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Integration of Local Wisdom-Based Deep Learning PCTS Model to Enhance Students' Critical Reasoning, Creativity, and Collaboration

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Abstract
The 21st century demands critical reasoning, creativity, and collaboration skills as essential competencies for facing modern challenges. However, current history learning still faces obstacles such as the lack of integration of local wisdom and monotonous learning methods, resulting in low student performance in these areas. The urgency of this research is to develop an effective learning model that combines deep learning and local wisdom to improve students' 21st-century skills. This study aims to examine the effect of integrating the PCTS (Problem-Centered Thinking Skill) Deep Learning Model based on local wisdom on improving students' critical reasoning, creativity, and collaboration. The method used was a quasi-experimental design with a Nonequivalent Control Group design involving 74 students divided into experimental and control groups. Data were collected through tests, questionnaires, observations, and interviews, then analyzed descriptively and using t-tests. The results showed a significant increase in mean gain in the experimental group for critical reasoning (8.19 vs. 3.20), creativity (8.19 vs. 3.58), and collaboration (8.06 vs. 3.56) compared to the control group, with a significance value of p = 0.000. Teachers implemented a project-based and collaborative participatory learning model despite facing technological challenges and teacher preparedness. The conclusion of this study confirms that the integration of the PCTS Deep Learning Model based on local wisdom effectively improves students' 21st-century skills in history learning.

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1. INTRODUCTION

The 21st century requires critical reasoning, creativity, and collaboration skills (Suharti & Faidin, 2023). These 21st-century skills encompass knowledge, skills, habits, and character that are essential for facing challenges in modern life (Daga, 2022). Creativity, critical thinking, and collaboration are 21st-century skills that must be mastered to achieve success in work, life, and citizenship (Somphol et al., 2022). Creativity relates to the ability to generate ideas, critical thinking to reasoning skills, and collaboration involving cooperation and responsibility (Sutarto, 2023). These three skills are essential because critical and creative thinking cannot function optimally without support from others (Fajri, Nursalim, & Masitoh, 2024). Therefore, the education sector must develop these capabilities to face the era of industrial revolution 4.0 and society 5.0 in its learning (Ardiansyah et al., 2022).

In this context, local wisdom-based history learning plays an important role, as its implementation in history learning can help students identify, analyze problems, build arguments, evaluate, and create solutions. However, the reality in the field shows that

teachers' efforts to improve students' thinking skills through history learning are still ineffective. Several problems found include the lack of integration of local wisdom in history learning materials, the use of lecture and question-answer methods that tend to be monotonous, and students' low ability to understand, analyze, and reflect on historical problems. Additionally, the existence of friendship circles that hinder the formation of group work reduces opportunities for students to develop their critical reasoning, creativity, and collaboration (Faidin & Suharti, 2023).

Previous research findings reveal that students' low critical reasoning and creativity result in their limitations in exploring information, thinking critically about problems, and creating new ideas (Faidin & Suharti, 2023). Students also lack enthusiasm in identifying information, especially in evaluation activities because the methods used by teachers in class are inappropriate (Suharti, Lukman, Yamin, & Faidin, 2025). Therefore, effective approaches and learning models are needed to improve these skills and face global challenges.

The Deep Learning approach and PCTS (Problem Centered Thinking Skill) model are solutions that can enhance students' critical reasoning, creativity, and collaboration. Deep learning is more than just a memorization process but focuses on developing 21st-century skills (Camargo & Fernández, 2024). This approach is closely related to high-quality learning outcomes (Masuku, Jili, & Sabela, 2020) and pays attention to underlying meanings (Alzahrani & Alnufaie, 2024). This approach involves learners critically with new ideas and facts (Li & Chano, 2024), as well as applying knowledge in real life through experience (Archiopoli & Murray, 2019). Deep learning also involves effective dialogue (Zhu, 2024). Thus, when students learn deeply, they know when, how, and why it's important to apply knowledge and skills (Bogard, Consalvo, & Worthy, 2018).

The implementation of deep learning will be more effective if integrated with the PCTS Model. This model teaches students to share and exchange ideas (Apriliana, Handayani, & Awalludin, 2019), explore new ideas and reflect on previous knowledge (Kuhn-Archer, Wiedeman, & Chalifoux, 2020). PCTS provides opportunities for students to learn collaboratively, encouraging deep understanding, active contribution, and evaluating their understanding (Kurniawati, Susilana, & Setiawan, 2024). Thus, this model transforms students from passive information receivers to active contributors in the learning process (Merrill, 2002). To realize such learning, teacher innovation is needed to foster critical thinking patterns.

