Exploring the Impacts of Learning Styles on Collaboration in Project-Based Learning across Gender

Dedi Aprianto[*], Sutarman, Wahyu Kamil Syarifaturrahman

Universitas Bumigora, Mataram, Indonesia

Abstract

The study investigates the impact of learning styles on collaboration in Project-Based Learning (PjBL) across gender and how these styles affect their collaborative behaviors in PjBL. Addressing a significant gap in understanding how these factors interact in collaborative educational contexts. The research aims to determine whether there are significant differences in learning styles and collaboration based on gender and how these styles influence collaborative behaviors. Using a mixed-method explanatory sequential design, the study involved 160 participants from the Computer Science and 35 from the Nutrition departments, with quantitative data analyzed using Two-Way ANOVA and qualitative insights gathered from 35 interviews across all classes. The findings reveal that male students tend to outperform in visual learning styles, while female students perform better in auditory learning contexts. Qualitative data further highlighted the importance of gender-responsive instructional strategies for enhancing teamwork effectiveness. In conclusion, the study highlights that integrating diverse learning styles into pedagogical practices fosters inclusivity and improves learning outcomes. It advocates adaptive teaching approaches that accommodate diverse cognitive needs, ultimately contributing to more effective collaborative learning experiences across diverse educational environments.

Keywords: Collaboration; Gender Differences; Learning Styles; Project-Based Learning.

How to Cite:

1. INTRODUCTION

Understanding individual learning preferences is essential for designing effective pedagogical approaches, particularly in student-centered environments such as Project-Based Learning (PjBL). The visual, auditory, and kinesthetic (VAK) model offers a useful framework for categorizing how students absorb and process information, which directly influences their engagement and interaction. Gender differences have also been observed in learning style preferences, with female students tending to be more inclined toward visual and auditory modalities. In contrast, male students often prefer kinesthetic approaches. These distinctions may influence collaborative dynamics in PjBL, where teamwork and task distribution are central to learning success. Despite existing research on gender and learning styles in individual contexts, there remains a gap in understanding how these variables interact within collaborative settings. Exploring this intersection is vital to enhancing the inclusivity and effectiveness of PjBL, ensuring that instructional strategies support diverse learners in contributing meaningfully to group tasks.

The role of learning styles in English as a Foreign Language (EFL) and English as a Second Language (ESL) contexts is crucial for enhancing engagement and academic achievement, with aligned instruction shown to improve comprehension and retention. Aydin (2019) found that EFL learners performed better when idioms were taught through literal representations, emphasizing the importance of aligning instruction with cognitive preferences. Similarly, Tazik (2019) demonstrated that adapting writing tasks to students learning styles improved writing proficiency, emphasizing the need for flexible and responsive pedagogy. Moreover, Al-Hubaishi and Al-Mekhlafi (2023) emphasized that perceptual learning styles significantly influence EFL students language strategies, highlighting the value of adaptive teaching for a more engaging environment. While Ik (2019) Although the study explored ESL learners motivation in computer-assisted language learning, it did not directly examine learning styles. Collaborative learning and technology integration effectively reduce writing apprehension, thereby enhancing engagement in EFL and ESL contexts (Palani & Sulaiman, 2022). Collectively, these studies reinforce the importance of incorporating learning styles into language instruction to promote student involvement and academic achievement.

PjBL is a transformative method in the EFL education context, enhancing student engagement and promoting real-life language use. It draws from constructivist theory, which emphasizes that knowledge is built through experience and reflection. Deweys experiential learning highlights the role of real-world contexts, where students participate in meaningful tasks requiring authentic language use (Coronado et al., 2021). Additionally, the sociocultural theory underlines the importance of social interaction in learning. PjBL supports this by enabling students to collaborate, negotiate meaning, and build communicative competence (Pürbudak & Usta, 2021). Studies show that PjBL enhances motivation and engagement by fostering a sense of ownership and relevance in language learning (Magaña et al., 2023). Integrating diverse learning styles within PjBL promotes inclusivity and addresses individual preferences, thus improving EFL instruction (Baherimoghadam et al., 2021). Moreover, PjBLs long-term impact on learning outcomes, especially in developing critical thinking and problem-solving skills. Through active project involvement, EFL learners strengthen both language proficiency and essential soft skills for global competence (Wang & Han, 2021). Therefore, PjBL is a dynamic pedagogy that supports contemporary educational goals and promotes effective learning.

