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PROJECT-BASED LEARNING, LEARNING STYLES, & CAMPUS ENVIRONMENT AS PREDICTORS OF PASSAGE PLANNING COMPREHENSION

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Abstract: This study aimed to determine the effects of Project-Based Learning and learning styles on students' comprehension of passage planning, with campus environment as a moderating variable. The research was conducted among Nautical Study Program students from Politeknik Pelayaran Sumatera Barat and Politeknik Ilmu Pelayaran Semarang, involving Semester 2 and Semester 4 students. A quantitative causal-comparative design was employed, and the data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The sample consisted of 684 respondents selected through quota sampling. The results showed that Project-Based Learning has a positive and significant effect on passage planning comprehension, learning styles also have a positive and significant effect, and campus environment directly influences passage planning comprehension. However, campus environment did not significantly moderate the relationship between Project-Based Learning and passage planning comprehension, nor between learning styles and passage planning comprehension. The findings indicated that active, student-centered learning and alignment with students' preferred learning styles were important determinants of comprehension in maritime navigation learning. The study implied that maritime vocational institutions should strengthen project-based instructional strategies and provide learning experiences that accommodate diverse learning styles, while continuing to improve campus facilities and learning support systems to enhance students' understanding of passage planning.

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INTRODUCTION

Understanding passage planning is a fundamental competency for students in the Nautical Study Program because it forms an essential part of their readiness before going to sea (Sharif et al., 2024; Al-mekhlafi et al., 2025). In maritime practice, a prospective navigation watch officer must be able to develop a safe, efficient voyage plan that complies with international safety procedures. The ability to understand passage planning is not only related to mastering navigational theory, but also to applying navigational principles in real shipboard situations (Xue et al., 2024; Xiong, 2025). Therefore, nautical students need to master this subject from the early stages of their education so that they possess adequate academic and professional preparation (Yi et al., 2025; Ghosh & Emad, 2025). In this regard, passage planning comprehension becomes an important foundation for developing students' maritime competence before entering the shipping industry.

However, the level of students' comprehension of passage planning still varies across learners at Poltekpel Sumbar & PIP Semarang. Based on interviews with three (3) lecturers teaching passage planning at PIP Semarang, students were found to still experience difficulties in understanding navigation calculation formulas on the Mercator chart and were not always careful when entering data into navigation software, which consequently meant that the implementation of the passage plan remained suboptimal. Another finding, based on interviews with two (2) lecturers teaching passage planning in the Nautical Studies Department at Poltekpel Sumbar, indicated that out of 145 students who took the practical passage planning examination in the form of a Focus Group Interview (FGI), some students still required additional explanation from the lecturers and had to undertake remedial practice in passage planning using the nautical simulator. In addition, some students experience difficulty in connecting theoretical explanations with practical navigation tasks, especially when learning is dominated by conventional instruction. This condition showed that passage planning is not always understood optimally, even though it is a core subject in maritime education. Such a gap indicated that students' comprehension is influenced not only by the subject matter itself, but also by the learning process and the surrounding academic environment.

To address this issue, student-centered instructional strategies are needed to support deeper understanding. One possible solution is Project-Based Learning, which enables students to engage actively in preparing, analyzing, and completing tasks that resemble real navigation conditions (Wiyono et al., 2025; Ashraf et al., 2025). Through this approach, students are expected to understand voyage planning stages in a more concrete and applicable way, thereby linking navigational concepts with practical field applications (García-llamas et al., 2025; Garay-rondero & Issa-zadeh, 2025). In addition, students' learning styles are important because each learner has a different way of receiving, processing, and retaining information (Gangadharan et al., 2025; Baradziej et al., 2026). The campus environment also plays a vital role because adequate facilities,

laboratories, simulators, and academic climate can strengthen students' learning engagement and facilitate the application of theory into practice (Yanti et al., 2025; Hasnur & Yatno, 2025). The campus environment is positioned as a moderating variable because it may strengthen or weaken the effect of Project-Based Learning and learning styles on passage planning comprehension.

