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Improving Critical Thinking Abilities on HOTs Questions through PJBL Model for Students of Elementary School Teacher Education

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ABSTRACT

The Students who did not meet the criteria for mastering critical thinking and not carry out Project Based Learning in Mathematics courses became passive, did not generate creativity and did not understand the mathematical concepts applied in the previous material in the learning process. The aim of this research was to identify and analyze the improvement of high-level thinking skills that could be obtained through HOTS (High Order Thingking Skill) questions using the Project Based Learning method. This research was descriptive research with a qualitative approach and it was conducted in second semester students at Sriwijaya University. Data collection techniques through observation, interviews, test and others were used to solve problem and the documentation was used to collect the process data and research results. The results of this research showed that there was a significant increase in acquisition. Application of the PJBL (Project Based Learning Model) a to critical thinking skills were in cycles 1 and 2, especially at the knowledge level. Based on the research results, the two studies increased critical thinking skills by 66.66% pre-action and 16.66% post-action, increasing to 85.3% in the method Project Based Learning. Apart from that, there was a significant increase in critical thinking skills with the "Very Good" category increasing from 66.67% to 85.3%. This showed that critical thinking skills had a positive impact on learning outcomes and collaborative spirit in the classroom. Overall, this showed that research applying the Project Based Learning method on HOTS questions was used to improve critical thinking skills to be more effective in strengthening problem solving by second semester students of elementary school teacher education.

Keywords: *Improving Critical Thinking, Project Based Learning Model, High Order Thingking Skill*

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INTRODUCTION

Mathematics learning in the 21st century does not focus on cognitive abilities, but mathematics learning also requires critical thinking aimed at solving problems in everyday life, analyzing problems well, thinking mathematically and being able to reason and make decisions in the right way. The aim of learning mathematics is to prepare to face life logically, rationally, critically, carefully, honestly, efficiently and effectively (Suhartini & Martyanti, 2017). Mathematics does not form higher reasoning but forms students' critical thinking (Daniel, 2017). Besides, Mathematics learning requires critical thinking from middle to upper class. This can be

expressed by the independent learning curriculum, namely improving students' critical thinking skills, increasing intellectual abilities in preparing students to face the modern world and solving problems in everyday life (Triayomi, & Pamugkas, 2023; Peranginangin et al., 2023). Developments in the era of globalization are very demanding for students. One of the important aspects in higher education is the development of critical thinking skills. Critical thinking can make students become individuals who are able to analyze information carefully, can evaluate it, and can make wise decisions (Djaja et al., 2023; Aziz, 2022; Haratua et al., 2024). Moreover, the intellectual ability to think critically can be the basis for academic progress. With the concept of academic progress in the independent learning curriculum, it aims to provide freedom and flexibility to students in choosing and managing the curriculum according to their interests, needs and future goals. This is to create an independent and relevant learning environment for students (F. Dewi, 2015).

However, critical thinking skills in the independent learning curriculum use effective learning methods through HOTs questions. Students can solve problems in everyday life. HOTS is a student's critical thinking ability, not only remembering but also being required to develop an idea (Saraswati & Agustika, 2020). Learning applied at all levels of education up to universities and in everyday life is Mathematics. Mathematics at the lecture level in semester II of Elementary school teacher education starts from the beginning of the lecture to continuing. It is crucial to provide instruction that isssssssmproves students' awareness and understanding of the trends, anxieties, and threats connected to globalization in order to effectively address these differences and challenges. Schools in particular have a big part to play in making sure that students have the information and abilities necessary to deal with these problems (Fauzi et al., 2023; Lestari et al., 2023; Devine, et.al, 2010). Critical thinking can solve the problems that humans will face in the Technological advances in 4.0 era of the 21st century which are becoming complex. This is one of the challenges for teachers to build and form knowledgeable human beings, increase community resources and achieve national development goals in accordance with the 1945 constitution, namely to educate Indonesian people (Anderha & Maskar, 2020). Mathematics subjects put forward concepts so that students can understand and implement directly. From year to year, the development of the times has greatly increased, technological systems have been put forwardand important learning models are applied to mathematics courses so that it can make people creative and innovative in developing mathematics as an applied basic science. According to Ummah (2021), learning mathematics means being able to develop technology and human thinking abilities. The low educational results in Indonesia recorded in 2015 ranked 45th out of 48 countries participating in TIMSS so that with these low ranking results the world of education in Indonesia must prepare itself to face the rapid development of knowledge and technology in the 21st century with the ability to address learning HOTs (Saraswati & Agustika, 2020; Alam et al., 2024). Therefore, with low ranking results, PGSD students can prepare and train themselves to become teachers who can face current developments by solving problems so that they can guide teachers in elementary schools.

Therefore, all students are taught math subjects up to the higher level of education in order to improve critical thinking skills logically, analytically, systematically, critically and creatively to solve problems. The student's inability to comprehend the subject as a narrative, their misrepresentation of the subject's question, and their lack

of experience with completing HOTS- based mathematics are the factors that make it difficult for them to work on mathematical problems based on the subject The problem of low results in HOTS-based mathematics in graduates of the third semester at the State University of Sriwijaya was demonstrated by the low results of HOTS based mathematical learning. Results of learning HOTS - based Mathematics with basic Mathematical Materials showed that of the 28 students there were 18 students who did not reach the KKM. The statement indicated that only 36% of students were qualified and 64% were not qualified. Based on the above exposure, a proper effort is needed to improve the results of learning mathematics based on HOTS basic mathematical materials in semester 2 at the State University of Sriwijaya.

One of the fundamental sciences that students need to know in order to use logical concepts to solve problems in daily life is mathematics (Kenedi, et.al, 2018). In the learning process, students are less motivated to develop their thinking skills, especially students' mathematics expressed by formulas, memorizing and working on problems while rarely being taught to analyze and apply mathematics in everyday life. According to Afsari, et al., (2021), Mathematics learning carried out by educators so far includes: 1) explaining mathematical objects, 2) providing new explanatory mathematical objects, 3) asking students to work on problems similar to the examples already explained, 4) offering various exercises starting with real world examples. Learning mathematics in this way can make students bored if they don't think creatively, analytically, systematically, and logically. Difficulties in learning mathematics are students cannot read the questions correctly, cannot remember the formulas explained, cannot remember the concepts correctly and are unable to solve existing problems. In addition, students alsodo not know the names and forms of mathematical symbols and are less able to solve problems with proof (Mujib, 2019; L. A. Putri & Dewi, 2020). Besides, student learning difficulties are not optimal in achieving student achievement results so that the ability of students can not develop to think critically. They are not weak souls but they have memorized a lot of objects as explained by their teacher. As a result, they may not be able to think critically and be unprepared to face the problems of everyday life. Because integrity education is the right tool to support improving their achievement results to increase quality resources (P. S. Dewi & Septa, 2019).

