Project-Based Learning Integrated Caring Assessment and Tiered Instruction: Implications for Creative Thinking and Collaboration

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Abstract
Creative thinking and collaboration are two competencies whose needs continue to increase in the context of 21st-century education. However, their development in the practice of project-based learning (PjBL) in junior high schools still faces obstacles, mainly due to overly product-oriented assessments and a lack of assignment adjustments to students' learning readiness. This study examines the influence of PjBL integrated with caring assessment and tiered instruction on these two competencies. The design was a quasi-experimental nonequivalent control group design involving 65 junior high school students, in which the experimental group ($n = 32$) received integrated PjBL and the control group ($n = 33$) received conventional PjBL. Data were collected through PBLWorks and P21 framework-based performance rubrics and written tests and then analyzed using descriptive statistics, the Wilcoxon Signed-Rank Test, and the Mann-Whitney U. As a result, the experimental group showed a significant improvement ($Z = -4{,}071$; $p < 0.001$; N-gain = 0.49), while the control group showed no significant change ($Z = -1.574$; $p = 0.116$; N-gain = 0.11). Creative thinking achievement ($U = 356{,}500$; $p = 0.024$) and collaboration ($U = 298{,}000$; $p = 0.002$) in the experimental group were also significantly higher. These findings indicate that the integration of caring assessment and tiered instruction in PjBL is able to encourage the development of these two competencies in a more structured manner than PjBL, which runs without these two components.

1. Introduction

The paradigm shift in 21st-century education places creative thinking and collaboration skills as core competencies that students must master. The World Economic Forum's Future of Jobs 2023 report shows that creative thinking and collaboration skills are the two skills with the fastest demand growth in the next five years (World Economic Forum, 2023). The results of the meta-analysis show that creative thinking skills can be improved through appropriate learning interventions, creativity develops through social interaction, and collaboration needs to be observed and facilitated directly (Susilowati et al., 2022; Barak & Yuan, 2021; Hayashi et al., 2024). Theoretically, project-based learning (PjBL) is suggested as an effective approach because it has been proven to increase student creativity when designed with the right stimulus (Purba et al., 2024; Pan et al., 2024) and can facilitate students' thinking skills and collaboration ability (Zhang & Ma, 2023). Thus, PjBL is relevant as a pedagogical strategy to develop creativity and collaboration simultaneously through project activities that demand ideas, interaction, and joint problem-solving.

In Indonesia, the Independent Curriculum has formally positioned PjBL as a key pedagogical strategy for competency development and learning recovery (Ministry of Education and Culture, 2022), and prior research consistently supports its potential in building creativity and collaboration (Widiastuti & Handayani, 2022; Silitubun et al., 2024). The gap, however, lies in execution. Junior high school students' creative thinking skills remain largely in the low to moderate category (Amaliyah et al., 2023), teacher-centered approaches and conventional methods continue to dominate classroom practice (Darmawanti, 2021; Hidayat et al., 2024), and project activities are still frequently managed without systematic attention to student engagement and contribution (Wardhani & Kurniawan, 2023). The gap between what PjBL promises and what it actually delivers in the classroom is, in other words, not merely theoretical.

If examined further, a significant part of this problem traces back to how project work gets assessed. Collaboration in PjBL classrooms is often dominated by only a few group members, a pattern that is closely tied to assessment practices still oriented toward final products rather than the learning process itself (Wardhani & Kurniawan, 2023; Aisyah & Novita, 2025). What product-oriented assessment tends to overlook are the creative

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thinking processes, individual contributions, and collaboration dynamics that develop, or fail to develop, during the project. Without consistent formative feedback along the way, students have little basis to improve their ideas or deepen their participation, and researchers have repeatedly pointed to adaptive and continuous assessment as a necessary condition for creativity and collaboration to grow systematically (Thornhill-Miller et al., 2023; Hayashi et al., 2024). Assessment, in short, cannot afford to wait until the project is done.