Teachers need to follow appropriate steps in the PCTS model, such as activating previous experiences, demonstration, application, and integrating skills in real-world activities (Dewi et al., 2023). All these stages are believed to significantly train critical and creative reasoning skills (Kurniawati, Susilana, & Setiawan, 2023). This process aligns with progressivism theory, which emphasizes the importance of building more critical, creative, and innovative learning awareness in History learning (Faidin & Suharti, 2022).

PCTS also provides a clear framework for developing critical reasoning, creativity, and collaboration (Faidin, Suharti, Subhan, Fajrun, & Buhari, 2024). Learning supported by local wisdom will be very meaningful and can serve as study material in the world of history to build students' critical, collaborative, and creative thinking skills (Suharti, Faidin, & Ibrahim, 2022; Faidin, 2017). Therefore, teachers need to advance perspectives, thinking, communication, and collaboration more creatively and innovatively (Faidin, Suharti, & Lukman, 2022).

The research problem formulation is: First, how does the integration of local wisdom-based deep learning PCTS model enhance students' critical reasoning, creativity, and collaboration? Second, how do teachers integrate the deep learning PCTS model? Third, what challenges do teachers face in implementing the deep learning PCTS model?

2. RESEARCH METHOD

A. Research Design

This study uses a quasi-experimental design with a Nonequivalent Control Group Design. This design consists of two groups: experimental and control groups that are not randomly selected. The sampling technique used is purposive sampling. The research subjects consist of 74 students, with the experimental group having 38 students and the control group having 36 students. The experimental and control groups were selected based on equivalent achievement in history learning, obtained from observations, interviews, and discussions with teachers at the school. This research was conducted over 8 face-to-face meetings.

B. Research Procedure

The research procedure in this study is as follows:

1) Literature Review

Researchers conducted a literature review to obtain information related to existing phenomena and unknown aspects in the context of this research. The first step was searching for relevant literature sources, selecting appropriate sources, recording needed information, and then presenting the obtained literature review.

2) Identifying and Limiting Problems

After conducting the literature review, researchers continued by identifying research problems through observation, literature reading, and preliminary surveys. Focus was made to limit problems that must be solved through this research.

3) Developing a Plan

Researchers then developed a research plan that includes the following steps:

a. **Determining Independent and Dependent Variables** - Determination of independent and dependent variables was done through review of the research title and problem formulation.

b. **Selecting Research Design** - The research design used is Nonequivalent Control Group Design, chosen to appropriately answer research questions.

c. **Developing Research Instruments** - Instruments used for data collection consist of tests, questionnaires, interview guides, and observations. These instruments have been tested and validated by experts in their fields.

d. **Determining Sample** - The sample was selected after conducting surveys regarding sample size, such as the number of students at the school that became the research location. Additionally, researchers conducted observations and interviews with teachers to ensure uniformity of students' cognitive data.

e. **Creating Data Collection Procedure Outline** - Data collection procedure outline was arranged so that collected data could be analyzed well.

f. **Formulating Statistical Hypotheses** - Null and alternative hypotheses were formulated in mathematical form for statistical testing.

3. RESULTS AND DISCUSSION

A. Analysis Results

1) Effect of Deep Learning PCTS Model Integration on Students' Critical Reasoning, Creativity, and Collaboration

Enhancement of critical reasoning, creativity, and collaboration abilities using Deep Learning PCTS Model in local wisdom-based history learning. Descriptive Analysis Results are shown in the following table.

Table 1. Descriptive Statistics of Research Results

Variable	Group	N	Pretest	Posttest	Gain

			Mean	SD	Mean	SD	
Critical Reasoning	Experimental	36	73.03	2.68	81.22	2.77	8.19
	Control	36	71.22	2.64	74.42	2.94	3.20
Creativity	Experimental	36	73.14	2.49	81.33	2.89	8.19
	Control	36	71.25	2.44	74.83	2.67	3.58
Collaboration	Experimental	36	72.97	2.98	81.03	2.93	8.06
	Control	36	70.72	2.85	74.28	3.06	3.56

For all three variables—Critical Reasoning, Creativity, and Collaboration—the experimental group experienced much greater mean gain increases compared to the control group. For example, in Critical Reasoning, the experimental group's mean pretest score was 73.03 and increased to 81.22 in the posttest, with a gain of 8.19. Conversely, the control group only experienced an increase from 71.22 to 74.42 with a gain of 3.20. Similar improvement patterns occurred in Creativity and Collaboration, with the experimental group showing gains around 8, while the control group only around 3.5. Standard deviation (SD) in pretest and posttest shows relatively consistent and not too large data variation, indicating that the data is quite homogeneous within groups.