Mathematics is a very difficult subject and has many negative effects on students' attitudes and motivation (Febriyani, et.al 2022). Mathematics subjects need to prioritize understanding of concepts rather than memorizing. The ability to understand mathematical concepts is a skill needed by someone in learning mathematics (Nursyeli & Puspitasari, 2021). Education's mathematics subject can be described in a variety of ways. For instance, it can be thought of as a language that is used to interpret social reality and as a tool for knowledge development (Skovmose, et. Al., 2013). Bintang, et al., (2021) states that the cognitive level of students showed superior cognitive abilities to connect mathematically related concepts. Therefore, in explaining mathematical concepts the teacher should not give the incorrect explanatory material (Agustina & Sumartini, 2021). In the learning process, the teacher shows the concepts contained in each material presented. Students are asked to understand the concept of the material provided and seek action and awareness. According to Hakim (2019), students who study mathematics. tend to develop attitudes, traits and skills towards mathematics consciously, regularly and spontaneously. This is called a mathematical property statement. Moreover, students must acquire to develop a

mathematical property index namely 1) Confidence in mathematics, solving problems, communicating ideas and thoughts 2) flexibility when trying to explore and discover mathematical ideas 3) completing assignments with enthusiasm; 4) interest and curiosity in solving mathematical problems; 5) a tendency to monitor and reflect on performance and reasoning; 6) other 7) to understand the concept of learning mathematics in a culture can assess mathematics as a tool and language (Febriyani et al., 2022)

Now critical thinking in mathematics plays an important role in solving problems in everyday life. In mathematics subjects in the central field of knowledge which is really needed in facing developments in the 21st century, by training critical thinking skills with HOTs questions using learning methods can make students understand mathematical concepts easily and pleasantly to solve problems that will be faced in everyday life so that you can train and guide teachers and colleagues regarding HOTs questions. Saputra (2020) asserts that critical thinking skills are thinking which involve cognitive processes and encourage students to think about problems. Critical thinking includes inductive reasoning skills such as finding connections, analyzing open problems, identifying, analyzing cause and effect, drawing conclusions, and reviewing relevant information. Because critical thinking is often defined in terms of skills or processes and is therefore associated with specific mental processes, historical thinking can be used to improve critical thinking (Ulu-Aslan & Baş, 2023). By altering the way history is taught, this viewpoint can be changed consequently, there needs to be a change in the way that history is taught so that students can question what they know and consider how useful it is. This therefore represents a shift toward a critical, reflective, and discussion- friendly approach to history where, as various authors have noted, discipline-specific skills are also included (Fuentes, 2002; Martínez-Hita & Gomez-Carrasco, 2018). It was clear how different "critical thinking" was from other definitions, as it was sometimes used to refer to "clinical reasoning," "problem-solving," or "decision-making." Critical thinking was measured directly in just two of the studies (Hanson, Andersen, & Dunn, 2020).

The methodical application of logic and reasoning concepts to problem-solving and decision-making processes is known as logical thinking skills (Rao, et.al, 2022). The research of Saraswati & Agustika (2020) entitled Critical Thinking Skills in Solving HOT Problems in Mathematics Subjects showed that fifth grade students at Elementary School 1 Padang Sambilang tended to have sufficient HOTs thinking abilities and were still low in answering questions with cognitive domain C6

The problem lied in the process of students making mathematical sentences. This research could enable researchers to apply critical thinking skills to students with HOTs questions using learning methods. Martyanti (2018) states that the questions used to conduct the TIMMS survey were questions that required critical thinking skills. Indonesiashows that Indonesian students have low critical thinking skills. Facing this situation, Indonesia must inform students and teachers that critical thinking is important for learning in order to improve the quality and performance of learning objectives at the international level. This critical thinking is very important for students according to Putri (2018) states that critical thinking is important because critical thinking empowers students to solve everyday problems.

High Order Thinking Skills (HOTS)

High Order Thinking Skills (HOTS**)** is the embodiment of high cognitive competencies that need to be mastered by students to understand a concept in learning. To increase HOTS in the 2013 curriculum, the Ministry of Education and Culture recommends several Inquiry Learning learning models. One of the goals that can be achieved by students is being able to solve math problems. These are HOTS type questions i.e. the thinking process of students at a higher cognitive level (Saraswati & Agustika, 2020). Therefore, HOTS questions are applied to specifically train and encourage students' thinking skills (Handayani, et.al, 2020). The dimension of the thinking process in Bloom's Taxonomy, as perfected by Anderson & Krathwohl, consists of the ability to: remember (remembering-C1), understand (understanding-C2), apply (applying-C3), analyze (analyzing-C4), evaluate (evaluating-C5), and create (creation-C6).(Nayef et al., 2013). When asking questions, there are levels of thinking in the cognitive domain, and there are six levels: Memorize (C1), Understand (C2), Apply (C3), Analyze (C4), Evaluate (C5), Create (C6). These six levels are divided into two levels LOTS (Lower Thinking Skills) and HOTS (Higher Thinking Skills). A tool called HOTS is used to assess higher order cognitive abilities, or thinking beyond merely recalling, comprehending, and applying knowledge. In the context of assessment, HOTS evaluates the following skills: 1) connecting ideas, 2) processing and integrating data, 3) looking for connections across a range of data, 4) applying data to solve problems, and 5) critically analyzing concepts and data. Thus, according to Brookhart (2010), the HOTS issues look at a person's capacity for analysis, evaluation, and creation. Bloom's taxonomy and skill levels included in the HOTS category are skills that can develop problem solving, reasoning, reasoning, forecasting, generalization, critical, systematic, and creative thinking skills (Simarmata et al., 2020). To think critically inorganizing and selecting information is accurate and useful for oneself, society and the country therefore critical thinking skills are very necessary. They are also important in this globalization era especially for intense competition in all industries. In this competitive environment, human resources that are having critical thinking skills will be a valuable asset. These higher thinking skills involve problem solving through critical, methodical, and creative thinking (Lavi, Tal, & Dori, 2021; Rovers, et.al, 2018; Sung, 2017).