A second problem runs alongside the first. Consider a classroom where students differ considerably in prior knowledge and learning readiness, yet all receive the same project task at the same level of complexity. Students with lower readiness tend to withdraw, while those with higher readiness end up dominating group decisions. This is not an unusual scenario. Tiered instruction addresses this directly by adjusting task complexity to match where students actually are while keeping learning goals consistent across the group, so that meaningful challenge and active participation become accessible to everyone. This differentiation, however, needs to be accompanied by an assessment process that sustains engagement and supports students when they encounter difficulty. This is precisely where caring assessment becomes relevant, because it emphasizes formative feedback and genuine attentiveness to students' learning experiences during the project, enabling teachers to provide timely support and help students treat mistakes as productive parts of the learning process (Hayashi et al., 2024).

Grounded in these two persistent gaps in conventional PjBL practice, this study proposes the integration of caring assessment and tiered instruction within PjBL as a structured response to the dual challenge of task differentiation and sustainable process assessment. Empirical studies that specifically test this combination as a support mechanism for developing junior high school students' creativity and collaboration remain limited, and the effectiveness of such an integrated approach has yet to be confirmed through systematic field trials. This study therefore aims to determine whether students who experience the integrated model achieve meaningfully different learning outcomes compared to those in conventional PjBL, and to examine how the integrated model shapes the development of creative thinking and collaboration skills among junior high school students. Beyond testing the intervention, this study is expected to contribute a practical framework combining differentiated task design with continuous formative assessment, accompanied by operational outputs including implementation flows, process assessment indicators, and examples of formative feedback tools applicable to junior high school learning contexts.

2. Method

This research is based on a quantitative approach. The design chosen was a quasi-experiment with a non-equivalent control group, considering that the formation of classes in schools was administrative and had been running before the research began, so there was no room for randomization at the individual level. The determination of sample classes refers to a number of criteria for academic ability equity, teaching teachers, and schedules identified through purposive sampling techniques. The two groups received different treatments but were measured using equivalent instruments at the beginning and end of learning. The difference lies in what happened between the experimental group, which underwent PjBL, which was integrated with caring assessment and tiered instruction, while the control group carried out PjBL without task differentiation or structured formative interventions. Both groups did a pre-test to ensure equality of initial ability, then did a post-test with identical grids but different question items to avoid the effect of repetition. The research design is shown in Figure 1.

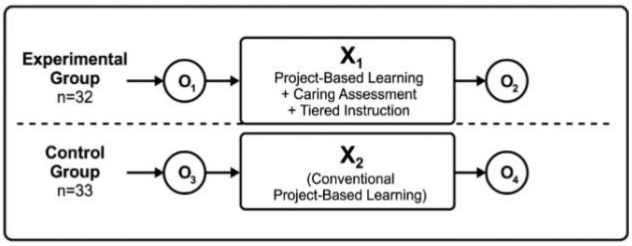

Figure 1. Research Design

Description:
O1 = Pre-test
O2 = Post-test
O3 = Pre-test
O4 = Post-test
X1 = PjBL + Caring Assessment + Tiered Instruction
X2 = Conventional PjBL

The participants of this study were 65 junior high school students in one of the regions in Indonesia, who were divided into two classes with a total of 32 and 33 students, respectively. These participants were chosen

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because they already have basic skills in the use of digital technology, and are in a transition period from concrete to abstract thinking, so that they need the right support (scaffolding) in developing creativity and collaboration. The selection of class samples was carried out purposively with the criteria that both classes have equivalent academic abilities, are taught by the same teacher, and have relatively simultaneous learning schedules. After the two classes are selected, the determination of each class role is made, which class receives intervention and which does not (random assignment), to minimize selection bias in the provision of treatment. The research was carried out for 4 meetings in a span of 2 months and was carried out in the subject of Informatics at grade VIII level.

Two types of instruments were used in this study to capture different dimensions of student performance. The first was a written test designed to measure learning outcomes, and the second was a performance assessment rubric targeting creative thinking and collaboration skills specifically. Written test items were developed from a 100-item question bank based on the PBLWorks Success Skills Rubrics, Torrance's creative thinking indicators, and the P21 collaboration framework. Before any empirical testing took place, the research team reviewed each item internally to check whether the indicators were properly represented, whether the wording was clear enough, and whether the items were consistent with the learning objectives. The pilot test then involved 100 students. Pearson product-moment analysis showed that 53 of 80 tested items met the validity criteria, and KR-20/Cronbach's alpha yielded a reliability coefficient of 0.774.