Table 2. Independent Sample T-Test Results

Variable	t-value	df	Sig. (2-tailed)	Mean Difference	**Conclusion**
Critical Reasoning	7.891	70	0.000	4.99	Significant
Creativity	7.342	70	0.000	4.61	Significant
Collaboration	6.845	70	0.000	4.50	Significant

The t-values for all three variables (Critical Reasoning: 7.891, Creativity: 7.342, Collaboration: 6.845) with degrees of freedom (df) 70 show significant differences between experimental and control groups in the posttest. The very small Sig. (2-tailed) value (0.000) below 0.05 confirms that score differences after this learning model intervention are statistically significant. The positive Mean Difference (around 4.5 to 5) demonstrates the effectiveness of the deep learning model in improving these three aspects compared to conventional learning methods.

Table 3. Distribution of Student Achievement Categories (Posttest)

Variable	Group	High (80-86)		Medium (77-79)		Low (<77)	
		F	%	**f**	**%**	**f**	**%**
Critical Reasoning	Experimental	24	66.7%	12	33.3%	0	0%
	Control	13	36.1%	21	58.3%	2	5.6%
Creativity	Experimental	25	69.4%	11	30.6%	0	0%
	Control	9	25.0%	24	66.7%	3	8.3%
Collaboration	Experimental	23	63.9%	13	36.1%	0	0%
	Control	12	33.3%	22	61.1%	2	5.6%

In the experimental group, the proportion of students achieving the High category (scores 80-86) was very dominant: 66.7% in Critical Reasoning, 69.4% in Creativity, and 63.9% in Collaboration. On the other hand, the control group had lower percentages for the high category (around 25-36%) with most students in medium and low categories. No students in the experimental group fell into the low category (<77), while the control group still had students in the low category (around 5-8%).

2) Teacher Practices in Integrating the Deep Learning PCTS Model

The learning process conducted by students to improve critical reasoning, creativity, and collaboration yielded questionnaire results. The following is a graph of learning conducted by students.

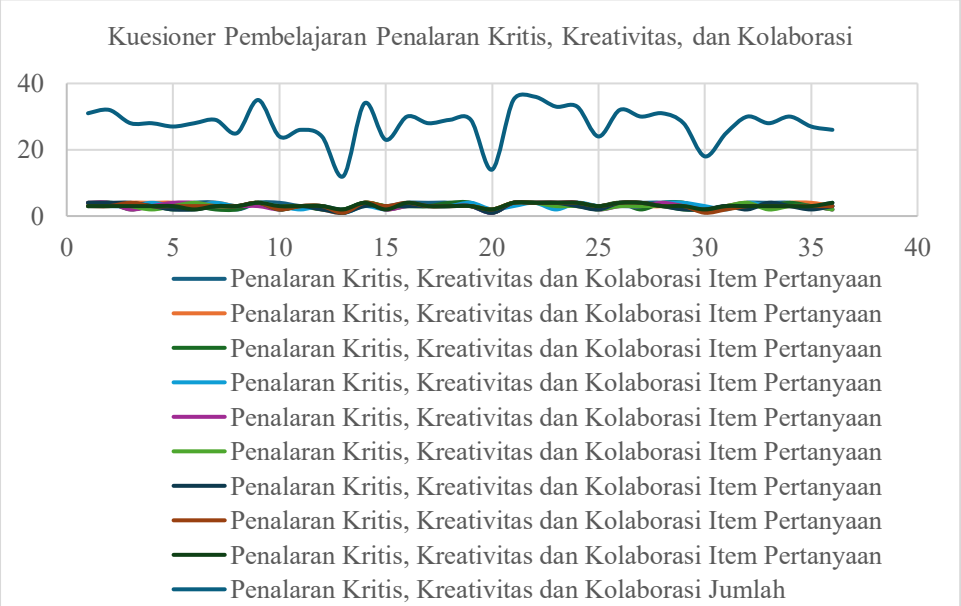

Figure 1. Student Learning Experience Questionnaire Results

To achieve the three abilities above, teachers played roles in accompanying, motivating, and facilitating discussions rather than just delivering material. Observation and interview results show changes in teachers' teaching styles becoming more participatory and reflective, and more frequently using case studies and real projects as learning media. Teachers adapted technology such as digital platforms and collaborative applications according to learning needs; survey results show that most teachers feel they need further training to optimize deep learning integration.

