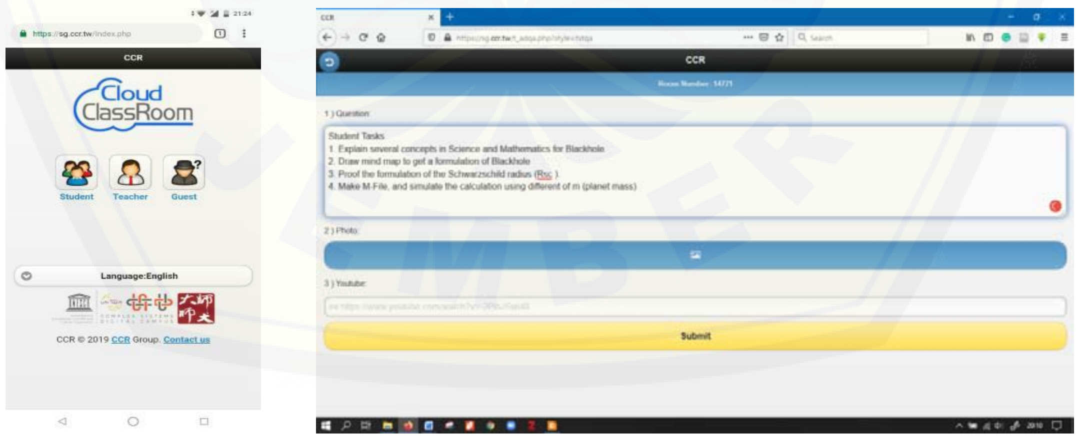


Figure 6. The interface of cloud classroom in astronomy course.

In technology information skills, we use Matlab programming software as simulation blackhole and CCR (Cloud Classroom) as student assessment, CCR interface shown in Figure 6. CCR also had a positive impact on the improvement of student response in the assessment process because CCR facilitates student and lecturer in the online classroom and online assessment process in realtime. The integration of CCR in the learning process can help teachers to reduce teaching load, and they can use class time to cover more relevant topics [17]. The online assessment presents using a cloud classroom as facilitating students using a menu, direct question, quiz, and GEARS (Gamified Electronic Audience Response System). The lecturer can provide interaction with a student, and student can express emotion by using an emoticon, The result of simulation from computer programming upload by using CCR, the advantages of using CCR is swapping research work into classwork

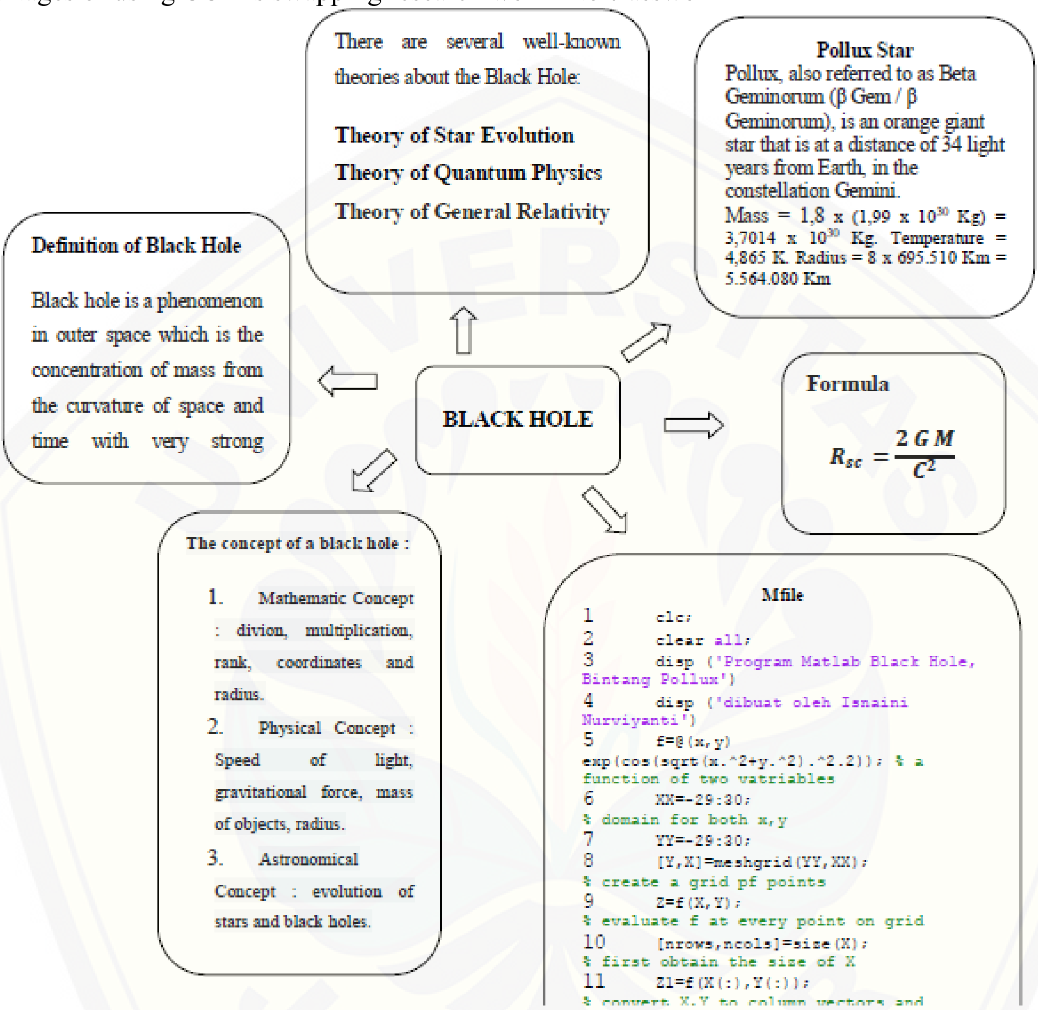


Figure 7. Mind mapping in Astronomy.