From this bank, two separate instruments were drawn. The pre-test consisted of 10 items and was intentionally designed without tier classification, so that students' initial abilities could be captured comprehensively before any placement decision was made. While the post-test consisted of 15 multiple-choice items selected from the question bank that had been piloted and analyzed for item quality. Both instruments measured the same constructs and competency indicators, although they differed in item composition and difficulty distribution.

The second instrument served a different purpose. Rather than measuring what students knew, the performance rubrics were designed to capture how students thought and worked during the project itself. The rubrics were adapted from the PBLWorks Success Skills Rubrics and aligned with the P21 collaboration framework and Torrance's indicators, with the adaptation process focused on translating the observable behavior descriptors into contexts that were realistic and relevant for junior high school PjBL activities in Informatics learning, without altering the core constructs of the original frameworks. The rubrics assessed creative thinking through originality, elaboration, flexibility, and idea implementation, and collaboration through active participation, responsibility, communication, and appreciative attitude. Each indicator was scored on a 1 to 4 scale, as summarized in Table 1.

Table 1. Research Instrument Grid

Variable	Aspects Assessed	Adaptation Source	Scale
Creative Thinking	Originality of the idea Elaboration of ideas Flexibility of thinking Implementation of ideas	PBLWorks; Torrance	1 – 4
Collaboration	Active participation Responsibilities Communication An appreciative attitude	P21; PBLWorks	1 – 4

In the experimental group, tier placement was based on pre-test scores. Students scoring below 60 were placed in Tier 1 and received highly structured tasks with intensive scaffolding, students scoring 60–79 were placed in Tier 2 and received moderately structured tasks, and students scoring 80 or above were placed in Tier 3 and received open-ended tasks requiring higher exploration and creativity. In the control group, all students completed tasks with the same level of complexity. Tier movement was determined through project performance, formative quizzes, and observations of collaborative engagement. Students who showed stronger idea development and problem-solving accuracy could move to a higher tier, while students who experienced stagnation received caring assessment support through reflective dialogue, formative feedback, and additional scaffolding.

Caring assessment is an inherent part of each meeting with an intensity that is adjusted at each tier level. The assessment covers four aspects of creativity: originality, elaboration, flexibility, and application of the product. In addition, four aspects of collaboration such as role responsibility and communication quality are also key indicators. At the end of the session, students' creative thinking and collaboration skills were measured again through post-tests. The implementation flow is presented in Figure 2.