Understanding gender-based learning styles is essential for enhancing collaboration in PjBL, as studies show gender influences learning preferences and interaction patterns, highlighting the need for tailored instructional strategies (Afrifa et al., 2022). These findings highlight the need for gender-responsive instructional design to enhance engagement and teamwork in PjBL. Although studies support gender-based differences in learning preferences, these variations are not consistently observed across contexts (Alonso-Martín et al., 2021; Raj & Kanagasabapathy, 2019). This suggests that gender may shape preferences, though its impact on collaboration remains inconclusive. Research shows that inclusive environments accommodating various learning styles improve participation and project outcomes (Baharu, 2019). Integrating gender perspectives into learning design can promote more equitable and effective collaboration, allowing both male and female students to optimize their roles in PjBL (Marantika, 2022; Puteh et al., 2021). Conversely, some studies report minimal gender-based differences in group learning preferences, suggesting that both male and female students can thrive in collaborative settings when using tailored approaches (Baharu, 2019). Moreover, gender affects learning styles in hybrid learning, influencing outcomes and problem-solving in EFL/ESL contexts (Anggrawan et al., 2019). Additionally, while male and female students may adopt different learning strategies, both frequently apply social strategies, though at varying levels (Sumarni & Rachmawaty, 2019). These findings emphasize the need for gender-responsive pedagogies to enhance collaboration and inclusivity in learning environments.

Research on gender-based differences in learning styles yields mixed and sometimes contradictory results. Some studies highlight the influence of gender on learning preferences, while others report no significant differences. Ozkara and Ibili (2021) observed that female students tend to exhibit distinct learning preferences. In contrast, other studies found no notable gender-based differences, underscoring the need to interpret these differences within specific educational contexts. Despite this inconsistency, several studies confirm a significant association

between gender and learning styles. Afrifa et al. (2022) reported that male and female students often demonstrate different dominant learning styles, which influence participation and performance. Raj and Kanagasabapathy (2019) similarly identified gender-based differences among medical students, affecting academic engagement. Meanwhile, Çelenk and Lehimler (2019) noted that although some research finds no significant disparities, context-specific distinctions persist, suggesting that conventional teaching methods may inadequately address these variations. Moreover, Aksoy and Üstünda (2023) contend that teacher-centered environments often neglect diverse learning styles, limiting student achievement. Similarly, the need for inclusive strategies that accommodate both male and female learners (AriCi et al., 2021; Türkmenolu Berkan & Karaman Özta, 2023). However, existing studies largely focus on conventional classroom contexts. As noted by Mai et al. (2020), there remains a lack of research on how modern pedagogical models, especially in EFL settings, can support gender-based learning preferences. This gap highlights the need for future inquiry into adaptive, inclusive instructional designs.

While previous studies have explored gender differences in learning styles, limited research has specifically examined their implications within PjBL environments. Most existing literature focuses on traditional instructional methods, leaving a gap in understanding how gender-based learning preferences influence collaboration in PjBL settings. This study seeks to bridge this gap by analyzing the impact of gender differences in learning styles on student collaboration within PjBL. The novelty of this research lies in its focused examination of gender-related learning dynamics in collaborative PjBL contexts, offering insights that can enhance instructional strategies for diverse student populations. Understanding how gender differences intersect with learning styles in PjBL offers critical insights for enhancing English language instruction in EFL contexts. Such insights enable teachers to develop adaptive, student-centered strategies that address diverse cognitive needs, thereby fostering greater inclusivity and engagement. Moreover, these findings inform the creation of pedagogical materials that enhance learning effectiveness across gender groups. Beyond practical applications, this perspective strengthens the discourse on equitable language education, aligning instructional design with the principles of gender responsiveness and learner diversity in 21st-century classrooms. By addressing these aspects, the research aims to help English teachers refine their approaches to PjBL, particularly improving learning outcomes. Ultimately, to achieve these objectives, the study seeks to answer the following research questions: (1) Is there a significant difference between learning styles in student collaboration in PjBL based on gender? And (2) How do these styles affect their collaborative behaviors in PjBL across gender?

2. RESEARCH METHOD

2.1. Research Design

This study employed a mixed-method explanatory sequential design to investigate the influence of gender-specific learning styles on student collaboration within PjBL environments. Quantitative data from 160 participants, from Computer Science and Nutrition students, were analyzed using Two-Way ANOVA to examine interactions among gender, learning styles, and collaborative behaviors. These findings informed the qualitative phase, which utilized thematic analysis based on the Miles and Huberman framework. Triangulation across methodologies, data sources, and investigators enhanced the studys validity. By integrating statistical trends with in-depth qualitative insights, this approach provided a comprehensive understanding of how diverse learning styles shape collaboration in PjBL, offering implications for inclusive and adaptive instructional design.