Sofyan, et.al, (2020) stated that the difficult factor for students in HOTS questions was students who did not understand the knowledge became inaccuracies in processing the questions. However, students who get these results have difficulty in understanding the entire material from the results of the questions (Hadi & Kurniawati, 2020). The four skills are as follows: (1)collaboration helps students to have the ability to work in a team, tolerance, understanding differences, and the ability to live together to a goal; (2) creativity encourages students to creatively find different solutions, design new strategies, or find ways that are unusual to use before; and (3) communication (communicative ability) helps students to be able to communicate widely, capture ideas, interpret information, and argue in a broad sense. According to Widana, et.al, (2019). The low ability of high-level critical thinking in students is due to the low level of student collaboration skills which are not being improved. In lectures there are still many lecturers who use conventional methods which make students passive and not creative. According to Efendi (2021), the HOTS questions show that learning

requires students to have high-level reasoning abilities and enable students to use higher-level rational thinking activities such as analysis, synthesis, recognition and resolution of conflicts, reasoning and evaluation. Furthermore, one of the skills that people should have is the ability to think critically. In the information era, people constantly got mess of information from printed and electronic media, including genuine and fraudulent materials (Imanuel, 2015; Pratiwi & Asyarotin, 2019). Applying aspects of thinking at a higher cognitive level areanalysis and evaluation. Meanwhile the creative side is created. The HOTS question indicators are seen in the table below

Table of High Order Thinking Skills Aspect Indicator

Aspect	Indicator	Activities
Critical Thinking	Analyze	Choose Compare
	Evaluate	Inspect Evaluate
Critical Thinking	Create	Make Conclude

Bloom's Taxonomy revised distinguishes between two types of thinking processes: lower order thinking skills (LOTS) and Higher Order thinking skills (HOTS). The cognitive processes involved in the cognition domain of HOTS questions are located in C4, C5, and C6 (Antara & Dewantara, 2022; Septiyani, Ramdhan, & Juhanda, 2020). HOTS questions are important learning aspects to improve critical thinking. Through HOTS question, students can analyze, hypothesize well and be able to solve problems. By thinking at a higher level through HOTS questions, students can have the ability to reason with opportunities to develop skills by solving problems that are given in collaborative group discussions between friends so that problems are solved. The basis for developing students' critical thinking skills is teaching them how to solve problems and provide presentations of their findings to the class. To improve their critical thinking skills, especially when it comes to providing clear explanations, students must be actively involved in asking and answering questions. Asking and answering questions, concentrating on questions, and evaluating arguments are examples of basic explanations (Cantona, et.al, 2023). Teachers should prepare students for the above paradigm by using learning and assessment to give them Higher Order Thinking Skills (HOTS) (Tang & Gruszka, 2017). Wilujeng, et.al, (2022) asserts that by thinking through HOTS questions, students' critical thinking skills are very important in educational process and can affect their learning skills, speed, and efficiency. Critical thinking skills are relevant to learning and it can help students to have a positive attitude towards educational development.

Project Based Learning (PJBL)

The learning method is as a design to implement into the process in lecture subjects. The learning model increases student activity and helps them focus more on ongoing lectures. Evaluation of learning models is very dependent on the subject matter. In 4.0 era, students are required to think critically in all aspects of education. The Project Based Learning method is one that can be applied in everyday life to improve critical thinking skills, discuss and solve problems. Thus, the Project Based Learning method can improve students' critical thinking skills to a high level. According to Saputra (2020), the main purpose of learning based on the Project Based Learning method is not to provide a lot of information to students, but to develop critical thinking skills by solving problems, to be able to construct knowledge actively. Therefore, teachers must create a learning environment that is creative, informative and fun.

The Project Based Learning method emphasizes context and innovation in coherent activities. Learning paths that lead to the process of putting existing problems into practice can be developed in the form of projects (Patabang & Murniarti, 2021). In addition to encouraging critical thinking in students solving mathematical problems based on HOTS, the use of concrete media in conjunction with a learning model involving actual students can make learning more meaningful. Utilizing works or projects as learning media, the Project Based Learning (PjBL) learning model is student-centered (focused on the student), the assertion and the statement (Nurul'Azizah & Wardani, 2019).

The advantages of Project Based Learning (PJBL) learning are 1) training students in resonating in doing business, 2) training students in simple business to open hypotheses in solving problems, 3) training critical thinking skills with real problems in simple business concepts, 4) Doing hypotheses in trials after finding business hypotheses, 5) training in making decisions on existing problems, to participate actively and concentrate in discussions, and to make problem analysis, problem synthesis and evaluation. There are five stages of model implementation. In learning mathematics with Project Based Learning (PJBL), Participants are divided into several groups consisting of 5- 6 students. Each group follows the steps in the learning model syntax of the Project Based Learning method (Azizah & Widjajanti (2019) namely 1) Project definition, 2) closing procedure planning, 3) preparing project implementation, 4) completion of equipment and teacher supervision, 5) reports and presentation of project results, 6) evaluation of outcomes and outcomes. For the expected conditions, it is hoped that the use of this technology based on project-based learning methods can be implemented both synchronously and asynchronously, so that it is able to provide students with experiences that can improve their skills in the future. The final implication is regarding the assessment used in teaching content subjects by carrying out projects.

Based on learning, this assessment must have planning, development and completion, so that learning objectives are achieved well (Untari & Padmadewi, 2022). Students using the Project Based Learning (PjBL) learning model must create leading questions to explore the material in meaningful ways on their own and carry out group experiments. In order to produce an actual project or work, students can learn how to solve problems on their own (Aghni, 2020).

At Sriwijaya University, Elementary School Teacher Education students in semester II have different characteristics. Observation activities carried out during the

learning process of many students did not arouse curiosity because learning mathematics was very monotonous and did not recognize basic concepts so that students found it difficult to carry out mathematics learning activities. This could be seen when teaching in student classes. No one was actively involved in asking or answering questions. Most students became passive. Some of the students paid little attention and most of them were busy with their respective activities. Based on observations of learning mathematics, results were obtained in the form of the ability to absorb learning material with different characteristics. There were some students who easily absorb mathematics and some who found it difficult to absorb mathematics.