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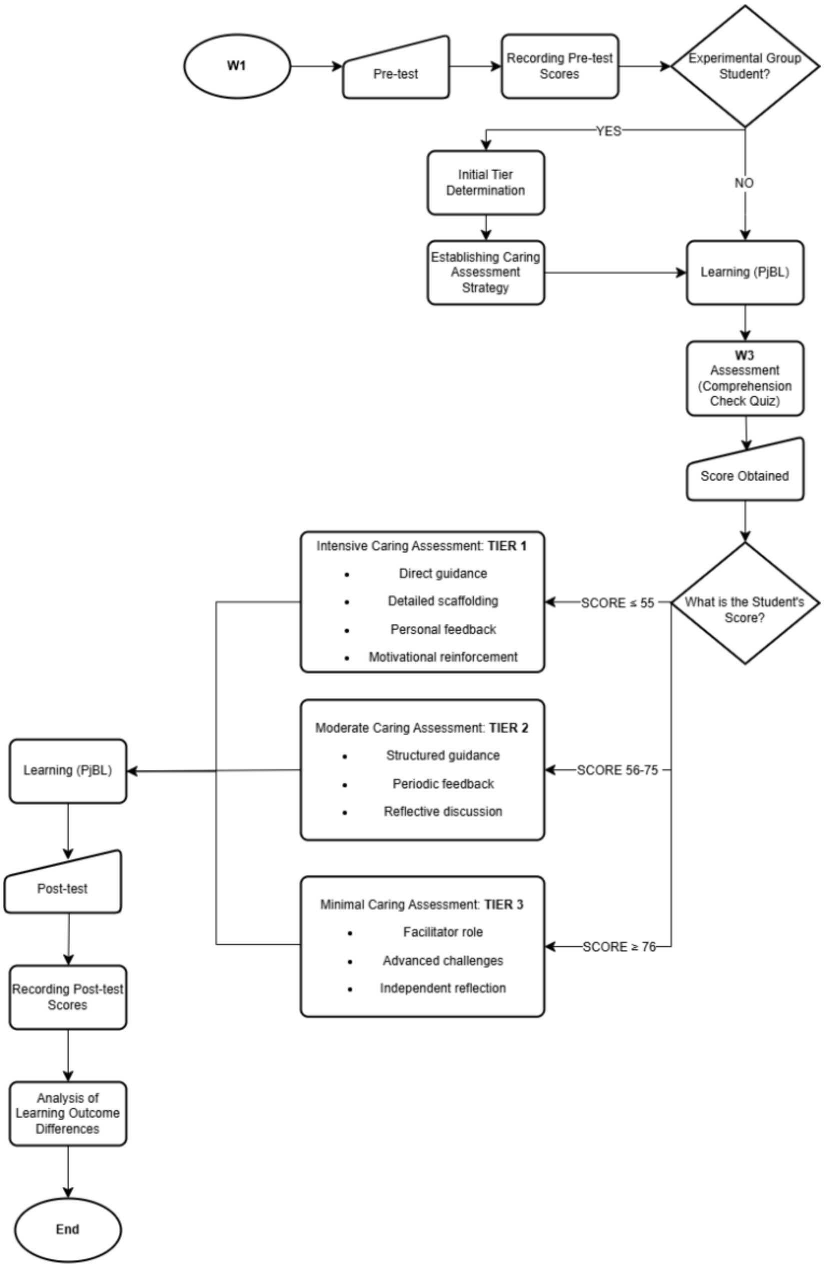

Figure 2. Research Design Flow Diagram

Pre-test and post-test results data were analyzed using descriptive and inferential statistics with SPSS. The first stage is to describe the distribution of the data through the calculation of means, medians, and standard deviations. The second stage is the testing of parametric statistical assumptions using the Shapiro-Wilk test for the normality test and the Levene's test for the homogeneity test of variance. If both assumptions are met, the analysis is followed by an independent sample t-test. However, if it is not met, alternative nonparametric tests will be used, namely the Mann-Whitney U test and the Wilcoxon Signed-Rank Test. The stages of data analysis, including descriptive statistics, assumption testing, N-gain calculation, and hypothesis testing, are summarized in Table 2.

Table 2. Stages of Data Analysis

Stages	Types of Analysis	Purpose	Test Equipment
1	Descriptive Statistics	Describe the distribution of data (mean, median, mode, SD)	SPSS
2	Normality Test	Test the normal distribution of data	Shapiro-Wilk
3	Homogeneity Test	Testing for variance similarity	Levene's Test
4	N-gain Test	Measure capability improvement	Hake Formula
5	Hypothesis Test	Comparing experimental and control groups	Independent t-test / Mann-Whitney U and Wilcoxon Signed-Rank Test

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To find out the amount of improvement in students' abilities, an N-gain (normalized gain) score is calculated using the Hake formula.

$$N - gain = \frac{Spost - Spre}{Smaks - Spre} \quad (1)$$

Description:
N-gain = Normalized gain score
Spost = Post-test score
Spre = Pre-test score
Smax = Ideal maximum score

To determine the level of improvement in students' abilities, the N-gain results were categorized based on the interpretation criteria shown in Table 3.