2.2. Population, Sample and Subject

The population of this study consisted of 234 students, from which a sample of 160 participants was drawn from two departments at Bumigora University, Mataram: three classes from Computer Science (Class A, B, and C) and one class from the Nutrition department (Class A). Non-English departments were chosen to capture authentic learning experiences in natural academic settings, free from direct language instruction. Their collaboration in subject-specific contexts reflects spontaneous language use and self-directed learning in PjBL environments. The absence of formal language supervision allowed for an unbiased analysis of gender-based learning preferences

and cognitive engagement. Additionally, 35 students were interviewed to achieve data saturation and ensure comprehensive, reliable qualitative insights.

Table 1. The Number of Samples and Their Demographic Information

Department /Class	Number of students	Questionnaires		Interview Participants		Numbers Based on Learning Styles					
						Visual		Auditory		Kinesthetic	
		M	F	M	F	M	F	M	F	M	F
Computer/A	42	25	17	8	5	8	7	7	7	7	6
Computer/B	43	26	17	8	5	8	8	7	6	7	7
Computer/C	40	24	16	7	5	8	6	7	7	6	6
Nutrition/A	35	5	30	2	8	1	10	2	11	3	8
Total	160	80	80	25	23	25	31	23	31	23	27

Based on Table 1, the study involved 160 students from the Computer Science and Nutrition departments across four classes. The gender distribution showed a male majority in Computer Science and a female majority in Nutrition, with 71 males (44%) and 89 females (56%) students. All participants completed a questionnaire, and 48 students (25 males, 23 females) were selected for in-depth interviews based on data saturation. The analysis of learning styles categorized students into visual (56 students, 35%), auditory (54 students, 34%), and kinesthetic (50 students, 31%). These classifications provided insights into how gender-based learning preferences influence collaboration in PjBL environments.

2.3. Instruments

This study used three primary instruments: the Barsch Learning Style Inventory, the Learning Collaboration in PjBL Questionnaire, and semi-structured interviews. The Barsch inventory, consisting of 24 validated items, categorized participants into visual, auditory, and kinesthetic learning styles. A pilot test confirmed validity, with a Cronbachs Alpha of 0.946, indicating high reliability. The Learning Collaboration in PjBL questionnaire, with 20 Likert-scale items on interaction, communication, and teamwork, demonstrated strong internal consistency (Cronbachs Alpha = 0.958). Moreover, semi-structured interviews were conducted to explore qualitative aspects of learning styles and gender dynamics in collaboration, focusing on learning frequency, resilience, and speaking performance. The instruments validity was confirmed with an S-CVI/Ave score of 0.93 > 0.80. Additional validation included expert judgment, member checking, peer review, and confirmability audits to ensure data accuracy. Triangulation and audit trails were used to enhance credibility and objectivity. This study employed mixed methods to examine the impact of learning styles on collaboration in PjBL, focusing on teamwork and gender dynamics. The summary of the instruments can be shown in Table 2.

Table 2. Summary of Research Instrument Assessments

Instrument	Indicators	Validity Test	Reliability Test	Conclusion
Barsch Learning Style Inventory	Visual, Auditory, Kinesthetic learning styles	Pearson Correlation (r-values >0.220 or Sig. (2-tailed) = 0.000)	Cronbachs Alpha = 0.946 >0.70	Valid & Reliable
Learning Collaboration in PjBL Questionnaire	Interaction, communication, teamwork engagement	Pearson Correlation (r-values >0.220 or Sig. (2-tailed) = 0.000)	Cronbachs Alpha = 0.958 >0.70	Valid & Reliable
Semi-Structured Interviews	Learning frequency, resilience, speaking performance	S-CVI/Ave = 0.93 >0.80 (valid), expert judgment, member checking, peer review, confirmability audit	Audit trails, triangulation	Valid & Reliable