Mind mapping used to make relations between concepts in Astronomy by using mind mapping students easier to understand how to make algorithms in Matlab. After making mind mapping student should derive the formulation of Schwarzschild radius Figure 8 show the derivation of Schwarzschild radius in Blackhole.

$$K_e = P_e$$

$$\frac{1}{2}mv^2 = \frac{GMm}{R_{sc}}$$

$$\frac{1}{2}v^2 = \frac{GM}{R_{sc}}$$

$$v^2 = \frac{2GM}{R_{sc}}$$

In relativistic condition $v = c$ $(constant\ velocity\ of\ light)$

$$R_{sc} = \frac{2GM}{c^2}$$

Figure 8. the derivation of Schwarzschild radius in Blackhole.

Matlab programming can help a student in making a simulation of Blackhole. From the derivation of formulation, the student chose the constant and variable used in Matlab programming. The result from Matlab programming compares to the simulation of Blackhole from relevant literature. Figure 9 shows student simulation results from Matlab programming.

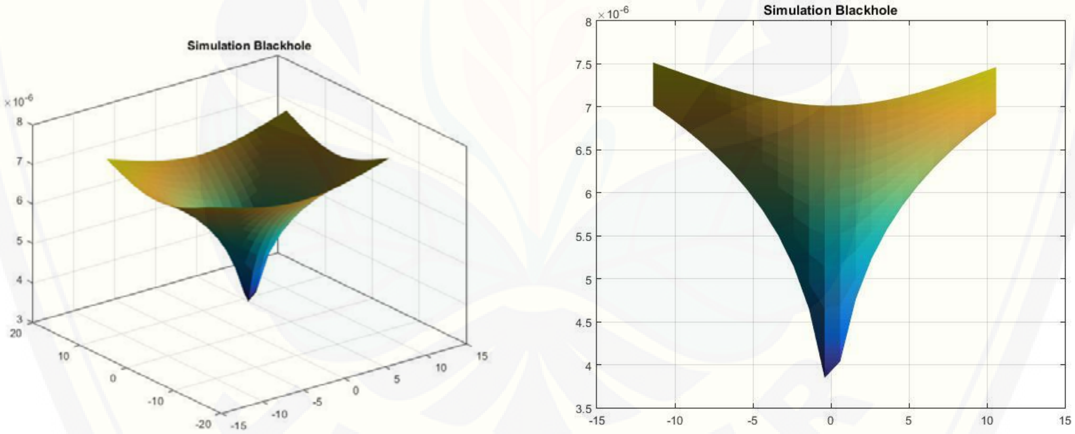


Figure 9. Simulation of Blackhole from the Computer simulation

In the last steps after students making the simulation of Blackhole, the student should make conclusion about blackhole formation Figure 10. Show student conclusions related to the Physics concept.

Conclusion

The star's radius changes after it turns into a black hole where the initial R> Rsc, according to the calculations from the star data that I use is the hamal star where the initial R = 9,6702 million km and Rsc = 3714,44×10[4] km. And has an initial ρ= $0.66 \times 10^9 \frac{kg}{m^3}$ and final ρ =1,163×$10^{17}\frac{kg}{m^3}$ its means $\rho\ initial < \rho\ final$, has initial mass = final mass that is m = 2,506×$10^{31}kg$, has an initial V = 3785,95×$10^{18}m^3$ and final V = 214,483 × $10^{18}m^3$.

Figure 10. Student conclusion in Blackhole.

Finally, to know about students' knowledge and perception about the implementation of the RBL model in the Astronomy course, the students were interviewed with several questions related to the teaching and learning process in the Astronomy course. The data obtained from interviews are discussed below by the teacher and student.

Teacher: Is this excited about learning Astronomy, especially in Blackhole, what is your new experience in this course?

Student : Yes, it's very exciting, a new experience in this course is I really analyze and design computer simulation of Blackhole from death star using computer programming.

Teacher: What is the Physics concept in the Blackhole course?

Student : Density, mass, potential gravity, kinetics energy

Teacher: In mathematics subject, what is the main concept in Blackhole?

Student : It's about to derive the formulation of Blackhole radius

Teacher: What is integrated technology which used in Astronomy course?

Student : I'm using the internet to get information about information of star-related to radius and mass, and I am using Matlab as software.

5. Conclusion

Teaching load in the conventional Classroom in Natural Science courses is one of the concerns. Characteristic of material with abstract description and lot of mathematics formulation is one of reason, it may be possible to reduce teaching load using CCR as a virtual class to discuss and a quiz to provide remedial assistance to a learner who needs extra help in improving Critical thinking skills. In conclusion, based on the research, we can conduct the implementation of the RBL method has a significant impact on the students' critical thinking skills in the experimental class. The result of the posttest from the experimental class and experimental class express the improvement of critical thinking skills. The student score in the experimental class is better than the control class, which teaches using RBL and integrated with CCR. Hence, the implementation of RBL integrated with CCR improves the student critical thinking skills in the Astronomy course.

Acknowledgment

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