Table 3. N-gain Interpretation Criteria

N-gain value	Categories	Interpretation
$g \geq 0.70$	High	Highly effective ability enhancement
$0.30 \leq g < 0.70$	Medium	Ability enhancement is quite effective
$g < 0.30$	Low	Less effective ability enhancement

To ensure that the conclusions drawn are not just statistical coincidences, post-test scores and N-gain between the experimental and control groups are compared through hypothesis testing. There are conditions that must be met first. If the data do not meet the parametric assumptions, the Mann-Whitney U test is used as a more appropriate nonparametric alternative. The two hypothetical statements are then formulated explicitly. H_0 stands on the position that there is no real difference between the two groups in the achievement of creative thinking or collaboration ($\mu_1 = \mu_2$). H_1, on the other hand, predicts the opposite, i.e. the experimental group will outperform the control group significantly ($\mu_1 > \mu_2$). The criteria used are simple but firm. If examined further, decision-making is based on the significance level of $\alpha = 0.05$. This means that if the p-value < 0.05, H_0 is rejected. This implies one crucial conclusion, namely that the integration of caring assessment and tiered instruction in PjBL has a significant influence on the two competencies tested.

3. Results and Discussion

3.1. Results

The findings of this study are presented through two interrelated flows. The first flow traced whether or not there was a significant difference in learning outcomes between the experimental and control groups, which were examined through a score comparison pre-test, post-test, and calculations of N-gain. The second flow answers the extent to which the intervention affects the two competencies measured, namely Creative Thinking and Collaboration, which is analyzed using the Mann-Whitney U based on performance rubric data. If examined further, the two flows do not stand alone. The two work synergistically to form a comprehensive understanding of the impact of integration of Caring Assessment and tiered instruction in project-based learning.

3.1.1. Descriptive Statistics of Learning Outcomes

Across both groups, post-test performance exceeded pre-test levels, however, the experimental group's progress stood out both in terms of the size of the gain and the degree to which participants' scores converged, pointing to a more consistent pattern of learning development within that group. To show the distribution of students' learning outcomes before and after the intervention, the pre-test and post-test descriptive statistics are presented in Table 4.

Table 4. Descriptive Statistics Pre-test and Post-test

Central Tendencies	Pre-Test		Post-Test	
	Experiments	Controls	Experiments	Controls
Mean	78.67	83.33	89.09	85.12
Median	80.00	80.00	93.00	90.00
Mode	70	80	93	100
SD	11.059	9.223	9.368	17.150
Minimum	60	60	67	27
Maximum	100	100	100	100

This substantial gap in learning progress suggests that the treatment condition had a far greater bearing on academic achievement than the instructional setting experienced by the control group. N-gain scores were

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subsequently computed using the Hake formula as a means of gauging the relative magnitude of each group's learning gains. To compare the magnitude of learning improvement between the two groups, the N-gain calculation results are summarized in Table 5.

Table 5. N-gain Calculation Results

Groups	N-gain		Categories
Experiments	$\frac{89.09 - 78.67}{100 - 78,67}$	= 0.49	Medium (Ability enhancement is quite effective)
Controls	$\frac{85.12 - 83.33}{100 - 83.33}$	= 0.11	Low (Less effective ability enhancement)

3.1.2. Descriptive Statistics of Creative Thinking and Collaboration

In the creative thinking variable, the experimental group obtained an average of 3.29 points, while the control group obtained 2.86 points. In the collaboration variable, the experimental group also showed a higher average, which was 3.35 points, while the control group had 2.93 points. The median and mode show a unidirectional tendency. In the experimental group, the number 4 was the score that appeared most often on both variables, and the number 3 was the score that appeared most often in the control group. Thus, descriptively the experimental group showed better performance and the ability to think creatively and collaboratively. To provide an overview of students' performance in creative thinking and collaboration, the descriptive statistics for both variables are summarized in Table 6.

Table 6. Descriptive Statistics of Creative Thinking and Collaboration

Central Tendencies	Creative Thinking		Collaboration	
	Experiments	Controls	Experiments	Controls
N	32	33	32	33
Mean	3.29	2.86	3.35	2.93
Median	3	3	4	3
Mode	4	3	4	3
SD	0.71	0.95	0.81	0.73

The narrower pattern of score spread in the experimental group indicated that the intervention not only raised the average, but also encouraged consistency of achievement among students, something that was not seen in the control group with a larger standard deviation, especially in the creative thinking variable (SD = 0.95).