2.4.   Data Collection

This study employed a mixed-methods approach, integrating quantitative and qualitative data collection methods to comprehensively examine the effects of students learning styles on their collaboration in PjBL. The students learning styles were identified and categorized based on their natural preference through the Barsch learning style inventory. For quantitative data collection, two structured instruments were administered: the Barsch Learning Style Inventory and the Learning Collaboration in PjBL Questionnaire. The Barsch Learning Style Inventory classified students into visual, auditory, or kinesthetic learners. Following this classification, the learning collaboration section of the PjBL questionnaire, consisting of Likert-scale items, was distributed to measure various dimensions of student collaboration, including interaction, teamwork engagement, and responsibility-sharing in PjBL settings. All the questionnaires used a five-point Likert scale: (5) Very Agree, (4) Agree, (3) Neutral, (2) Disagree, and (1) Very Disagree. The collected data were analyzed statistically to examine the impacts of learning styles on collaborative behaviors in PjBL across gender. For qualitative data collection, semi-structured interviews were conducted to gain an in-depth understanding of students perspectives on collaboration within PjBL. The interviews examined the impact of learning styles, gender dynamics, collaborative challenges, and strategies for adaptive PjBL design. Participants' insights were thematically analyzed to capture their experiences and perceptions regarding interaction patterns, gender influences, and approaches to enhancing collaboration.

2.5.   Data Analysis

The study employed a mixed-methods approach to analyze the relationship between learning styles and collaboration in PjBL. Quantitative data collected through the Barsch Learning Style Inventory and a collaboration questionnaire were examined using a Two-Way ANOVA to assess the interaction effects of learning style and gender on collaborative performance. Before analysis, assumptions of normality and homogeneity of variances were tested. The Kolmogorov-Smirnov test confirmed normality ($0.200 > .05$), so the Two-Way ANOVA was applied. Descriptive statistics further summarized the distributions of learning styles and collaboration levels. To complement, qualitative data from semi-structured interviews were analyzed through Miles and Huberman (1994), a thematic model encompassing data reduction, display, and conclusion drawing/verification. Themes were validated through triangulation, including expert judgment, member checking, and peer review. The integration of quantitative and qualitative analyses provided a comprehensive understanding of how learning styles shape collaboration in PjBL, while also accounting for gender-related dynamics.

Systematic procedures for both quantitative and qualitative data analysis were used in this study. The quantitative analysis involved five stages: data preparation, descriptive statistics, assumption testing, Two-Way ANOVA, and interpretation of results. These steps ensured accurate data entry, statistical validity, and meaningful interpretation of the relationships between learning styles, gender, and collaboration. For qualitative data, the analysis followed Miles and Hubermans model, comprising data reduction, data display, and conclusion drawing/verification. This rigorous approach enabled thematic categorization, visual pattern identification, and validation through triangulation methods, thereby enhancing the credibility and depth of the studys findings.

3.   FINDINGS AND DISCUSSION

3.1.   Learning Styles and Their Impact on Student Collaboration in PjBL across Gender

To examine differences in student collaboration in PjBL by learning style and gender, a descriptive statistical analysis was conducted. The following table presents the mean scores and standard deviations for collaboration across visual, auditory, and kinesthetic learners, categorized by gender.

Table 3. Means and SD of Student Collaboration in PjBL based on Learning Styles and Gender

Descriptive Statistics				
Dependent variable: Learning collaboration in PjBL				
Learning styles	Students sexes	Mean	Std. Deviation	N
Visual	Male	86.24	2.204	25

Descriptive Statistics				
Dependent variable: Learning collaboration in PjBL				
Learning styles	Students sexes	Mean	Std. Deviation	N
	Female	70.16	3.865	31
	Total	77.34	8.679	56
Auditory	Male	78.35	3.433	23
	Female	84.94	1.982	31
	Total	82.13	4.234	54
Kinesthetic	Male	72.43	1.562	23
	Female	74.41	1.986	27
	Total	73.50	2.043	50
Total	Male	79.21	6.254	71
	Female	76.60	6.939	89
	Total	77.76	6.750	160

Table 3 shows that descriptive statistics indicate variations in student collaboration in PjBL by learning style and gender. Among visual learners, males (M = 86.24) scored significantly higher in collaboration than females (M = 70.16). In contrast, among auditory learners, females (M = 84.94) outperformed males (M = 78.35). For kinesthetic learners, the difference between males (M = 72.43) and females (M = 74.41) was minimal. Overall, males had a slightly higher collaboration score (M = 79.21) than females (M = 76.60). These results suggest that gender influences collaboration differently across learning styles, with males excelling in visual learning while females perform better in auditory learning. Further inferential analysis is needed to determine the significance of these differences.