The results of observations conducted by interviewing students had difficulty in understanding mathematics learning with direct formulas given regardless of where the formula was obtained. There were even students who said mathematics was difficult to learn and students had difficulty in solving difficult story questions called HOTS questions. HOTS questions are explained through critical thinking skills which are impossible to do by memorizing facts but students must understand, analyze, or collaboratively categorize new problems, manipulate them, speak creatively, and apply them to find solutions to new problems (Riadi, 2016). Rohim (2019) concluded that the problem was a detailed, high-level thought process about managing information to address and solve complex problems that require skills, analysis, evaluation, and design. According to Khoiriyah, et al., (2021), there are three categories of the application of HOTS questions in Mathematics questions, namely: 1) category C4 - analyze, this category can describe a problem can analyze the relationship between one element and another element 2) category C5 - evaluate, standard evaluating can be in the form of quality evaluating including criticizing cognitive concepts 3) category C6-creating, to rearrange elements into new patterns or structures. This includes creation: hypothesizing, planning, and producing. The creative process consists of three phases. Present the problem, plan the solution, and implement the solution. The students' other skills, such as their capacity for group collaboration, problem-solving. Students with higher levels of creativity can attain higher learning outcomes in comparison to those with lower levels of creativity (Sulistiyono, et.al, 2017). This will lead to a decrease in students' motivation to study the subject matter when they are given assignments that are somewhat varied. To achieve the goal of math learning with an emphasis on the ability to use a tingkat tinggi, high-quality content is required. This soal-soal needs to be evaluated in terms of analysis and evaluation (Lewy, et.al, 2009)

Observations showed that learning mathematics had increased so that it ran factually. One of them was improvement, development and innovation in education. HOTS questions can maximize critical thinking skills and problem solving to support thinking patterns at a high level. Against the backdrop of this research, group activities aim to develop critical thinking and solve HOTS questions. The steps taken were to apply the Project Based Learning method to mathematics education in the second semester at the Elementary School Teacher Education Study Program, Sriwijaya University

METHOD

This research was descriptive research with a qualitative approach and it was conducted by observing and analyzing the application of the Project Based

Learning approach to critical thinking skills in line with HOTS questions. Besides, the Project Based Learning approach was based onHOTS questions in mathematics learning for 4 meetings. The application of this approach began with observation. After obtaining data regarding the students' initial abilities, group divisions were carried out. It proposed a research design in the form of a mental cycle involving planning, action, observation, and reflection. Defects are checked and corrected at the end of the session and then learning was carried outaccording to the critical thinking ability groups of students based on HOTS questions using the Project Based Learning approach. According to the description above, the aim of this study was to compare the simultaneous effects of scientific learning outcomes and critical thinking abilities between groups of students who received instruction using the HOTS Problem-Oriented Problem-Based Learning Model to students who did not receive such instruction using post-test-only b. This study aimed to investigate how the critical thinking abilities of second semester students and learning outcomes of basic mathematical concepts were influenced by the project- based learning model. All second semester students at Srwijaya University majoring in Elementary School Teacher Education (ESTE) form the research population as the sample.

This research was conducted on 34 students of ESTE at Sriwijaya University who did not understand the concept of mathematics learning. Apart from that, students' levels of thinking ability had different characteristics. This difference became a problem in the process of learning mathematics concepts in the classroom. Data collection techniques in this research used research instruments in the form of interviews, questionnaires and documentation. Interviews were conducted with ESTE lecturers in mathematics courses to obtain information regarding the obstacles and difficulties experienced by teachersin implementing HOTS questions using the Project Based Learning approach to strengthen students' critical thinking skills. Questionnaires were used to measure and keep clear and detailed records regarding the research process and results. This data analysis technique applied the data analysis method according to Achjar, et.al, (2023). The analysis consisted of three activity flows that occurred simultaneously, namely: data reduction, data presentation, drawing conclusions/verification. As follows

1. Data Reduction

   Data reduction is defined as the process of selecting, focusing on simplifying, abstracting and transforming rough data that emerges from written notes in the field. Data reduction occurs continuously throughout a qualitative research-oriented project. Anticipation of data reduction is already apparent when the researcher decides (often without fully realizing it) the conceptual framework of the research area, the research problem, and which data collection approach to choose. During data collection, the next stages of reduction took place (summarizing, coding, exploring themes, creating clusters, creating partitions, making memos). This data reduction/transformation continues after the field assessment, until a complete final report is prepared. In this research, researchers carried out data reduction with the following steps:

   a. Correcting the response results from 37 students on each item of the HOTs-based test in basic mathematics learning concept material
   b. Presenting a description of the mistakes of the 5 selected subjects
   c. Describing student errors in solving HOTs questions based on the type oferror

2. Data Presentation

   Achjar, et.al, (2023) defines a presentation as a collection of structured

information that provides the possibility of drawing conclusions and taking action. They believe that better presentations are the main way for valid qualitative analysis, which includes: various types of matrices,graphs, networks and charts. Everything is designed to combine structured information in a form that is coherent and easy to achieve. In this way, an analyst can see what is happening, and determine whether to draw the correct conclusion or continue to carry out the analysis according to the suggestions told by the presentation as something that might be useful.

Therefore, researchers presented data regarding the description of students' answers in solving high-level thinking questions, especially regarding the types of errors made by students in answering these questions. The data was presented in the form of narrative text with the aim of making it easier for researchers to analyze patterns of errors that were often made by students. The presentation of data in this research included descriptions of student answers used as interview subjects, as well as notes on the results of researchers' interviews with students.

3. Drawing Conclusion

Drawing according to Achjar, et.al, (2023) is only part of one activity of a complete configuration. Conclusions were also verified during the research. From the results of interviews and the results of students' work in solving high-level thinking questions regarding mathematics learning concepts, researchers concluded about the mistakes that students often made in solving high-level thinking questions related to basic mathematics learning concepts.

The scores obtained from the results of student critical thinking skills assessment tests based on HOTS questions were then calculated using the formula from Akbar (2013) as follows:

Note:

X : Average score

Tse: Total empirical score

Tsh: Total expected maximum score

After calculating the scores obtained related to critical thinking skills based on HOTS questions with the Project Based Learning approach, they were then interpreted based on Likert scale categories. The categories used to analyze the results of the HOTS test questions on mathematics learning concepts refer to Sugiyono (2015) as in table 1:

Table1. Evaluation

No	Score interval (%)	Category
1	81-100	Very good
2	61-80	Good
3	41-60	Sufficient
4	21-40	Bad
5	0-20	Very bad

The indicators of critical thinking skills used in this research refer to Indicators

Table 2. Aspects of High Order Thinking Skills Aspect

	Indicator	Activity
Critical thinking	Analyze	Choose Compare
	Evaluate	Check Evaluate
Critical thinking	Create	Make Conclude

RESULT AND DISCUSSION

The Analysis results were obtained from 4 meeting with 3rd semester students majoring ESTE at Sriwijaya University which are divided into 2 cycles of learning basic mathematics concepts using the Project Based Learning method approach. The first step in implementing HOTs questions using the Project Based Learning approach in this research was to carry out diagnostic/initial assessment activities. This assessment was used to find out how much initial knowledge students had before implementing learning using the Project Based Learning approach. The diagnosticassessment showed that the class was divided into 6 groups, each group had 5 to 6 students.