3.1.3. Differential Statistical Test

Hypothesis testing cannot necessarily be carried out without an initial verification stage. Two conditions need to be ascertained first, namely whether the data is normally distributed and whether the variance between the two groups is equal. These two conditions determine which analysis path will be taken. The Shapiro-Wilk test was used to check normality. The normality of the pre-test and post-test data was examined using the Shapiro-Wilk test, and the results are presented in Table 7.

Table 7. Pre-test and Post-test Normality Test

Groups	Variable	SW Statistics	Sig.	Remarks
Experiments	Pre-Test	0.898	0.008	Abnormal
	Post-Test	0.876	0.002	Abnormal
Controls	Pre-Test	0.905	0.027	Abnormal
	Post-Test	0.781	0.0001	Abnormal

Assumption testing revealed that none of the pre-test or post-test scores met the normality assumption. Shapiro-Wilk values in the experimental group were 0.008 (pre-test) and 0.002 (post-test), while the control group returned 0.027 and 0.0001 respectively. All four fell below the 0.05 threshold. Variance between groups, however, proved homogeneous across both measurement points, as confirmed by Levene's test (pre-test: Levene = 0.968; p = 0.329; post-test: Levene = 2.295; p = 0.135). Given the violation of normality, non-parametric procedures were selected for subsequent analysis. The Shapiro-Wilk test was also applied to the creative thinking and collaboration scores, and the results are presented in Table 8.

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Table 8. Test of Normality of Creative Thinking and Collaboration

Groups	Variable	SW Statistics	Sig.	Remarks
Experiments	Creative Thinking	0.918	0.0159	Abnormal
	Collaboration	0.795	0.0004	Abnormal
Controls	Creative Thinking	0.851	0.0000	Abnormal
	Collaboration	0.829	0.0002	Abnormal

As shown in the rubric assumption tests, creative thinking and collaboration scores were also not normally distributed. Non-normality, across all four score sets, held firm. Where the picture shifted was in the variance. Levene's test pointed in a different direction entirely, confirming homogeneous variance for both creative thinking (Levene = 0.252; $p = 0.617$) and collaboration (Levene = 2.776; $p = 0.101$), which directed the subsequent analysis toward non-parametric procedures.

3.1.4. Hypothesis Test

Because the pre-test and post-test data are not normally distributed and are paired in the same group, the score change test is carried out using the Wilcoxon Signed-Rank Test. Wilcoxon's analysis only involves a complete pair of pre-test and post-test data. Therefore, in the experimental group, only 30 data pairs could be analyzed, while in the control group, only 24 data pairs were complete. This incompleteness of data is caused by the absence of some students during the pre-test or post-test, so that data pairs cannot be formed. Students who took only one of the measurements were excluded from the Wilcoxon analysis to maintain the integrity of the paired comparisons, although their data were still used in descriptive analyses and the Mann-Whitney U test, which did not require pairing completeness. Table 9 shows a significant improvement in the experimental group, while the control group did not show a significant change.

Table 9. Wilcoxon Pre-test and Post-Test Test Results

Components	Groups	
	Experiments	Controls
N	30	24
Negative Ranks	2	8
Positive Ranks	25	15
Ties	3	1
Z	-4.071	-1.574
Sig. (2-tailed)	<0.001	0.116
Remarks	Significant	Insignificant

Furthermore, the difference in creative thinking and collaboration scores between the experimental and control groups was tested using the Mann-Whitney U, because the data were abnormal and came from two independent groups Table 10 shows that the experimental group obtained significantly higher creative thinking and collaboration scores than the control group.

Table 10. Results of the Mann-Whitney U Test on Creative Thinking and Collaboration

Components	Creative Thinking		Collaboration	
	Experiments	Controls	Experiments	Controls
N	32	33	32	33
Mean Rank	38.36	27.80	40.19	26.03
Mann-Whitney U	356.500		298.000	
Z	-2.254		-3.024	
Sig. (2-tailed)	0.024		0.002	
Remarks	Significant		Significant	

Based on the overall results, it can be concluded that the intervention in the experimental group was not only followed by a significant increase in learning outcomes in the group but also resulted in better creative thinking and collaboration outcomes than the control group.