To investigate the effects of different learning styles on collaboration in PjBL between male and female students. The following table presents the tests of between-subjects effects, including the sum of squares, degrees of freedom, mean squares, F-values, and significance levels for each source of variance.

Table 4. ANOVA Results for the Effects of Learning Styles on Students Collaboration in PjBL

Tests of Between-Subjects Effects					
Dependent variable: The results of collaboration in PjBL			Mean Square	F	Sig.
Source	Type III Sum of Squares	df			
Corrected model	6147.481[a]	5	1.229.496	172.441	.000
Intercept	952.463.977	1	952.463.977	1,34E+08	.000
Learning styles	1.740.589	2	870.294	122.062	.000
Gender	247.371	1	247.371	34.695	.000
Learning styles * Gender	3.886.712	2	1.943.356	272.562	.000
Error	1.098.013	154	7.130		
Total	974.611.000	160			
Corrected Total	7.245.494	159			
a. R Squared = .848 (Adjusted R Squared = .844)					

Based on the Table 4, the study showed that Two-Way ANOVA indicate that the model significantly explains the variance in student collaboration in PjBL (F(5, 154) = 172.441, p = 0.000), with a high explanatory power (R^2 = 0.848, Adjusted R^2 = 0.844), suggesting that 84.8% of the variance in collaboration scores is influenced by learning styles, gender, and their interaction. A significant main effect of learning styles (F(2, 154) = 122.062, Sig. = .000) indicates that different learning styles contribute to variations in collaboration. Similarly, the main effect of gender (F(1, 154) = 34.695, Sig. = 0.000) suggests a significant difference between male and female students in their collaboration levels. Moreover, a significant interaction effect between learning styles and gender (F(2, 154) = 272.562, Sig. = 0.000) highlights that the influence of learning styles on collaboration differs across genders. These

findings underscore the complex interplay between learning preferences and gender, necessitating further post hoc analysis to identify specific group differences and their implications for collaborative learning strategies in PjBL.

Therefore, Table 5 presents the estimated marginal means for student collaboration in PjBL, categorized by learning styles and gender. It includes the mean scores (M), standard errors (SE), and 95% confidence intervals for each group, providing a clearer comparison of collaboration performance across different learning styles and gender groups:

Table 5. Estimated Marginal Means of Student Collaboration in PjBL by Learning Styles and Gender

Types of Learning Style * Students' Sexes					
Dependent variable: The results of Collaboration in PjBL					
Learning styles	**Students sexes**	**Mean (M)**	**Std. Error (SE)**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Visual	Male	86.240	.534	85.185	87.295
	Female	70.161	.480	69.214	71.109
Auditory	Male	78.348	.557	77.248	79.448
	Female	84.935	.480	83.988	85.883
Kinesthetic	Male	72.435	.557	71.335	73.535
	Female	74.407	.514	73.392	75.423

As shown in Table 5, statistically significant differences in student collaboration within PjBL were observed by learning style and gender. Male students with a visual learning style demonstrated significantly higher collaboration scores (M = 86.24) than their female counterparts (M = 70.16), as indicated by non-overlapping confidence intervals (Male: 85.19 to 87.30; Female: 69.21 to 71.11). Conversely, female auditory learners outperformed their male counterparts (M = 84.94 vs. M = 78.35), with distinct confidence intervals (Male: 77.25 to 79.45; Female: 83.99 to 85.88), suggesting a statistically significant gender difference. In contrast, kinesthetic learners showed only a marginal difference, with females (M = 74.41) slightly outperforming males (M = 72.44), though overlapping confidence intervals (Male: 71.34 to 73.54; Female: 73.39 to 75.42) suggest this difference may not be statistically significant. These findings suggest that gender-based learning preferences may influence collaboration effectiveness in PjBL, particularly among visual and auditory learners, which should be considered in instructional design and pedagogical approaches.

3.2.   How Diverse Learning Styles Shape the Collaboration Process in PjBL Across Genders

Understanding the influence of learning styles on student collaboration in PjBL across gender is crucial for optimizing teamwork dynamics. This qualitative analysis examines students experiences, perceptions, and strategies for navigating collaboration based on their preferred learning styles: visual, auditory, and kinesthetic. It also explores gender-related patterns in communication, role distribution, and teamwork. Findings reveal that diverse learning styles shape task approaches, communication flow, and team dynamics, highlighting both challenges and adaptive strategies. By addressing these factors, the study offers insights into fostering inclusive and effective PjBL environments and promoting equitable participation.