Teacher Observation

Based on observations conducted by researchers, the results show that:

- Teachers conveyed learning objectives clearly and systematically, and connected them with real contexts relevant to students' lives.
- Teachers used a constructivism approach by providing project-based tasks (Project Based Learning) focusing on real problem-solving (Problem-Based Learning) that made students actively seek solutions and collaborate.
- Teachers actively encouraged students to think critically through open-ended questions and group discussions.
- The use of varied learning media and digital teaching aids that support students' deep understanding was consistently applied.
- Teachers created conducive and enjoyable classroom atmospheres by using ice breakers and interactive activities to increase student motivation and concentration.
- Teachers facilitated collaboration among students in small heterogeneous groups to develop creativity and social skills.

Teacher Interview:

Question: How was your experience implementing the Deep Learning PCTS Model in class?

Teacher: "I feel this approach is challenging yet satisfying. I have to prepare materials that are not only theoretical but also contextual and applicable. I also try to engage students in discussions and collaborate on real projects. Sometimes it does take more time to manage the class, but the results are visible when students become more active, critical, and creative."
Question: What are the main challenges you faced during the integration of this model?
Teacher: "The biggest challenge in my opinion is the limitation of time and resources, especially technology tools that are not evenly distributed. Besides that, some students still need extra encouragement to get used to thinking critically and collaborating. However, with practice and the right approach, they slowly begin to change."
Question: How do you motivate students to stay actively involved in learning?
Teacher: "I often use interactive quizzes and educational games as ice breakers. Besides that, I design projects that are relevant to students' interests and daily lives so they feel this learning is meaningful."
These observation and interview results illustrate how teachers actively implement the Deep Learning PCTS Model in learning practice with a focus on developing students' critical reasoning, creativity, and collaboration, as well as the challenges that must be faced and strategies used to overcome them.
Student Interview:
Question: What do you think about your teacher's teaching style when using the Deep Learning PCTS Model?
Answer: Our teacher doesn't just teach material as usual, but more often gives project assignments and makes us discuss in groups. We also often do presentations and share opinions. The classroom atmosphere becomes more active and enjoyable because the teacher uses various learning media and occasionally there are quizzes and games that make us more enthusiastic about learning.
Question: Does the teacher help you during discussions or working on projects?
Answer: Yes, the teacher always accompanies and motivates us. If there are problems, the teacher gives directions so we can think deeper and find solutions ourselves. Sometimes the teacher also gives challenging questions so we think critically.
Question: What are the benefits of learning with this model in your opinion?
Answer: Learning becomes not boring, we become more creative and learn to work together with friends. We also learn to think hard and find solutions, not just memorize material.