3.2. Discussion

The findings show that integrated PjBL led to stronger learning outcomes, creative thinking, and collaboration than conventional PjBL. The difference was not caused by project activities alone, but by how the project was supported. Tiered instruction adjusted task complexity to students' readiness, while caring assessment kept feedback active during learning. This made the project process more responsive to students' actual needs.

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Tiered instruction helps explain the stronger learning development in the experimental group. In heterogeneous classrooms, uniform project tasks can make higher-readiness students dominate while lower-readiness students remain less involved. By offering different levels of challenge within the same learning goals, tiered instruction gave students a more suitable entry point into the project. This interpretation aligns with Hidayat et al. (2024), who emphasized that differentiated instruction could support flexible learning conditions and students' original ideas.

Caring assessment strengthened the process by making students' ideas, roles, communication, and participation visible while the project was still ongoing. Feedback was not delayed until the final product, so students had room to revise their ideas and improve their group contribution. Shao et al. (2024) similarly found that formative assessment is related to confidence and intrinsic motivation. For collaboration, this finding also supports Johnsen et al. (2024), Lee et al. (2024), and Tangney et al. (2024), who showed that group interaction develops better when it is structured and supported.

3.3. Implications

At the classroom level, these findings imply that teachers need to prepare PjBL as a guided learning process, not merely as a final project assignment. Before the project begins, teachers can identify students' initial readiness and design tiered tasks that differ in complexity, structure, and level of support, while still leading to the same learning objectives. This step is important because students in one class rarely begin from the same point. The findings also suggest that formative assessment should be placed within the project process itself. Teachers need to provide feedback at several points during the project, monitor students' roles, and use rubrics to observe creative thinking and collaboration as they develop. In junior high school Informatics learning, this approach can help make project activities more balanced because students are not only assessed based on the final product, but also on how they think, contribute, communicate, and respond to feedback during the process.

3.4. Limitations

Several limitations deserve honest acknowledgment before these findings are taken too broadly. The most fundamental constraint sits in the quasi-experimental design itself: without individual randomization, pre-existing differences between groups in motivation, peer dynamics, classroom atmosphere, or prior learning experience could not be fully ruled out, even though both classes were selected based on comparable academic performance, the same teacher, and similar schedules. Beyond that, 65 students from a single school observed across only four meetings within two months simply cannot carry the weight of wide generalization, whether across different schools, subjects, or grade levels, nor can they confirm how long the gains in creative thinking and collaboration would actually hold. Incomplete data pairing further reduced the usable cases in the Wilcoxon analysis to 30 pairs in the experimental group and 24 in the control group. Future research would benefit from larger and more diverse samples, longer implementation windows, follow-up measurements, and designs that test caring assessment and tiered instruction separately, so that the specific contribution of each component within integrated PjBL can be identified with greater confidence.

4. Conclusion

This study concludes that PjBL integrated with caring assessment and tiered instruction is more effective than conventional PjBL in supporting junior high school students' learning outcomes, creative thinking, and collaboration skills. The integrated model addresses two common weaknesses in conventional PjBL: product-oriented assessment and task design that does not sufficiently consider students' readiness. Caring assessment provided feedback during the project process, while tiered instruction offered task challenges that were more aligned with students' initial abilities. Together, these components made PjBL more structured, responsive, and supportive of creative and collaborative development. Since this study involved one school, a limited sample, and a short intervention period, further studies are needed in broader contexts and longer learning cycles.

Author Contributions

The first author was responsible for conceptualization, development of instructional materials, formal analysis, data curation, validation, visualization, project administration, and writing the original draft of the manuscript in its entirety. The second author contributed to the conceptual framework of caring assessment and tiered instruction, assessment design, investigation, and data collection. The third author contributed to supervision, validation, and manuscript review. All the authors have read and approved the final manuscript.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

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Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

Artificial intelligence (AI) tools were employed in a strictly limited capacity during the preparation of this manuscript, specifically for language checking and editorial refinement of the written text. The tools played no role in the generation of ideas, development of theoretical frameworks, research design, data collection, interpretation of findings, or any substantive intellectual contribution. All conceptual, analytical, and scholarly content presented in this manuscript originates exclusively from the authors.

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