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Does Collaborative Inquiry Project Laboratory Promote Teenagers' Problem Solving Skills? A Feasibilty Study

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Abstract

This research aims to test the effectiveness of Collaborative Inquiry Project Laboratories in enhancing problem-solving skills among adolescents. Problem-solving skills are one of the essential competencies needed to face challenges in the modern era, particularly in the context of 21st-century education. The research method used is a quasi-experimental design with a pretest-posttest control group. The research sample consists of high school students divided into experimental and control groups. The experimental group engaged in collaborative inquiry project-based learning, while the control group followed conventional learning methods. The results indicate a significant improvement in the problem-solving skills of adolescents involved in the collaborative inquiry project laboratory compared to the control group. This suggests that the inquiry project-based learning approach, which emphasizes collaboration, can be an effective strategy for developing adolescents' problem-solving abilities. These findings are expected to contribute to the development of learning models that support 21st-century skills, particularly in science education.

Keywords: *Collaborative Inquiry Project Laboratory; Problem-Solving Skills; Adolescents; Science Education; Collaboration.*

Introduction

Students need to master 21st century skills in order to adapt to the changes that occur in the future. These skills include critical thinking, problem solving, communication, collaboration, use of information and communication technology, life skills, cross-cultural understanding, creativity, innovation, social responsibility, cultural awareness, global awareness, initiative, self-management, entrepreneurship, self-direction, transformational leadership, and innovation (Dede, 2010; Ghamrawi et al., 2017; McLoughlin & Lee, 2008; Redecker et al., 2011; Trilling & Fadel, 2009; Wagner, 2010). One of the key skills that are key to success and must be mastered is problem solving skills (Yoon et al., 2020; Funke et al., 2018; Magaji, 2021). This is because the ability to solve problems can bring new experiences through the process of finding solutions (Mahanal et al., 2022), can be applied to overcome various obstacles in various fields of life (Rios et al., 2020), and is the most needed skill in the 21st century workforce (Rahmawati et al., 2018). One of the characteristics of the independent curriculum is problem-solving oriented learning (Firdaus et al., 2022). With learning that leads to problem solving, it is expected that students' problem solving skills can increase. However, research shows that students' mastery of problem-solving skills is still low.

However, in reality, problem solving skills in students in Indonesia are classified as low. This is also evidenced by data from the Program for International Student Assessment (PISA) which states that the ability of students in Indonesia to have problem solving skills is still low where Indonesia still ranks 62nd out of 70 countries in the survey, with an average score of 403 and an international average of 493 (Adinia et al., 2022). The low capacity is the cause of the decline in the quality of human resources as evidenced by the low ability in problem solving. The low ability is due to the learning method in the classroom has not practiced the ability to solve problems (Nurhayati et al., 2021). One of the problems faced by the world of education is the weak learning process (Rachmadtullah et al., 2021; Anggraini & Azmy, 2022; Zakaria et al., 2023). Wahyuningtyas & Kusmaharti (2023) said that the low problem-solving ability is caused by students who tend to memorize and are not accustomed to working on non-routine problems, so students have difficulty when given practice problems different from the previous ones. In the learning process, children are less encouraged to develop problem-solving skills. Developing problem-solving skills involves applying an appropriate learning approach (Sari et al., 2021). Therefore, one of the efforts that can be made by

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teachers is to plan and use effective learning models and media to improve students' problem solving skills in practicum learning in the laboratory.

Based on research observations carried out in the target schools in this study, many schools do not have adequate facilities to support practicum activities. One of them is that teachers experience obstacles in implementing due to lack of confidence, academic backgrounds that have never been equipped with inquiry practicum activities, have limited understanding, and obstacles in using laboratory equipment (Chichekian et a., 2016; Fitzgerald et al., 2019). Incomplete laboratories, inadequate equipment, and limited practicum materials are the main obstacles. To overcome the obstacles in practicum learning, so by applying a practicum learning model that is relevant to the nature of science is the lab project inquiry model practicum. Lab project inquiry practicum can instill the basics of scientific thinking in students, so that in this learning process students learn more on their own, develop creativity in solving problems (Wang et al., 2015). One way to improve scientific achievement is to implement an enabling assignment approach, and one way is through project-focused learning and practicum (Keiler, 2018). Such tasks can facilitate students to be independent and work creatively and critically in solving problems (Albay, 2019).