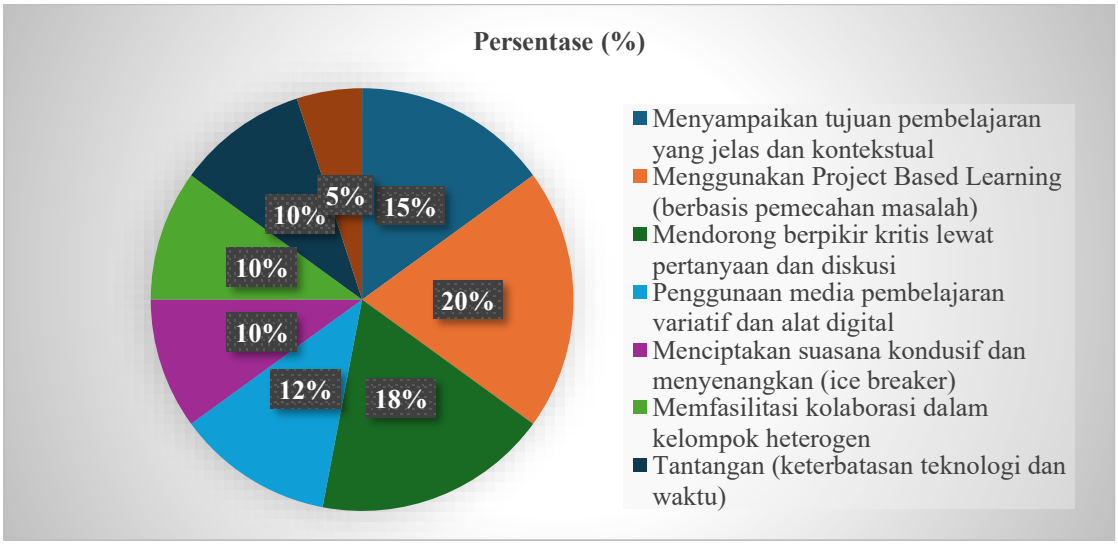

Figure 2. Proportion of Deep Learning PCTS Model Implementation

3) Teacher Challenges in Implementing the Deep Learning PCTS Model

The main challenges for teachers in their teaching activities are pedagogical constraints: Traditional curriculum and methods are not yet fully aligned with the deep learning approach, so teachers must adapt learning designs. Infrastructure and Technology Support: Limited devices and internet, or limited resources, become implementation obstacles. And Teacher Readiness and Competence: Lack of training and understanding about deep learning among teachers. The following are interview excerpts with Teachers:

Question 1: What is your understanding of the Deep Learning PCTS Model and how is it applied in learning?

Answer: The Deep Learning PCTS Model is a learning approach that integrates deep learning processes with Project, Collaboration, Thinking, and Sharing (PCTS) stages. In its application, teachers facilitate students to be active in real projects that require cooperation and critical thinking, as well as sharing learning results with classmates. This model significantly increases student engagement and learning outcomes.

Question 2: How do you integrate this model into your daily teaching practice?

Answer: I change the learning method from direct instruction to more interactive by giving projects or group assignments. I often use technology such as digital platforms to facilitate collaboration and presentation of student work. I also encourage students to think critically through discussions and reflection after each activity.

Question 3: What challenges do you face when implementing the Deep Learning PCTS Model?

Answer: The main challenges include time limitations because material preparation and project management are quite complex. Besides that, not all students immediately get used to this way of learning, so it takes adaptation time and extra accompaniment. Uneven technology facilities are also obstacles, especially in schools with limited facilities.

Question 4: How do you overcome these challenges?

Answer: I try to improve learning planning, creatively utilize existing learning resources, and provide motivation for students to be active. I also continue learning and attending training related to educational technology to be able to use digital tools more optimally. I also collaborate with fellow teachers to exchange experiences.

Question 5: In your opinion, what is the greatest benefit of implementing the Deep Learning PCTS Model for students?

Answer: This model makes students more active, independent, and creative in learning. They also learn to work together and communicate well in teams. Besides that, their critical thinking ability improves because they are often trained to analyze and solve problems deeply, not just memorize.

Student Interview:

Question: Are there any difficulties you see when the teacher implements this learning model?

Answer: Sometimes the teacher looks difficult because they have to prepare many materials and tools. There was also a problem with slow internet connection so our digital project was disrupted. Some friends also found it difficult at first because they were used to learning with lectures only.

Question: How do teachers and friends overcome these difficulties?

Answer: The teacher is always patient in guiding and giving direct examples. We also help each other in groups if someone doesn't understand yet. The teacher also sometimes gives extra time to repeat or try again tasks that are difficult.

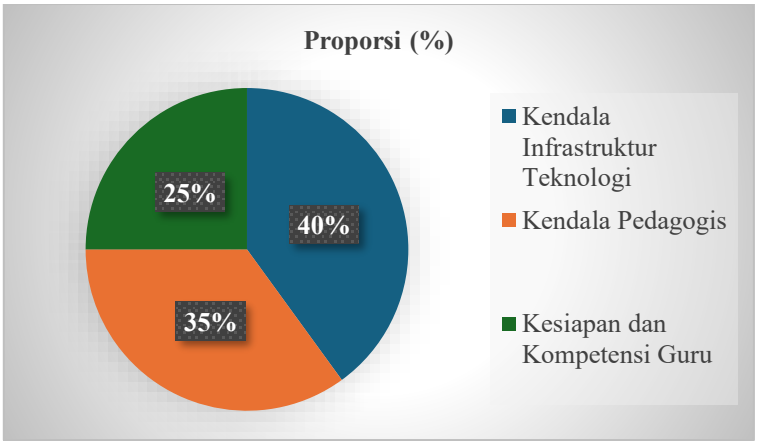

Figure 3. Proportion of Challenges Faced by Teachers

Note: This proportion illustrates that the biggest challenge is related to technology infrastructure limitations, followed by pedagogical constraints and teacher readiness.