Previous studies have extensively examined Project-Based Learning, learning styles, and learning environment in relation to various learning outcomes; however, only a limited number of studies have specifically positioned passage planning as an object of nautical students' comprehension (Gibson & Warren, 2025). In addition, few studies have simultaneously tested these three variables within the context of maritime vocational education (Adhinugraha et al., 2024; Munif & Sulaiman, 2023). A research gap is also evident because relatively few studies have placed campus environment as a moderating variable in the relationship between Project-Based Learning and learning styles and passage planning comprehension (Mashartanto et al., 2024; Kurniawan et al., 2025). At the same time, comparative studies involving students from two different maritime institutions remain scarce (Wahl & Hybertsen, 2025; Mojafi & Westhuizen, 2025). These findings show that the present study is grounded in both empirical and contextual gaps.

The urgency of this research lies in the need to improve the quality of maritime learning so that nautical students can achieve stronger conceptual understanding and practical readiness. From an educational perspective, this study also highlights the importance of moderation in academic research because learning achievement is often shaped by interactions among pedagogy, learner characteristics, and the campus climate. The novelty of this study lies in integrating Project-Based Learning, learning styles, and campus environment into a single analytical model to explain passage planning comprehension among nautical students. This combination provides a more comprehensive explanation of how instructional, personal, and contextual factors work together in maritime education.

Based on the foregoing discussion, this study aims to analyze the influence of Project-Based Learning and learning styles on passage planning comprehension among students in the Nautical Study Program. This study also aims to examine the moderating role of campus environment in strengthening or weakening the relationships among these. Specifically, the research focuses on students from Politeknik Pelayaran Sumatera Barat and Politeknik Ilmu Pelayaran Semarang, particularly those in Semester 2 and Semester 4 who are beginning to study core navigational subjects, including passage planning. Thus, this research seeks to provide an evidence-based explanation of passage planning comprehension in maritime vocational education. Specifically, the research objectives are to address the following hypotheses: (1) Project-Based Learning on students' Passage Planning Comprehension, (2) Learning Styles on students' Passage Planning Comprehension, (3) Campus Environment on students' Passage Planning Comprehension, (4) Campus Environment moderates the effect of Project-Based Learning on students' Passage Planning

Comprehension, and (5) Campus Environment moderates the effect of Learning Styles on students' Passage Planning Comprehension.

RESEARCH METHOD

This study employed a quantitative causal-comparative design with path analysis based on Partial Least Squares Structural Equation Modeling (PLS-SEM) (Lestari et al., 2025). This analysis aimed to test the effects of project-based learning and learning styles on students' passage planning comprehension, as well as the moderating role of campus environment in moderating the effects of these two exogenous variables on the endogenous variable. The research instrument was a closed-ended questionnaire using a 5-point Likert scale (1 = Strongly disagree to 5 = Strongly agree) (Domínguez-figaredo & Gil-jaurena, 2025). The questionnaire consisted of four latent constructs: Project-Based Learning (PjBL) (5 indicators), Learning Styles (LS) (5 indicators), Passage Planning Comprehension (PPC) (5 indicators), and Campus Environment (CE) (5 indicators), with a total of 20 items. The items were developed based on a literature review and theories relevant to each variable and were adapted to the context of students at Poltekpel Sumbar and PIP Semarang. The questionnaire blueprint is presented in Table 1.

