Enhancing critical thinking and academic achievement through different learning

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ABSTRACT

This research examines the impact of implementing different learning models on students' critical thinking abilities (CTS) with different academic achievements. This research was a quasi-experiment and involved 134 high school students in Jember. Research classes are divided into project-based learning (PjBL) and conventional learning, then divided based on academic achievement, namely high and low. Data was collected using essay exams supported by the CTS assessment rubric. Information was analyzed using analysis of covariance (ANCOVA) and continued with the least significant difference (LSD) test. The research results show that i) there is a significant difference in the development of CTS between students who follow the PjBL learning model and students who follow conventional learning; ii) there are differences in CTS development between high and low-achieving students; and iii) there is an interaction between the learning model and student academic achievement which influences the development of CTS. Based on these findings, it can be interpreted that the PjBL learning model effectively increases the development of CTS in high and low-achieving students, especially in low-achieving students. The PjBL learning model encourages students to be active, think critically, work together and solve problems. Teachers can improve the critical thinking skills of students with low academic abilities through the PjBL learning model.

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1. INTRODUCTION

The critical role of the learning process in the 21st century is empowering students in critical thinking abilities (CTS) aspects. This is because CTS is one of the provisions that is very necessary for students to be able to adapt and be successful in dealing with changes that are constantly occurring in a global society [1]–[3]. The CTS concept involves students' achievement to critically analyze, evaluate, and interpret information so that they can make good and responsible decisions in various life situations [4]–[7]. Therefore, the learning process in the 21st century is expected to empower students through the development of student CTS [8], [9]. The development of CTS has a very significant relationship with the success rate of students in the learning process. This is due to CTS students' achievement in building their knowledge, which in turn has a positive impact on increasing their academic achievement. Through CTS, students can actively construct knowledge, critically explore information, and use their skills to solve complex problems [10]–[12]. Therefore, CTS is recognized as one of the most important future skills [13], [14]. CTS equips students to meet the evolving requirements of a world where adaptation, technological literacy, and a deep understanding of science are critical for success [15]. By having a strong CTS, students can become independent learners, can continue learning throughout life, and are ready to face challenges in various aspects of life [16]–[19]. However, in reality, many learning processes in the field still follow the traditional approach. In the learning process, teachers generally use the lecture approach more often, followed by giving assignments to students [20], [21]. This method produces more passive learning activities, in which students passively receive the material the teacher presents [22], [23]. Apart from that, in conventional learning, students also often study in groups and interact with each other to solve problems given by the teacher [24]. This causes students to seek help from each other and interact more in a face-to-face learning atmosphere. The learning process emphasizes obtaining high student scores, with the primary goal of achieving high academic achievement. Furthermore, in conventional learning, the main focus is memorizing concepts and working on objective questions [25]. In conventional learning, understanding concepts and applying critical skills often do not get adequate attention.

Conventional learning tends to pay less attention to the importance of a contextual learning process, where students can see the relationship between the material being studied and their real-life context [26]. In addition, conventional learning also pays less attention to CTS empowerment, which involves students' achievement to critically test, question, connect, and evaluate information [27]–[29]. In conventional learning, the main goal is for students to be able to memorize the contents of the material being taught. This method often emphasizes students' achievement in remembering and repeating information given [30], [31]. In addition, in the context of conventional learning, students are rarely taught to test, question, relate, and evaluate the material being studied. Conventional learning tends to provide little space for students to develop their CTS. Students focus more on passive acceptance and understanding of the material than in-depth analysis, reasoning, and evaluation [32], [33].

Furthermore, students with low academic achievement often do not get adequate attention in the conventional learning process. This is due to the assumption that low academic achievement indicates a student's achievement in completing the given tasks. However, it is essential to realize that students with low academic achievement need particular learning strategies to study well [34]. Low academic achievement should not be an obstacle in their development but should be a focus to improve the quality of learning. Therefore, teachers need to apply appropriate learning models to increase the CTS of students with different academic achievements, especially students with low academic achievement, in the learning process.

This research has very high importance because there are rare research reports related to an increase in CTS in students with different academic achievements, especially in students with low academic achievement. Therefore, this research has a vital role in filling this deficiency. The main objective of this study is to determine the increase in CTS in students with different academic achievements by applying a project-based learning (PjBL) model. By conducting this research, it is hoped that there will be an increase in the understanding and application of CTS to students with different academic achievements. Using the PjBL mastery model in this study is expected to provide a more relevant and exciting learning context for students with diverse academic achievements.