B. Discussion

1) Effect of Deep Learning PCTS Model Integration on Students' Critical Reasoning, Creativity, and Collaboration

Research results show that the integration of local wisdom-based Deep Learning PCTS Model significantly impacts the improvement of students' critical reasoning, creativity, and collaboration. This finding aligns with the statement that "deep learning is more than just a memorization process, but focuses on developing 21st-century skills" (Camargo & Fernández, 2024). Statistical data shows a very striking increase in mean gain in the experimental group compared to the control group, with gain values around 8 for all variables in the experimental group, while the control group only achieved gains of 3.2-3.6.

The superiority of this model lies in the approach that "involves learners critically with new ideas and facts" Li & Chano, (2024) and "application of knowledge in real life through experience" (Archiopoli & Murray, 2019). This is proven from Independent Sample T-Test results that show significant differences ($p < 0.05$) for all three variables, with high t-values (Critical Reasoning: 7.891, Creativity: 7.342, Collaboration: 6.845).

Critical Reasoning The significant improvement in critical reasoning (from 73.03 to 81.22) shows that the Deep Learning PCTS model successfully developed students' abilities to "identify, analyze problems, build arguments, evaluate and create solutions." This result supports findings that "when students learn deeply, they know when, how, why it's important to apply knowledge and skills" (Bogard, Consalvo, & Worthy, 2018).

The distribution of student achievement shows 66.7% of experimental group students were in the high category (80-86), very different from the control group which only had 36.1%. The absence of experimental group students in the low category (<77) indicates the model's effectiveness in raising all students' abilities.

Creativity The improvement in creativity (mean gain 8.19) demonstrates that the PCTS model successfully "teaches students to share and exchange ideas" Apriliana, Handayani, & Awalludin, (2019) and "explore new ideas and reflect on previous knowledge" (Kuhn-Archer, Wiedeman, & Chalifoux, 2020). With 69.4% of students achieving the high category, this result shows that local wisdom-based learning "will be very meaningful" (Suharti, Faidin, & Ibrahim, 2022) in developing student creativity.

Collaboration The significantly improved collaboration ability (mean gain 8.06) proves that this model successfully "provides opportunities for students to learn collaboratively, encouraging deep understanding, active contribution, and evaluating their understanding" (Kurniawati, Susilana, & Setiawan, 2024). This aligns with the principle that "critical and creative thinking cannot function optimally without support from others" (Fajri, Nursalim, & Masitoh, 2024).

2) Teacher Practices in Integrating the Deep Learning PCTS Model

Implementation of the Deep Learning PCTS model demands a paradigm shift in teaching from teacher-centered to student-centered. Observation results show teachers successfully implemented a constructivism approach by providing project-based tasks (Project Based Learning) focusing on real problem-solving (Problem-Based Learning).

Teacher practices in integrating this model reflect the principle that "teachers need to follow appropriate steps in the PCTS model, such as activating previous experiences, demonstration, application, and integrating skills in real-world activities" (Dewi et al., 2023). Teachers act as facilitators who accompany, motivate, and facilitate discussions rather than just delivering material.

The transformation of teachers' teaching styles to become more participatory and reflective aligns with progressivism theory that "emphasizes the importance of building more critical, creative, and innovative learning awareness in History learning" (Faidin & Suharti, 2022). The use of technology such as digital platforms and collaborative applications shows teachers' efforts to "advance perspectives, thinking, communication, and collaboration more creatively and innovatively" (Faidin, Suharti, & Lukman, 2022).

Student learning experience questionnaire results show positive responses to changes in this learning method. Students feel learning becomes more active and enjoyable because it "transforms students from passive information receivers to active contributors in the learning process" (Merrill, 2002).