The next step, after dividing into groups, a project implementation design for the Project Based Learning approach and create HOTS questions was created. When the learning device design was first used, problems occurred. This was because the learning materials are not used appropriately with the learning model. The creation of HOTs questions was carried out for the first time during the pretest. There were problems when answering questions, students were confused and asked a lot of questions. This was because students did not understand the concept of basic mathematics learning with critical thinking but there were also characteristics of students who had critical thinking skills. Since learning outcomes assessment can motivate students to think deeply and broadly about the material, it is anticipated that students' high-level thinking abilities will improve as a result (Hong & Lawrence, 2011).

The learning media that were designed were implemented in basic mathematics learning concepts in student classes. Learning activities had an opening, content and closing. In determining the learning model that was implemented, the educational basis emphasizes projects. According to Sampurno (2009) it can maximize student activities in learning, can increase students' creativity, critical thinking skills and scientific performance and help students to develop long-term learning skills. Project-based learning had enormous potential to create a more interesting and meaningful learning experience for students and could improve students' scientific performance in learning, while the teacher only played the role of facilitator and mediator. A learning model known as project-based learning (PjBL) employs an activity to solve a problem and generate learning materials. (Rahayu, 2019). The first stage of cycle I implementation involves the researchers conducting research, which includes creating the Learning Business Plan (RPP) for two meetings, preparing PowerPoint media, gathering the Students Work Sheet (LKPD), and creating the evaluation tool. Next, execute the action and cycle I observations in accordance with the prepared plan. Through the creation of works,

the actions are modified to conform to the Project Based Learning (PjBL) syntax. Students engage in active, cooperative, and creative problem-solving during this learning exercise. Group II finished the group project satisfactorily. Additionally, group II produces more original and creative results than any other group, making it the most creative group. Simply put, there are two groups. After that, cycle I is the subject of a posttest reflection using the same precycle question. Based on the posttest results, a HOTS-based mathematical learning outcome can be obtained, and the following data is entered

Table 3 Mathematical learning results based on HOTS Cycle

No	Pre-cycle indicators	Cycle 1
1.	Average Learning Outcomes	69,4%
2.	Number of students enrolled	17
3.	Percentage sequence	58%
4.	Number of students not enrolled	11
5.	Unclaimed percentage	42%

I

A case study conducted by Tamim & Grant (2013) also concluded that PJBL could support, facilitate and improve the quality and learning process, and at the same time could also enrich students' learning creativity. Other advantages of project-based learning according to the results of investigations by Yalcin, et.al, (2009) were that it could (1) create a varied learning atmosphere, (2) avoid the atmosphere of boredom that was usually found in schools, and (3) create an environment learning which was more interesting, fun, exciting and proud for students. Based on these reasons, project-based learning needs to be applied in the learning process.

The opening, whilst and closing learning activities carried out in class adapted to the learning tools. The opening activities included checking the attendance, singing national song "Garuda Pancasila", opening questions, presenting learning material and conveying learning objectives. Before the main activities, pretest on HOTS questions was given, followed by group formation according to the PJBL syntax. This activity was done to create a project containing basic mathematics learning concepts. This assessment was carried out by observing students while they were involved in learning activities and group discussion activities to complete projects on HOTS questions. Furthermore, in the closing activity, students with the lecturer concluded the basic mathematics learning concept material that had been studied to answer HOTs questions with critical thinking skills. Then the lecturer gave reinforcement so that they understood better and if the conclusions reached by the students were still not perfect, they would perfected by the lecturer. Besides, an evaluation was carried out to measure abilities on HOTs questions to strengthen students' critical thinking.

Results of improving critical thinking and problem solving skills for Elementary School Teacher Education students in the second semester of 2023-2024 at Sriwijaya University, whose total was 30 students in thePalembang class showed that based on the results of the observation assessment and analysis of critical thinking skills, interesting data was then analyzed as follows: a) Students had not been able to understand mathematics problems with facts and concepts, b) Students had not

recognized the basic concepts of learning mathematics regarding fractions, c) Students had not completed the answer correctly and had not been able toidentify the problem, d) Students had not been able to solve the problem of the concept of fractions given e) Students had not been able to conclude that the material was related to critical thinking skills. The average results in cycle 1 for the category of critical thinking skills on HOTS questions in mathematics courses could be seen as follows:

a. Average calculation:

$$X = \frac{\sum}{n}$$

Note:
X= class average score
∑=Total score obtainedby students
N= The number of students

$$X = \frac{\sum}{n}$$

$$X = \frac{1950}{30}$$

X = 65

b. Calculating the percentage of student learning completeness

$$TB = \frac{\sum n}{N} \times 100$$

Note:
TB = Mastery learning
∑ ≥62=The numbers of students who had a greaterscore than or equal to 62
100%= fixed number

$$TB = \frac{\sum n}{N} \times 100$$

$$TB = \frac{20}{} X10030$$

TB = 66,67%

Based on the data obtained, the class average for students' critical thinking skills was 65 and the percentage of student learning completion was66.67%. Data on the results of students' average scores related to critical thinking skills on HOTS questions in cycle 1 were presented in Figure 2