A.   Interaction of Diverse Learning Styles in the Collaboration Process

Students diverse learning styles play a crucial role in shaping their contributions to collaborative work in PjBL. Visual learners excel at structuring information, often taking on roles that involve organizing project frameworks, developing conceptual diagrams, and ensuring logical coherence in presentations. Their ability to synthesize information visually helps streamline complex ideas, making them more accessible to the group. Auditory learners, on the other hand, enhance collaboration by fostering communication. They are instrumental in facilitating discussions, summarizing key points, and ensuring clarity in verbal exchanges. Their strong listening and speaking skills help mediate conflicts, reinforce shared understanding, and maintain active engagement within the team. Kinesthetic learners contribute by driving hands-on activities and experimentation. Their strength

lies in applying concepts practically, whether through prototyping, conducting simulations, or testing project implementations. Their engagement ensures that theoretical ideas are translated into tangible outcomes, making learning more dynamic and experiential.

Despite these strengths, challenges emerge when students struggle to align their working styles. Miscommunication can occur when visual learners focus on structured plans while kinesthetic learners prioritize action, or when auditory learners rely on verbal instructions that others may not easily process. Differences in pacing and task preferences can also create friction, resulting in workflow inefficiencies. Therefore, fostering an adaptive and integrative approach, such as combining structured visual guides, open discussions, and interactive tasks, can enhance collaboration and ensure that all learning styles contribute effectively to the PjBL process.

B.   Gender-Based Collaboration Dynamics in PjBL

Gender differences shape how students collaborate in PjBL, influencing task delegation, communication styles, and decision-making processes. Male students often assume task-oriented roles, emphasizing efficiency and execution, while female students tend to prioritize group cohesion and inclusive discussions. However, these tendencies are not rigid, as some students challenge conventional gender norms by adopting diverse roles within their teams. The interaction between learning styles and gender further complicates collaboration dynamics. For instance, male kinesthetic learners may take an experimental, trial-and-error approach to problem-solving, whereas female auditory learners may prefer structured discussions and meticulous planning before executing tasks. Similarly, visual learners, regardless of gender, often act as organizers, structuring project workflows through diagrams or written outlines. These differences necessitate active negotiation and team adaptability to ensure balanced contributions. Effective collaboration in PjBL requires recognizing and integrating these diverse tendencies. Teams that acknowledge both learning and gender-based preferences tend to develop more inclusive communication strategies, allocate tasks more equitably, and foster mutual understanding. Encouraging open dialogue about work styles and promoting flexible role distribution can enhance teamwork efficiency, leading to a more productive and harmonious PjBL environment.

C.   Challenges and Adaptation Strategies in Collaboration

Students encounter various challenges when collaborating in PjBL, particularly due to differences in learning styles and gender-based communication patterns. One of the primary difficulties is synchronizing work processes, as some students prefer structured approaches while others thrive in more flexible and dynamic environments. Visual learners may struggle with the fast-paced verbal discussions favored by auditory learners, while kinesthetic learners might find prolonged theoretical discussions disengaging. These differences can lead to misunderstandings, delays in task completion, and inconsistencies in teamwork. Gender dynamics further complicate collaboration, as students perceive differences in communication styles and decision-making approaches. Some reports indicate that male students tend to adopt assertive, task-oriented roles, whereas female students often focus on maintaining group cohesion and facilitating discussion. These tendencies can sometimes create imbalances in participation, affecting group efficiency and inclusivity.

To overcome these challenges, students implement various adaptation strategies. Role rotation allows members to experience different responsibilities, fostering empathy and a better understanding of each others strengths. Structured discussion sessions help ensure that all voices are heard, preventing dominant personalities from overshadowing quieter team members. Integrating multimodal learning techniques, such as combining visual aids, hands-on activities, and verbal discussions, accommodates different learning preferences, making collaboration more effective. Furthermore, establishing clear communication norms and inclusive decision-making processes helps bridge gaps between different collaboration styles. By setting guidelines for respectful discussion, active listening, and equitable task distribution, teams create a more adaptive and cohesive working environment. These strategies not only enhance teamwork but also cultivate a more inclusive and productive PjBL experience for all students, regardless of their learning styles or gender.