The learning model must be based on problems that require authentic investigation, namely investigations that require real resolution of a problem using a learning approach that trains students to actively learn, so that they can formulate and solve problems based on the information that has been provided (Destalia et al, 2014; Abdulfattah et al, 2019). In addition to learning models and methods, it is also necessary to have one of the approaches that can be used in learning biology is the existence of practical activities or laboratory work. This is because in learning that uses laboratory work will make students more active in experimental or practicum activities, students will be able to interact directly with nature and students can obtain science concepts learned through experimental or practicum activities.

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Laboratory activities aim to provide students with direct experience to study natural phenomena and provide students with an understanding of how scientists study nature (Saputra et al., 2019). Laboratories also provide opportunities for students to interact directly with the scientific phenomena being studied (Saputra et al., 2021). Running a project-based learning or laboratory is not only limited to giving project assignments to students. Quality projects have the ability to stimulate and strengthen students' understanding according to the field of science being studied (Coman et al., 2020; Darling-Hammond et al., 2020). Therefore, it is important to organize the projects given to students by emphasizing an approach that is oriented towards inquiry-based and Laboratory-based learning (Pedaste et al., 2015; Shariff et al., 2013).

The use of laboratory project inquiry-based learning methods is very suitable to be applied in the context of science because it can effectively enrich students' scientific potential (Saputra et al., 2019). Thus, the unification of project-based learning and practicum with an inquiry approach can be effectively implemented through the use of Inquiry-Project Lab (IPro-Lab) (Firmansyah et al., 2022a; Zhang & Ma, 2023). So, students are really placed as subjects who learn or like a scientist conducting scientific investigations (Saputra et al., 2023).

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Method

The type of research method used is Educational Design Research (EDR), which focuses on the development of learning models. The main objective of this research is to develop the CIPro-Lab model as a reliable product that meets the criteria of validity, practicality, and effectiveness in training students' problem-solving skills in biology (Plomp, 2013; Limatahu et al., 2018). This development process follows the McKenney development model, which consists of three stages: 1) the preliminary study stage, which includes literature review, field studies, and needs analysis; 2) the model design stage; and 3) the model testing stage. The evaluation of the quality of the research product is conducted through classroom implementation with limited trials, extensive trials, and model trials (Hair et al., 2019). The overall trials aim to collect qualitative and quantitative data (mixed methods) related to the implementation of the developed model, in order to obtain information regarding its practicality and effectiveness, as illustrated in Figure 1.

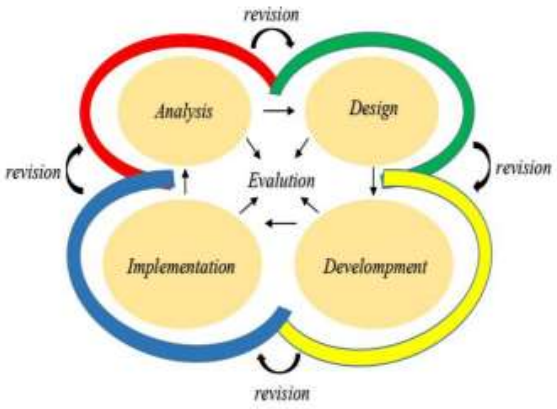

Figure 1: Development Stage of the ADDIE Model

The research data consists of students' ability to create lesson plans (RPP), student worksheets (LKPD), and textbooks for biology subjects. Data on the ability to create RPP, LKPD, and textbooks is obtained from process data and outcome data. Process data refers to student engagement in interactions with instructors and among peers during the teaching and learning process. Outcome data involves evaluating the results of project-based learning models in producing products, namely RPP, LKPD, and textbooks. The source of process data includes instructors and students during biology lessons. The source of outcome data is derived from students' ability to produce RPP, LKPD, and textbooks. The research instruments are tools used in the implementation of the research. The tools used include the validation sheet for RPP assessment, the validation sheet for learning material assessment, the validation sheet for LKPD, observations, and questionnaires.