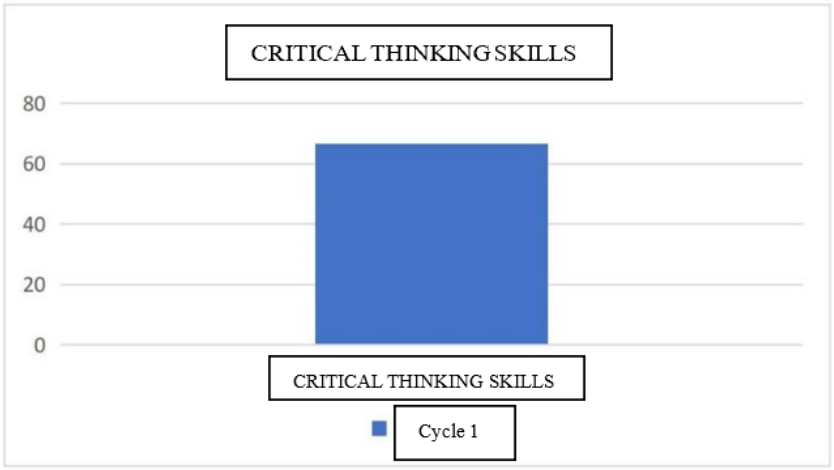


Figure 2. graph of cycle 1 of critical thinking skills using the PJBL method From the results of cycle I, they did not get a good enough score, where students still had difficulty solving HOTs questions, therefore the researchercarried out cycle II during learning using the Project Based Learning method in which HOTS questions were given. Based on the results of the average value of cycle II, it was obtained:

a. Average calculation:

$$X = \frac{\sum}{n}$$

Note:
X= class average
∑= Total score obtainedby students
N= The number of students

$$X = \frac{\sum}{n}$$

$$X = \frac{2550}{30}$$

$$X = 85$$

b. Calculating the percentage of student learning completeness

$$TB = \frac{n}{N} \times 100$$

Note:
TB = Mastery learning ∑ ≥62= The numbers of students who had a greater score than or equalto 62
100%=fixed number

$$TB = \frac{n}{N} \times 100$$

$$TB = \frac{25}{30} X100$$

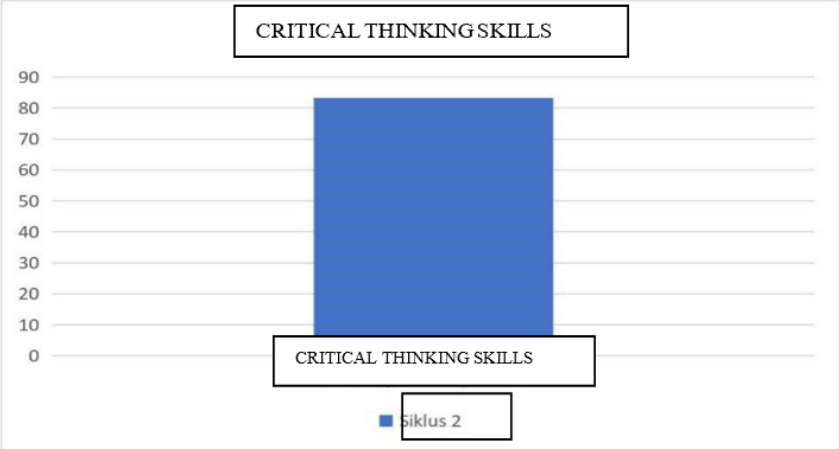
TB = 83,3%

cycle II of students' critical thinking ability was 85 and the percentage of student learning completion was 83.3%, increasing critical thinking in students. Data on the results of students' average

scores related to critical thinking skills on HOTs questions in cycle 1 are presented in Figure 3.

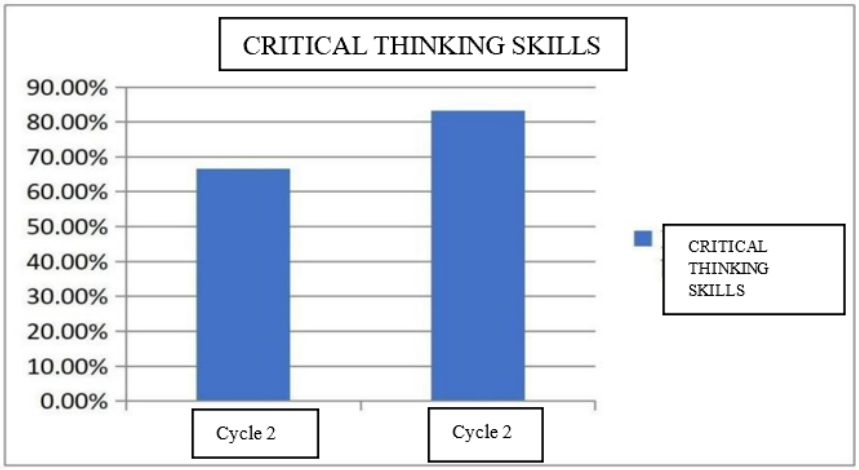
The researchers revised the learning activity planning for the second cycle. Preparing RPPs for two meetings, creating a Working Sheet of Student Participants (LKPD), creating PowerPoint materials, and creating assessment tools are among the tasks scheduled for the second cycle. Actions and observations were then made in accordance with cycle II planning, utilizing the same learning model from cycle I—that is, Project Based Learning. (PjBL). Every group can successfully complete the PPT product on Cycle II action. The work's outcomes are equally imaginative. Every group works well together and is creative. There are just two pupils who struggle with problem-solving, so they require support from friends and instruction from teachers. The same question from the pre-cycle and cycle I is then used for a posttest reflection on cycle II. The following data presents the mathematical learning results based on HOTS, which can be obtained based on the posttest:

Figure 3. Graph of critical thinking ability using the PJBL learning method



The assessments done in cycle I and cycle II were data obtained from the results of the average value calculations carried out. Based on the results of the score calculation, an average value was obtained which was used as a reference in measuring the effectiveness of implementing the PJBL model with the ability of HOTs questions to strengthen critical thinking skills. The average score obtained from cycle I increased in cycle II. This increase is presented in the graphic figure 3

Figure 4 : Critical Thinking Ability from HOTs questions



Based on the results of the assessment carried out on critical thinking skills on HOTs questions in cycle I, the results showed that 7.56% of students got the very good category, 60.50% got the good category, 27.83% got the adequate category, 4.08% got the poor category and there were no students who received the very poor category. Then in cycle II, the results were that 20.43% of students got the very good category, 43.22% got the good category, 20.10% got the fair category, and there were no students who got the poor and very poor categories. Based on these results, it could be seen that there had been an increase in critical thinking skills on HOTs questions. Student assessment data regarding critical thinking abilities is presented in Figure 4.