D.   Designing an Adaptive and Inclusive PjBL Environment

To create a more adaptive and inclusive PjBL environment, participants emphasize the need for instructional strategies that accommodate diverse learning styles while promoting equitable participation. Integrating multimodal learning resources, such as visual aids, interactive discussions, and direct activities, ensures that students with diverse learning preferences can engage effectively with project tasks. Additionally, flexible team structures allow students to take on roles that align with their strengths while encouraging them to develop new skills through guided role rotation. The use of collaborative digital tools, such as shared workspaces and real-time communication platforms, further supports inclusivity by facilitating structured yet adaptable interactions. These tools enable students to contribute in ways that suit their learning styles, whether through visual organization or verbal discussions. Moreover, guided reflection sessions can help teams assess their collaboration processes, identify challenges, and develop adaptive strategies to improve teamwork.

Beyond instructional design, fostering awareness of learning diversity within teams is crucial. Encouraging open discussions about learning preferences and communication styles can enhance mutual understanding and reduce potential conflicts. Instructors can also implement training on adaptive collaboration techniques, equipping students with strategies to navigate differences effectively. These findings highlight the complex relationship between learning styles, gender, and collaborative behaviors in PjBL. An adaptive instructional approach that integrates diverse learning modalities, fosters inclusive communication, and promotes flexibility in team dynamics is essential for optimizing project-based collaboration. By embracing these strategies, PjBL environments can support all learners equitably, maximizing both individual and team success.

3.3.   Discussion

The findings of this study highlight the significant role of learning styles in shaping the effectiveness of collaboration in PjBL. The results indicate that learning styles influence the effectiveness of student collaboration in PjBL, with variations reflecting gender differences. Males tend to excel in collaboration when using the visual approach, while females are more effective with the auditory approach. This reinforces the view that learning preferences are influenced not only by individual differences but also by socio-cognitive factors such as gender (Wakhid et al., 2024). In the context of PjBL, teaching approaches that are responsive to learning styles and gender can increase participation and the quality of teamwork (Benabbes et al., 2022). Therefore, integrating learning-style-based differentiation strategies and gender awareness is key to designing inclusive and adaptive collaborative learning environments.

Different learning styles contribute differently to group dynamics, influencing how students interact in teamwork and problem-solving. Visual learners tend to excel at conceptual planning and organizing ideas, although they may occasionally struggle with verbal communication. Pre-training in visual and verbal strategies is crucial for improving learning outcomes, especially for visual learners who process information through imagery. These imagers excel at organizing complex content visually (Sato et al., 2022), but often struggle with verbal communication due to their preference for non-verbal cues (Chang et al., 2022). This highlights a contrast: while visual learners are strong in planning and structuring ideas, their dependence on visual methods can hinder verbal expression (Wang & Han, 2021). Auditory learners exhibit pronounced communication skills and actively engage in group discussions and consensus-building, playing a pivotal role during collaborative processes (Oktaviani et al., 2023). Meanwhile, kinesthetic learners are more effective in practical activities and hands-on implementation, though they often require additional guidance during the strategic planning stage (Sofhiya et al., 2023). These findings underscore the importance of adopting a collaborative approach that accommodates diverse learning styles to optimize each members contribution in PjBL.

The relationship between learning styles and gender shows potential differences in collaboration patterns, which may reflect the diverse distribution of roles in teamwork. Male students with visual learning styles may tend to be strategic planners, whereas female students with auditory preferences may play a significant role in team coordination. However, more research is needed to substantiate these claims and understand the nuances involved,

as findings in this area can vary and do not imply superiority of one group over another (Wahyuni et al., 2023). Strategies such as role allocation based on individual strengths and role rotation systems have been identified as effective methods to foster participation and equalize learning experiences in PjBL environments (Khamphaya et al., 2022). Additionally, this approach promotes inclusive collaboration and can enhance the development of interpersonal and cognitive skills across different learning styles and genders.

Qualitative findings suggest that diverse cognitive styles influence the dynamics of collaboration in PjBL, affecting roles, communication strategies, and teamwork effectiveness (Harjono et al., 2024). Visual cognitive styles can assist in structuring information, auditory styles may enhance engagement through discussions, and kinesthetic styles contribute to hands-on applications in learning environments (Cintamulya et al., 2024). However, this diversity can also pose challenges, including variations in students work preferences and potential communication barriers among team members (Achilla et al., 2024). Prior research indicates that differences in cognitive styles can affect how individuals process and convey information, potentially hindering effective collaboration if not managed appropriately (Luo, 2023). Consequently, an adaptive approach that integrates structured planning, verbal discussion, and practical activities is essential to bridge cognitive differences and optimize learning collaboration.