Result and Discussion

Research Results

a. Analysis of the Validity Data of the CIPro-Lab Learning Model

The validity data of the CIPro-Lab learning model is obtained from the results of product validation, specifically the validation of lesson plans (RPP), student worksheets (LKPD), and teaching materials. The analysis of expert validation data on the project-based learning model is described as follows. Analysis of Expert Validation Data on Lesson Plan Assessment (RPP). The analysis of expert validation data on the assessment of the Lesson Plan (RPP) is shown in Table 1 below.

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Table 1. Description of Expert Validation Results for Lesson Plans (RPP)

No.	Assessed Aspect	M	Notes
1.	Relevance among basic competencies from KI1, KI2, KI3, and KI4	3.6	Very Valid
2.	Relevance of the achievement indicator formulation with the basic competencies (from KI1, KI2, KI3, and KI4) to be achieved.	3.6	Very Valid
3.	Relevance of learning objective formulation with the competency achievement indicators	3.6	Very Valid
4.	Relevance of teaching materials with the indicators and basic competencies to be achieved	3.6	Very Valid
5.	Clarity and sequence of teaching materials	3.6	Very Valid
6.	Relevance of teaching strategies (methods, approaches, and models) with learning objectives and teaching materials	3.4	Valid
7.	Relevance of teaching strategies to student characteristics	3.4	Valid
8.	Clarity of the learning scenario (steps of learning activities) with the goals to be achieved	3.6	Very Valid
9.	The learning scenario (steps of learning activities) reflects the CIPro-Lab model	3.8	Very Valid
10.	Appropriateness of closing activities in the learning process	3.6	Very Valid
11.	Assessment includes aspects of basic competencies from KI1, KI2, KI3, and KI4 that must be achieved	3.8	Very Valid
12.	Relevance of assessment techniques with the indicators/competencies to be achieved	3.2	Valid
13.	Completeness of assessment tools (questions, keys, scoring rubrics)	3.4	Valid
14.	Integration and synchronization among components in the RPP	3.4	Valid
	Average	3,5	Very Valid

Table 1. shows that the average score for the RPP assessment aspects is M = 3.5, with the achieved indicators/competencies categorized as very valid. These assessment aspects include the relevance among basic competencies, the relevance of the achievement indicator formulation with the basic competencies, the clarity and sequence of teaching materials, and the learning scenario (steps of learning activities) reflecting the syntax of the CIPro-Lab learning model, which includes aspects of basic competencies and the relevance of assessment techniques with the indicators/competencies to be achieved.

Based on the analysis of the expert validation results for the Lesson Plan (RPP), it can be concluded that this aspect falls into the very valid category with an average score of M = 3.6. The analysis of expert validation data on the assessment of Student Worksheets (LKPD) is shown in Table 2 below.

Table 2. Description of Expert Validation Results for Student Worksheets (LKPD)

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No.	Assessed Aspect	M	Notes
1.	The title/name of the LKPD is clearly formulated.	3.8	Very Valid
2.	LKPD is integrated into the lesson plan (RPP).	3.6	Very Valid
3.	Accuracy of content (facts, concepts, theories).	4	Very Valid
4.	Design aligns with the competencies of the core and basic competencies.	3.6	Very Valid
5.	LKPD aligns with learning objectives.	3.6	Very Valid
6.	LKPD reflects the steps of the scientific approach.	3.6	Very Valid
7.	There are learning steps in the preparation of the LKPD.	3.2	Valid
8.	LKPD reflects the application of authentic assessment.	3.6	Very Valid
9.	Uses clear and easy-to-understand language.	3.8	Very Valid
10.	LKPD reflects activities for reflection and conclusion drawing.	3.4	Valid
11.	Includes learning resources.	3.6	Very Valid
	Average	3.6	Very Valid

concluded that this aspect is in the very valid category with an average score of M = 3.6. Analysis of Expert Validation Data for Learning Materials Design. The analysis of expert validation data for the learning materials design is shown in Table 3 below.