No	Very Good	Good	Sufficient	Bad	Very Bad
Cycle 1	7,56%	60,50%	27,83%	4,08%	-
Cycle II	20,43%	43,22%	20,10%	-	-

Based on the graph above, it showed that critical thinking skills on HOTS questions using the Project Based Learning method of Elementary School Teacher Education students in the second semester at Sriwijaya University in the Palembang class whose total was 30 students had 2 cycles. In cycle 1, students worked on HOTS questions that had not implemented the Project Based Learning method. The results obtained were that thegraphic students' critical thinking skills were above 60.00%, namely at 66.66%. Meanwhile, in cycle 2, students worked on HOTS questions which had applied the Project Based Learning method, and the results of critical thinking skills were 83.3%, which was above the graph of 80%. From the results of the cycle 1(pre-action graph) and cycle 2 (post-action graph), there was an increase of 16.66%. This means that the students' thinking abilities had increased with HOTS questions using the Project Based Learning method.

The index had three subjects with learning difficulties at various stages of problem solving. Each of these subjects had different difficulties because students had different difficulties. Based on the graphical results of the critical thinking ability on HOTS questions in C4-analyzing, C5-evaluating, and C6-creating, the indicators had been achieved. The students had done their best and could solve problems well. There was an explanation of this indicator as follows:

Based on the HOTS question aspect indicator C4-analyzing, students were able to carry out selecting and comparing activities and there was an increase in their ability to think critically about HOTS questions after applying the Project Based Learning method.

Based on the HOTS question aspect indicator C5-evaluating, students were able to carry out checking and assessing activities, there was an increase in their ability to think critically about HOTS questions after applying the Project Based Learning method. Based on the HOTS question aspect indicator C6-creating, students were able to carry out creating activities and concluded that there had been an increase in their ability to think critically about HOTS questions after applying the Project Based Learning method. Based on three aspects of indicators, students were able to solve problems. Therefore, there was an increase in critical thinking. Students were able to solve subject problems which include:

1) Through reading activities, students could identify existing problems. During this reading phase, students could note key words, made notes of information they knew, and reviewed questions.
2) Through exploration, students in this phase could identify a given

problem, translate it in an understandable way and look for information needed and not needed to solve the problem.

3) Choosing a strategy in this phase, students knew how to hypothesize to solve problems obtained in the previous two phases to find or create patterns in the form of strategic arrangements to solve problems.
4) At this stage, students could use math skills such as counting to find answers. This activity was carried out during the prediction phase. Students could use their math skills to solve problems or use a calculator with math skills when necessary
5) Reviewing and discussing at this point, students could review their answers and identify variations in problem solving. Activities undertaken by students during this phase involved reviewing their answers and discussing their answers.

Therefore, applying the Project Based Learning method improved critical thinking skills and could solve problems and the results were 83%. Implementing the Project Based Learning method had been structured with process steps. The increase in critical thinking skills showed a significant increase after the implementation of the independent learning curriculum using software in the post-implementation student group which was significantly higher than pre-implementation (Djaja et al., 2023). This is in line with research by Wilujeng et al. (2022) research entitled "Applying the Project Based Learning method to develop higher order thinking skills in the classroom" which stated previously about the application of the Project Based Learning method in improving students' critical thinking skills in solving problems well and collaborating with group discussions. The Project Based Learning method had a syntax that could help students solve problems. There were good collaborative group discussions, self-confidence and cognitive, effective and psychomotor development of students. In addition, it allowed students to improve problem-solving skills and understand critical thinking,flexibility, orientation, accuracy, and reformulation. In addition to having critical thinking skills, participants must always be able to communicate. Theability to exchange information, understand information, and provide accurate and good information is known as communication skills. Communication is a means of expressing thoughts and emotions (Muharromah, 2019).

This indicates that speaking is an act that provides insight into someone's mental state. During the teaching process, the instructor used direct communication to paint a picture of his thoughts for the student, but different students absorbed information differently, even when it came from the same source. The reason for this was varying degrees of information comprehension. As a result, interaction was necessary for learning, particularly for communication, so that teachers were aware of their students' level of comprehension. Challenges and support included factors that could influence the success of curriculum implementation. They learned from teaching staff, resource providers and students who played an active role in education (Buda, et.al, 2022). By using the learning model, critical thinking skills could increase so that they were involved in analyzing, evaluating ideas and expressing reasons through sharing ideas with friends, studying different ideas and being able to jointly evaluate the results of thinking (M. D. Putri & Arifin, 2017). The results of research on UNBK 2019 Mathematics High School students obtained low results in critical thinking abilities (Akhyar, 2019). Therefore, the solution to solve this problem is by using an

appropriate learning model. According to Putri, et.al (2020), there were two learning models that were implemented which showed different and not the same results. Not all learning models had the results of increasing critical learning abilities by using HOTS questions. The problem with Pasari Huni Elementary School was that there was not enough effort to help students develop their critical thinking and collaborative skills during learning activities. For example, learning activities were still carried out using the lecture method, and learning designs did not yet incorporate HOTS principles. As a result, students did not develop their critical thinking skills and are not used to working in groups (Ridwan, et.al, 2023). Regarding the independent curriculum, it was found that the curriculum for autonomous learning should be quite simple to design and implement. But when it was put into practice, it ran into issues that remained unclear to the government, such as how to put curriculum content into practice quickly to achieve desired results (Pratikno,et. al, 2022).

With a high level of critical thinking, students can work on HOTS questions in the mathematics learning semester for Elementary School. Teacher Education, Sriwijaya University. Rohim (2019) concluded that HOTS questions were in-depth high-level thinking about information management in dealing with and solving complex problems and involve skills, analyzing, evaluating and creating. Based on the HOTS questions given, they included analyzing, evaluating and creating. Based on the results of the HOTS cycle 1 questions given, students were not able to complete the HOTS analyzing questions- C4-analyzing, C5-evaluating, and C6-creating. It cannot be denied that these results were because students were not used to working on high-level thinking questions, especially on C4-analyzing, C5-evaluating, and C6-creating, but students were used to working on C1-understand, C2- Apply, C3-analyze questions. It can be seen from the data obtained by students that students did not meet the characteristics of critical thinking abilities. Students still seemed passively busy with their own activities, no one was active enough to have curiosity in learning mathematics. This also happened because students were not yet familiar with the concept of learning mathematics, providing simple explanations, developing basic skills and argumentation, making further explanations and formulating strategies and tactics.