Gender dynamics further influence collaboration, shaping task delegation and decision-making processes. Male students tend to focus on efficiency and execution, emphasizing task completion and achievement (Sukumaran et al., 2023). Conversely, female students place greater importance on group cohesion and inclusive discussions, seeking to foster an environment of collaboration and cooperation (Lailiyah et al., 2021). However, these tendencies are subject to context and adaptability, with students modifying their roles based on varying learning styles and situational demands (Selvaratnam et al., 2024; Yeo et al., 2022). Male kinesthetic learners may favor trial-and-error approaches that align with action-oriented tendencies (Fu & Santello, 2015), whereas female auditory learners might prefer structured discussions before task execution, highlighting their verbal strengths and inclination towards interpersonal interactions (Jacobs & Castek, 2022). Encouraging open dialogue about collaboration preferences and promoting flexible role distribution can foster more equitable teamwork, ensuring balanced contributions from all members.

Although diverse learning styles offer various advantages in PjBL, students frequently encounter obstacles in harmonizing their collaborative processes, which may result in suboptimal communication and inefficiencies in task execution (Rasyid & Khoirunnisa, 2021; Tegeh et al., 2023). Variations in cognitive approaches, such as the contrast between students who favor systematic planning and those inclined toward spontaneous, action-oriented strategies, can lead to mismatches in workflow and coordination (Janssen et al., 2010). Additionally, Research indicates that male students frequently adopt more assertive decision-making styles, while female students are inclined toward strategies that promote consensus and inclusivity. This divergence in communication tendencies can foster participation imbalances if left unchecked, as male assertiveness may overshadow female contributions in discussions (Hossain et al., 2024; Tittler & Wade, 2022). In response to these challenges, effective teams often adopt adaptive strategies, such as rotating roles, conducting structured reflective discussions, and integrating multimodal learning techniques that align with the groups diverse cognitive preferences (Lee et al., 2015). Establishing explicit communication protocols and fostering equitable decision-making practices are essential to bridging stylistic differences, thereby enhancing group cohesion and optimizing collaborative outcomes (Cen et al., 2014).

To create a more inclusive PjBL environment, instructional strategies should accommodate diverse learning preferences while promoting equitable participation. The integration of multimodal learning techniques, such as visual aids, interactive discussions, and hands-on activities, has been shown to enhance engagement and learning outcomes among students with diverse cognitive styles (Sutrisno et al., 2024). Digital collaboration tools also support inclusivity by enabling asynchronous and synchronous contributions, allowing students to participate in ways that align with their individual strengths (Susiyawati et al., 2024). Furthermore, structured reflection sessions can be effective in helping learners evaluate group processes, improve communication, and build self-regulated learning strategies. However, specific empirical support for this aspect may be limited (Lakshmi V et al., 2024). By fostering role flexibility and inclusive communication practices, educators can optimize PjBL for diverse learners,

ensuring both individual and collective success.

The study further emphasizes that PjBLs effectiveness is not solely dependent on cognitive ability but also on the synergy between learning preferences and group dynamics. When diverse learning styles are integrated effectively, they contribute to a more enriched collaborative experience, fostering deeper engagement and higher-quality project outcomes. These insights suggest that future research should explore additional mediating factors, such as self-regulation and motivation, to provide a more comprehensive understanding of how learning styles influence collaborative success in PjBL contexts. This study complements previous research on gender differences in learning styles while extending the understanding to Project-Based Learning contexts. Unlike prior studies focused on traditional instructional methods, it demonstrates how gender-based learning preferences influence collaboration, role allocation, and communication in PjBL. By providing empirical evidence from diverse learning environments, this research supports existing findings while offering new insights into designing inclusive and effective teamwork strategies in project-based learning settings.

4.　CONCLUSION

This study reveals that learning styles significantly influence collaborative effectiveness in Project-Based Learning (PjBL) across genders. Male students tend to perform better in collaborative planning and idea organization through visual strategies, while female students achieve greater success through auditory approaches, especially in coordination and verbal communication. Kinesthetic learners of both genders actively contribute during the implementation phase but face challenges in abstract or preparatory tasks. These findings emphasize the need for inclusive instructional strategies that accommodate diverse learning preferences to ensure balanced and effective collaboration in PjBL environments.

Future research should involve more diverse populations and employ longitudinal approaches to capture the dynamic nature of learning styles over time. Further exploration of mediating factors, such as motivation, self-regulated learning, and technological facilitation, is also recommended to deepen understanding of how learning styles and gender interact to shape collaborative success in PjBL settings.

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