2. METHOD

2.1. Research design

The research design used a quasi-experimental method. This study uses the pretest-posttest nonequivalent group design, which is carried out by manipulating the learning model and academic achievement as independent variables, and CTS as the dependent variable. Details regarding the implementation of the treatment can be found in Table 1.

Table 1. Quasi-experiment research design

Pretest	Group	Posttest
O1	S1A1	O2
O3	SIA2	O4
O5	S2A1	O6
O7	S2A2	O8

O1, O3, O5, O7 is pretest score; O2, O4, O6, O8 is posttest score; S1 is PjBL learning model; S2 is conventional learning; A1 is high academic achievement; and A2 is low academic achievement.

2.2. Sample and data collection

This study involved secondary schools as a population in the 2021/2022 academic year, with a total sample of 134 students. This is in line with Sekaran [35], stated that an appropriate sample size in research is between 30 and 500. Sampling was carried out using a cluster sampling technique, in which class groups were selected randomly. The classes that became the study sample were tested for equality using analysis of variance (ANOVA) using IBM SPSS statistic 25.0 for Windows software on placement test scores.

Four classes received treatment in this study. Two classes use the PjBL learning model, while the others are taught using the conventional learning method. Furthermore, each class was divided into two groups: the group with a high level of academic achievement and the group with a low level of academic achievement. Students' CTS was measured using a pretest and posttest using an exposition test. The validity of the exposition test was approved by learning specialists and was considered valid for this study. For empirical validation by using Microsoft Excel, the result of analysis showed that the instruments were valid (0.365-0.601) and reliable (0.876). Answers to test questions are assessed based on the CTS rubric referring to previous study [36] with indicators (focus, reasons, conclusions, situation, clarity, and general description) modified by Zubaidah [37]; the score range in this rubric is 0-5.

2.3. Analyzing of data

Information about critical thinking skills is then analyzed using covariance analysis (ANCOVA) which relates it to the impact of learning models, academic achievement, and the interaction between learning models and academic achievement on students' CTS. This test was conducted to test the following hypotheses: i) there was a difference in CTS between students who took the PjBL learning model and students who took conventional learning; ii) there was a difference in CTS between students with high and low academic achievement; and iii) there was a difference in critical thinking achievement related to the interaction between learning model and academic achievement.

3. RESULTS AND DISCUSSION

The results of the ANCOVA analysis are presented in Tables 2-5. A summary of the ANCOVA test results is in Table 2. In the table, it can be seen that the learning model, academic achievement, and the interaction between the learning model and academic achievement have a higher p-level smaller than the alpha value of 0.05 ($p<0.05$) with a significance value of 0.000 each; 0.000; and 0.043. This shows that the alternative hypothesis is accepted. Thus, it can be concluded that there is a significant influence between learning model, academic achievement, and learning model interaction with academic achievement in CTS after students follow the PjBL learning model and conventional learning.

Table 3 identifies the differences between the PjBL model and conventional learning. The PjBL model has significant differences compared to conventional learning. In percentage terms, there is a significant increase in the average score of 8.13% in the PjBL model compared to conventional learning. The results of the study show that the PjBL learning model is more effective in increasing students' critical thinking achievement when compared to conventional learning.

Table 4 clearly illustrates the difference between high and low academic achievement. High academic achievement is significantly different from low academic achievement. In percentage, there is a significant increase in the average score of 11.33% in high academic achievement compared to low academic achievement. The results showed that students with high academic achievement had better critical thinking skills than students with low academic achievement.

Table 5 shows no significant difference between the PjBL learning model at low academic achievement and conventional learning at high academic achievement. As a percentage, it can be seen that the average corrected score in conventional learning at high academic achievement is only 3.40% higher than the PjBL learning model at low academic achievement. The results showed that the PjBL learning model improved students' academic achievement, especially for students with low academic achievement.