Table 3. Description of Expert Validation Results for Learning Materials Design

No.	Assessed Aspect	M	Notes
1.	Includes Basic Competencies (KD) according to the RPP.	3.6	Very Valid
2.	Includes learning objectives according to competency achievement indicators.	3.6	Very Valid
3.	The explanation/design of the learning materials aligns with the demands of the KD.	3.6	Very Valid
4.	The design of learning materials covers essential concepts and materials according to the demands of the SKL, KI, and KD.	3.2	Valid
5.	The design of learning materials is supplemented with clear illustrations.	3.8	Very Valid
6.	The design of learning materials supports the development of student worksheets (LKPD).	4	Very Valid
7.	Includes an authentic assessment design.	3.6	Very Valid

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No.	Assessed Aspect	M	Notes
8.	Includes learning resources.	3.6	Very Valid
	Average	3.6	Very Valid

Table 3 shows that the average score for the assessment aspects of the learning materials design is M = 3.6, categorized as very valid. The detailed breakdown reveals that only the aspect. The design of learning materials covers essential concepts and materials according to the demands of the SKL, KI, and KD" is rated as valid. Based on the analysis of expert validation results for learning materials design, it can be concluded that this aspect is in the very valid category with an average score of M = 3.6.

b. Analysis of the Effectiveness Data of the CIPro-Lab Learning Model

The effectiveness data of the CIPro-Lab learning model in biology lessons was obtained from the analysis of students' problem-solving skills on pretest and posttest, which were analyzed using descriptive and inferential statistics, as shown in Table 4 below.

Table 4. Categorization of Pretest and Posttest Score Frequencies for Problem-Solving Skills of SMA Negeri 2 Patra Nusa Students

Participant	Gender	Pre-Test	Post-Test	Gain	N-Gain	Average	Category
Control class	Female	42	54	0,2	20%	21%	Rendah
	Male	43	54	0,2	20%		
Eksperiment class	Female	38	57	0,4	40%	39%	Sedang
	Male	45	65	0,4	40%		

Based on Table 4, the average N-Gain test results show that the control class achieved 21%, categorized as low, while the experimental class achieved 39%, categorized as moderate. Therefore, the problem-solving skills of students using the CIPro-Lab learning model in biology lessons at SMA Negeri 2 Patra Nusa fall into the moderate category.

Table 5. Categorization of Pretest and Posttest Score Frequencies for Problem-Solving Skills of SMA Negeri 3 Langsa Students

Participant	Gender	Pre-Test	Post-Test	Gain	N-Gain	Average	Category
Control class	Female	51	69	0,4	40	31%	Rendah
	Male	57	67	0,2	20		
Eksperiment class	Female	61	82	0,6	60	50%	Sedang
	Male	67	82	0,5	50		

Based on Table 5, the average N-Gain test results show that the control class achieved 33%, categorized as low, while the experimental class achieved 52%, categorized as moderate. Therefore, the problem-solving skills of students using the CIPro-Lab learning model in biology lessons at SMA Negeri 3 Langsa fall into the moderate category.