According to the critical thinking indicators, HOTS questions were quite low in answering questions C4-analyzing, C5- evaluating, and C6-creating, but what was more dominant was that students were quite low in C4 analyzing questions. This happened when they lacked practice in answering questions with solutions from existing designs. This problem was also found during interview observations involving several students in the class. Valerie (2000) asserted that the cause of the obstacles experienced by students was that learning activities were still based only on the transformation which were focused on the cognitive domains C1, C2 and C3 or LOTS questions, without any activities that criticized difficulties and found the different domains in C4 and C6 questions.

Therefore, the students had difficulty in answering the questions that had been given. Students tended to make mistakes in answering questions because the questions given were different from the procedures that had been given previously. After carrying out cycle 2, the results obtained by students were increase in critical thinking skills on HOTS questions on indicators C4- analyzing, C5-evaluating, and C6-creating, which increased by 16.66% due to the learning

model based on the HOTS question aspect indicator C4- analyzing, students had been able to carry out selecting and comparing activities. There is an increase in the ability to think critically about HOTS questions using the Project Based Learning method. The results from cycle II showed that a) Students could understand mathematics problems with facts and concepts, b) Students could recognize the basic concepts of learning arithmetic regarding fractions, c) Students could complete answers correctly and could determine the questions, d) Students could solve the conceptual problems given, e) Students could imply that the material includes critical thinking skills. There were appropriate indicators for improving critical thinking. Students were trained to work on HOTS questions, especially C6 questions and the questions related to daily life (Saraswati & Agustika, 2020). Beside using learning models, it was important to establish evaluation procedures that facilitated the growth of problem class cognitive abilities (HOTS). To achieve this, educators need to have a thorough understanding of what, why and how learning based on higher thinking skills (HOTS) is (Purwowidodo, 2023).

According to Facione (2011), State includes interpretation, analysis, evaluation, conclusion, declaration, self-regulation, etc. Inter-practice is the ability to understand problems. Besides, analysis is the ability to see relationships between statements, questions, concepts and explanations.Reputation is a skill that earns trust. Reasoning is identifying and obtaining elements to draw conclusions. Finally, self-regulation is the ability to monitor factors used in cognitive and problem-solving activities. Critical thinking in mathematics subjects minimizes the occurrence of problem solving, and because critical thinking and learning mathematics are interdependent and constant, the correct conclusion is finally reached (Kurniawati & Ekayanti, 2020). Based on the results of the analysis and discussion, the PJBL learning model could improve the learning process and stages compared to students who did not use the learning model at all during pre-implementation.

Project Based Learning for high level critical thinking skills had the potential to meet learning requirements. Based on significant study results, the Project Based Learning method helped students learn solid and relevant skills knowledge through authentic assignments and worked and expanded knowledge through original curriculum activities through the design of learning activities. According to Yuliati & Lestari (2018), the cognitive domain of analysis, evaluation and creation required complex solutions because it had a high level of critical ability. Similarly, Anggraini, et.al (2019) states that the ability to think critically in HOTS questions is an ability that does not rely on memory but tries to think in a complex way that involves being creative and critical in a problem to find a solution. So, with the ability to think critically on HOTS questions by using the learning model as a problem solver when facing problems, a person needs to have the skills to implement their knowledge with wise judgment and be able to criticize all parties involved by giving logical reasons.

This skill improved students' ability to analyze HOTS questions better in problem solving. Cognitive critical thinking skills in analyzing directly could be increased. In indicators of critical thinking abilities in problem solving planning, students were able to determine formulas according to concepts to solve problems. Students were not yet confident in answering but had created an active attitude in thelearning process. All students had asked about the concepts given Students had

fulfilled the characteristics of critical thinking abilities. In the second post-action cycle, students were able to improve their ability to determine formulas with concepts and could solve problems according to planning, carry out independent reviews and students could face challenges in the era of technology 4.0. Such approximates of practice education should take into account and strike a balance between two factors: the authenticity of real- world practice and the complexity of the necessary cognitive demands. A balance between authenticity and cognitive demand is mentioned in other research approaches, and these approaches suggest the use of simulations, which are described as "imitating one process by another process." (Hartmann, 1996, p. 83).

This helped students become more familiar with environmental mathematical issues because they understood that mathematics was more than just formulas and numbers – instead, it was connected to the real world and everyday experiences (Lubis, 2023). In the problem solving indicator, they answered questions with clear guidance and plans. Students then improved their ability to solve problems according to planned steps, provide correct answers and use alternative solving strategies for high-level reasoning questions. Students could share information in group discussions, collaborate and exchange ideas with colleagues in the direct learning process. Students' learning responses to mathematics learning received a positive response. It was stated that students were happy with all kinds of high-level critical thinking questions, minds-on activities. Moreover, the existence of an independent curriculum made an important contribution in understanding the role of an independent learning curriculum in preparing students to face the challenges of change in the modern world. It played an important role in continuously evaluating and perfecting higher education strategies (Banawi, 2019; Sudianto, Dwijanto, & Dewi, 2019).Furthermore, critical thinking skills can increase if the educators use appropriate learning models, students can easily understand how to solve problems.

The results with the PJBL learning model regarding student responses to mathematics learning had increased critical thinking skills which could make students active and curious. With answer completion indicator, students provided answers to advanced HOTS questions. In cycle II, students could work on difficult questions. The limitation of this research was using one learning model and there was no comparison with other learning models, but it could be seen that the results of PJBL learning model increased after it was used. What was reviewed was based on experience and previous publications by emphasizing critical thinking skills with other learning models and also seeing that many things could not be achieved as desired. Furthermore, feedback and opinions of others are expected so that future data studies can be done with more data collection or future studies on modifications to the current methodology. The problems given were related to everyday life which were often encountered, encourage students to answer questions only to solve the problem. The answers to the questions were completed and all could be answered when it came to problem solving, for solving problems in mathematics lessons and for daily tasks in general

CONCLUSION

Critical thinking skills regarding HOTS questions of Elementary School Teacher Education at Sriwijaya University for second semester students were increased. This happened because students receive HOT questions that suited their abilities, motivated

them in learning, and made students more active in the learning process. Apart from helping solve problems with critical thinking skills, the Project Based Learning model approach also increased critical thinking skills on HOTs questions. This model approach also had a positive impact on students collaborating well. Lecturers considered the Project Based Learning approach model to be helpful in developing critical thinking on HOTs. Even though he admitted the difficulty in creating HOTs questions that were adapted to material using the Project Based Learning model, apart from that, a level of critical thinking ability was also required to solve problems in implementing them. Overall, the Project Based Learning model had proven to be effective in improving students' critical thinking skills on HOTs questions

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