Table 2. Summary of ANCOVA test outcomes from critical thinking skills

Source	Type III Sum of Squares	df	Mean Square	F Sig.
Corrected model	9926.516a	4	2481.629	25.182.000
Intercept	6987.769	1	6987.769	70.907.000
X-CTS	6039.179	1	6039.179	61.282.000
Learning_Model	1476.445	1	1476.445	14.982.000
Academic_Achievement	2872.222	1	2872.222	29.145.000
Learning_Model*Academic_Achievement	412.990	1	412.990	4.191.043
Error	12712.685	129	98.548	
Total	857705.991	134		
Corrected total	22639.201	133		

Table 3. The outcomes of the LSD test related to the impact of learnings on critical thinking skills

Learning model	Pretest		Posttest		Difference	Enhancement	CTScor	LSD notation	
	M	(SD)	M	(SD)					
Conventional	46.58	9.36	75.20	14.57	28.61	61.43%	75.37	a	
PjBL	47.73	8.03	82.27	10.56	34.54	72.36%	82.04		b

Table 4. The outcomes of the LSD related to the impact of academic achievement on critical thinking skills

Academic achievement	Pretest		Posttest		Difference	Enhancement	CTScor	LSD notation	
Low	48.87	8.33	75.92	13.23	27.05	0.55	73.98	a	
Hight	45.46	8.73	82.06	12.19	36.60	0.81	83.44		b

Table 5. The outcomes of the LSD test related to the effect of the interplay between learning and academic achievement toward critical thinking skills

Interaction	Pretest		Posttest		Difference	Enhancement	CTScor	LSD notation		
Conventional low	47.45	9.49	69.08	13.59	21.63	0.46	68.87	a		
PjBL low	50.00	7.22	81.32	10.20	31.32	0.63	79.08		b	
Conventional hight	45.79	9.32	80.76	13.31	34.97	0.76	81.87		b	c
PjBL hight	45.12	8.23	83.36	11.01	38.23	0.85	85.01			c

The analysis shows that there is a tendency that the use of learning models can increase students' CTS. The results are consistent with research conducted by several researchers, such as research that reports that learning models affect increasing student CTS [38], [39]. The application of different learning models has different potentials to improve CTS. The PjBL learning model has been reported to produce significantly better CTS test scores than conventional learning. This finding is consistent with previous research reports, indicating that each learning model has a different potential to increase students' CTS [31], [38], [40]. The PjBL learning model is an approach that trains students to be active in the learning process and construct knowledge. The steps contained in the PjBL model encourage students to be actively involved in learning to build their knowledge [41], [42]. In addition, several findings [43]–[45] emphasize that building knowledge through social interaction in the learning process is also an essential factor in increasing student CTS.

The increase in student CTS in the PjBL learning model can be attributed to the structured learning steps from beginning to end. The PjBL learning model starts with the essential questions stage, in which students choose topics relevant to the real world and conduct investigations. Next, they design a project plan with the help of collaboration between students and teachers to integrate various materials. Students also create project completion schedules and actively monitor the progress of their projects, following directions and rubrics provided by the teacher. The next stage involves assessing the reported results, in which students report on the progress and competencies they have achieved. Finally, students and teachers evaluate their experiences and reflect on the activities and results of the projects that have been carried out. Through these steps, students are encouraged to develop the achievement to formulate problems, formulate solutions, and design, and evaluate project activities to solve problems. The PjBL learning model can encourage students with learning difficulties to be active in the learning process [46]–[48].

In comparing the PjBL learning model and conventional learning, conventional learning in this study is commonly used by teachers. The results showed that conventional learning resulted in low student CTS scores. This is caused by the focus of learning, which is only on standard mastery, without giving students opportunities to be actively involved, so learning techniques become meaningless. Conventional learning does not encourage students' higher-order thinking skills because students do not get learning experience, motivation, and confidence to be actively involved [49]. Furthermore, conventional learning is dominated by rhythm and assignments without providing opportunities and confidence for students to construct their knowledge [50], [51]. Thus, a significant difference between the PjBL learning model and conventional learning is that the PjBL learning model provides opportunities for students to be actively involved in learning, encourages higher-order thinking skills, and allows students to construct knowledge.

Academic achievement indicates learning achievement that includes students' knowledge and skills. In this study, higher academic achievement was associated with higher achievement than lower academic achievement. High academic achievement influences the way students learn. Students with high academic achievement tend to have a broader range of knowledge and skills that can be used to solve complex problems involving CTS aspects. Academic achievement affects students' achievement to analyze, interpret, and make decisions [52]. In addition, students with high academic achievement are better able to solve complex problems that require a higher level of thinking than students with low academic achievement [31].