3) Teacher Challenges in Implementing the Deep Learning PCTS Model

Despite showing significant results, the implementation of the Deep Learning PCTS Model is not without various challenges. Research results identify three main categories of challenges faced by teachers:

Pedagogical Challenges Traditional curriculum and methods that "are not yet fully aligned with the deep learning approach" become the main obstacle. This requires teachers to "adapt learning designs" and requires "teacher innovation to foster critical thinking patterns" (Merrill, 2002). The transition from conventional learning to deep learning requires adaptation that is not easy.

Infrastructure and Technology Challenges Limited devices and internet become significant obstacles in implementation. As revealed in interviews, "Uneven technology facilities are also obstacles, especially in schools with limited facilities." This challenge aligns with the reality that not all educational institutions have adequate technology infrastructure to support deep learning.

Teacher Readiness and Competence Challenges "Lack of training and understanding about deep learning among teachers" becomes a fundamental challenge. Survey results show most teachers feel they need further training to optimize deep learning integration. This indicates the need for continuous professional development for teachers.

4) Theoretical and Practical Implications

Research results strengthen the theory that "deep learning approach (Deep Learning) and PCTS (Problem Centered Thinking Skill) model are solutions that can improve students' critical reasoning, creativity, and collaboration." This model proves effective because it is "closely related to high-quality learning outcomes" (Masuku, Jili, & Sabela, 2020) and "pays attention to underlying meanings" (Alzahrani & Alnufaie, 2024).

The integration of local wisdom in history learning proves to be "study material in the world of history, can build students' critical, collaborative, and creative thinking skills" (Faidin, 2017). This shows the importance of contextualizing learning with local values to increase learning meaning and relevance.

"All these stages are believed to significantly train critical and creative reasoning skills" Kurniawati, Susilana, & Setiawan, (2023), as proven from research results showing significant improvements in all three variables. The PCTS model successfully "provides a clear framework for developing critical reasoning, creativity, and collaboration" (Faidin et al., 2024).

5) Research Limitations

Although this research shows significant results, there are several limitations that need to be acknowledged and become considerations for future research:

Methodological Limitations

Limited Research Duration: This research only measures short-term impacts of Deep Learning PCTS Model implementation. There has been no follow-up measurement to determine whether improvements in critical reasoning, creativity, and collaboration can be maintained long-term. As known that developing "21st-century skills" Somphol et al., (2022) requires a continuous process.

Measurement Instruments: This research only used written test instruments to measure the three variables. Using a single instrument may not capture the full complexity of "creativity, critical thinking, and collaboration" Somphol et al., (2022) which are multidimensional in nature.

Sample and Generalizability Limitations

Limited Sample Size: With 36 students per group, the sample size is relatively small for broad generalization. This can affect the research's external validity, especially considering that "critical reasoning, creativity, and collaboration skills" Suharti & Faidin, (2023) are needed universally in education.

Specific Context: This research was conducted in the context of local wisdom-based history learning in one specific location. Generalizing results to other subjects or different cultural contexts may be limited, whereas "the education sector must develop these capabilities to face the era of industrial revolution 4.0 and society 5.0" Ardiansyah et al., (2022) applies universally.

Variable Control Limitations

Confounding Variables: This research did not fully control external factors that could influence results, such as individual student motivation, socio-economic background, or learning style differences. These factors can influence how students respond to "deep learning approach (Deep Learning) and PCTS model" (Camargo & Fernández, 2024).

Hawthorne Effect: The possibility of a Hawthorne effect in the experimental group, where students show better performance because they realize they are being researched, not purely due to the learning model's effectiveness.

4. CONCLUSION

The integration of local wisdom-based Deep Learning PCTS Model significantly improves students' critical reasoning, creativity, and collaboration in history learning. Quantitative data shows mean gain increases in the experimental group of 8.19 (critical reasoning), 8.19 (creativity), and 8.06 (collaboration) respectively, far exceeding the control group which only achieved around 3.2-3.6. T-test results prove these differences are statistically significant ($p < 0.05$) for all three variables. From a qualitative perspective, teachers successfully implemented the model with a student-centered approach through projects and group discussions, where students became more active, critical, and creative. However, teachers face challenges in the form of limited technology facilities, incompatibility with traditional curriculum, and the need for further training. This research confirms the need for support in developing teacher competencies and technology facilities to support meaningful learning based on local wisdom. This model provides an important contribution in preparing students to master essential 21st-century skills.

5. ACKNOWLEDGMENTS

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