Table 6. Categorization of Pretest and Posttest Score Frequencies for Problem-Solving Skills of SMA Negeri Unggul Aceh Timur Students

Participant	Gender	Pre-Test	Post-Test	Gain	N-Gain	Average	Category
Control class	Female	41	61	0,3	30	33%	Rendah
	Male	50	66	0,3	30		
Eksperiment class	Female	58	80	0,5	50	52%	Sedang
	Male	58	78	0,5	50		

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Based on Table 6, the average N-Gain test results show that the control class achieved 33%, categorized as low, while the experimental class achieved 52%, categorized as moderate. Therefore, the problem-solving skills of students using the CIPro-Lab learning model in biology lessons at SMA Negeri Unggul Aceh Timur fall into the moderate category.

c. Results of the CIPro-Lab Learning Model Trial

The trial of the project-based learning model was conducted following the guidelines outlined in the developed learning materials. The trial of the project-based learning model was carried out in a single session. The purpose of the CIPro-Lab learning model trial was to gather feedback, suggestions, and observe the implementation of the learning syntax designed for the learning process

Table 7. Recapitulation of the CIPro-Lab Learning Model Implementation Results

No	Activity	Implementation	
		Implemented	Not Implemented
1	Opening the lesson with greetings and checking student attendance	√	
2	Presenting the learning objectives	√	
3	Dividing students into groups	√	
4	Distributing Student Worksheets (LKPD)	√	
5	Defining the problem question to be solved	√	
6	Collaborating to conduct the experiment	√	
7	Presenting the project results	√	
8	Evaluating and reflecting on the project results	√	

Based on Table 7, which summarizes the implementation of learning activities during the trial of the project-based learning model, it can be concluded that all activities were carried out in accordance with the planned learning stages.

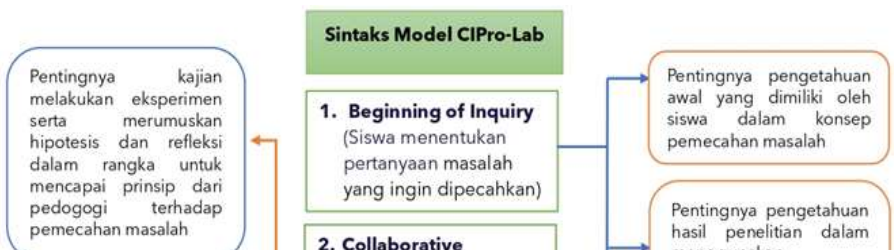

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Figure 2. Stages of Implementing the Syntax of the CIPro-Lab Learning Model

Discussion

Based on the research conducted, student learning outcomes were assessed through Pretests and Posttests. The Pretest and Posttest results were then analyzed using descriptive analysis to determine students' problem-solving skills before and after the application of the CIPro-Lab learning model in biology lessons. From the descriptive analysis results, the average student score before using the CIPro-Lab learning model in biology lessons was lower compared to the average student score after the implementation, which fell into the moderate category. To assess the extent of improvement, an N-Gain test was conducted. The N-Gain analysis showed that SMA Negeri Unggul Aceh Timur saw an increase of 52%, categorized as moderate.

This research aligns with the findings of Wuryantari (2019), which focused on the development of PjBL-based modules. The research results showed that the module met the criteria for validity, practicality, and effectiveness. The validity aspect was rated at 89.07%, categorized as very valid, while the practicality aspect had an average of 87.92%, categorized as very practical. The effectiveness aspect was evaluated through knowledge and project tests. In a test conducted on 30 students, the average score was 86.67%, categorized as good, and in the skills (project) domain, it was 86.67%, categorized as very high. It was concluded that the development of the PjBL-based module attracted students' attention, helped them understand the material, and promoted collaboration within groups.

This research also aligns with classroom action research conducted by Yuliansyah (2021) and Zare-Behtash (2017), where the implementation of the PjBL learning model increased student engagement in the Electrical Maintenance of Light Vehicles course.

Therefore, the CIPro-Lab learning model that was developed has demonstrated high levels of validity, practicality, and effectiveness, making it suitable for use and a recommended model, especially in high schools in Aceh.

Conclusion

Based on the research findings, it can be concluded that the profile of the project-based learning model

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produced in this study includes: (1) Lesson Plans, (2) Student Activity Sheets, and (3) Teaching Materials, all of which meet the criteria for validity, practicality, and effectiveness. Student responses to the CIPro-Lab learning model are in the high category. The effectiveness of the CIPro-Lab learning model is also categorized as high.

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