Low academic achievement in students can be caused by a lack of skills in finding, obtaining, and using information. Students who have low academic achievement often face obstacles in the learning process.

Students with low academic achievement tend not to have effective strategies in the learning process [53]. They may have difficulty managing and organizing information efficiently. In addition, students with low academic achievement may experience challenges in constructing their knowledge [54]. They may have difficulty understanding new concepts and relating them to existing knowledge. This can cause obstacles in their learning process.

The analysis results show that the PjBL learning model tends to increase the CTS of students with high and low academic achievement, especially for students with low academic achievement. Applying the PjBL learning model is considered very effective in increasing student CTS. This can be seen from the results that there is no significant difference between the CTS of students in the PjBL learning model with low academic achievement and the CTS of students in conventional learning with high academic achievement. These findings are consistent with previous research [55] which concluded that the BOPPPS learning model can improve students' academic achievement in general. In addition, other research [56] also shows that the RMS learning model tends to increase the CTS of students with low academic achievement.

The PjBL model is a learning model that can potentially improve students' CTS, especially for students with low academic achievement. This suggests that students with low academic levels can experience positive learning experiences. This positive experience is obtained through the steps in the PjBL model, which helps train students with low academic achievement to complete assignments well. This finding is in line with the several researches [57], [58], which state that PBL can train students to seek, discover, and apply their knowledge to identify and find a solution to the problem at hand.

Problem-based learning process has high effectiveness and produces meaningful learning experiences [59]–[61]. The PjBL learning model has advantages in training students to learn collaboratively, discover, and use information in project contexts. In the PjBL model, students are encouraged to dig up more facts about a topic and read the relevant material to gain broader insights about various problems, teamwork, problem-solving, and applying concepts in problem contexts. This is consistent the findings [62], [63], which state that collaborative learning provides essential support in planning and communication in solving problems. In addition, cooperative learning can improve students' scientific skills and competencies [64]. Thus, it can be concluded that the PjBL learning model, with a focus on collaborative learning, significantly enhances students' skills, competencies, and learning experience in solving problems effectively.

Based on the research, it was found that the lowest corrected CTS score occurred in conventional learning in students with low academic achievement. Furthermore, there is a significant difference between conventional learning for students with high academic achievement and the PjBL learning model for students with high academic achievement. One of the factors causing the low CTS score in conventional learning is the lack of practice and opportunities for students to build their knowledge, which causes the low quality of conventional learning. Several researches [65], [66] shows that conventional learning does not encourage students to learn actively. In addition, Sharma *et al.* [67] stated that conventional learning does not teach students the analytical and evaluation skills needed to solve problems, contributing to low CTS scores. Furthermore, Wen *et al.* [68] stated that conventional learning does not increase student achievement and does not develop independence in learning. Thus, it can be concluded that conventional learning has limitations in increasing students' CTS, especially for students with low academic achievement.

4. CONCLUSION

Compared to conventional learning, the PjBL learning model has been proven effective in improving thinking skills, especially for students with low academic achievement. In this context, the PjBL learning model can improve students' CTS with low academic achievement by developing critical simulation skills. Therefore, through the implementation of the PjBL learning model, students with low academic achievement have the opportunity to improve their thinking skills and technological competence through the use of critical simulations. Instructors or teachers can improve the competency of students' technological skills with low academic needs through the PjBL learning model. In PBL, instructors create learning experiences focused on problem-solving and practical application, helping students develop technology skills. PBL engages students actively, encouraging critical thinking, collaborative work, and real problem-solving. With PBL, instructors provide opportunities for students with low academic needs to develop real-life, relevant technology skills.

The practical implications of these findings highlight the need for the integration of PjBL models in educational curricula, especially for students with low academic achievement. Through PjBL, schools can provide opportunities for students who experience difficulties in conventional learning to develop critical thinking and technology skills through practical experiences focused on problem-solving, which can increase their interest in education and academic achievement. From an educational policy perspective, the support and development of training programs for teachers in implementing the PjBL model are crucial. Increasing teachers' skills and understanding of this learning approach will ensure its effectiveness in improving students' competence, especially those who need special attention. In addition, the need to provide supporting resources and infrastructure, such as the technology required for implementing PjBL, must also be considered when developing supporting education policies.

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