Table 1. Pilot Test Questionnaire

No.	Variable	Indicator	Code
1	Project-Based Learning (X1) Adapted from: (Novalia et al., 2025)	The lecturer gives me a challenging initial question or problem before the project begins.	PjBL1
		I am involved in systematically planning the project work.	PjBL2
		Project activities help me organize work stages and deadlines more effectively.	PjBL3
		I monitor and evaluate the progress of the project during the learning process.	PjBL4
		The project outcomes encourage me to test, revise, and improve my understanding of the material.	PjBL5
2	Learning Styles (X2) Adapted from: (Ferrer-Valdivia et al., 2025)	I understand the material more easily through pictures, diagrams, maps, or visual simulations.	LS1
		I understand the material more easily when the lecturer explains it orally and I can discuss it.	LS2
		I learn more easily when there is hands-on practice, demonstration, or task simulation.	LS3
		I remember the material more easily when reading text, notes, or written guides.	LS4
		I learn more effectively when the way the material is delivered matches my preferred learning style.	LS5
3	Passage Planning Comprehension (Y) Adapted from: (Xie et al., 2026)	I understand the objectives and main steps in preparing a passage plan.	PPC1
		I can correctly read and interpret nautical charts, navigation symbols, and route information.	PPC2
		I am able to identify navigational hazards and consider them in voyage planning.	PPC3
		I understand the importance of navigation rules and safety when preparing a passage plan.	PPC4
		I am able to adjust a passage plan based on weather conditions, currents, vessel traffic, and updated	PPC5

		navigational information.	
4	Campus Environment (M) Adapted from: (Ninnemann et al., 2026)	The learning facilities on my campus support the learning process effectively.	CE1
		The classroom and study environment on my campus are comfortable for attending lectures.	CE2
		My campus provides adequate access to technology and learning resources.	CE3
		I feel that the campus environment supports safety and order during learning.	CE4
		The campus atmosphere encourages me to be active, focused, and engaged in learning.	CE5

Source: Pilot Test Instrument (2026)

The population of this study consisted of Semester 2 and Semester 4 students in the Nautical Study Program at Poltekpel Sumbar and PIP Semarang in the 2025/2026 academic year, with a total of 720 students. Semester 2 and Semester 4 students were selected because Passage Planning is only taught in those semesters in the Nautical Study Program, making them the most relevant group. This study was conducted during the even semester, which corresponds to the period when these courses are delivered and the target respondents were actively enrolled in them. Sampling was conducted using quota sampling, namely 10% for the pilot test sample and 90% for the main study sample (Boujaoude et al., 2025). The pilot test sample consisted of 72 respondents for content validity, preliminary reliability, and item revision purposes. The main study sample consisted of 684 respondents who served as research participants.

Data were collected using a structured questionnaire survey, distributed online via Google Forms (Kunselman, 2024). Respondents were given an explanation of the research objectives, confidentiality assurance, and informed consent for participation (Riyanto et al., 2026). Data validation was conducted using the PLS-SEM outer model assessment, including convergent validity, discriminant validity, and reliability testing, while hypothesis testing was performed through bootstrapping analysis in SmartPLS 3 based on path coefficients, t-statistics, and p-values.

RESULT AND DISCUSSION

Result

Validity & Reliability Test Result

The instrument pilot test was conducted with 72 respondents who were not included in the research sample. Thus, the Product Moment r-table value at a significance level of $\alpha = 0.05$ for $n = 72$ ($df = n - 2$) was 0.2319. The validity criterion was that if the correlation coefficient (r-calculated) of each item was greater than or equal to the r-table value (r-calculated ≥ r-table) at the $\alpha = 0.05$ significance level, then the item was declared valid. The reliability criterion was that if Cronbach's Alpha ≥ 0.7, then all questionnaire items were declared reliable. Validity and reliability testing in this study was conducted using SPSS 24.0. The results are shown in Table 2.

Table 2. Validity and Reliability Testing

No	Variable	Indicator	r-calculated	Validity	Cronbach's Alpha	Reliability
1	Project-Based Learning (X1)	PjBL1	0.863	Valid	0.962	Reliable
		PjBL2	0.684	Valid	0.964	Reliable
		PjBL3	0.690	Valid	0.964	Reliable
		PjBL4	0.463	Valid	0.968	Reliable
		PjBL5	0.862	Valid	0.962	Reliable
2	Learning Styles (X2)	LS1	0.854	Valid	0.963	Reliable
		LS2	0.825	Valid	0.963	Reliable
		LS3	0.841	Valid	0.963	Reliable
		LS4	0.703	Valid	0.964	Reliable
		LS5	0.743	Valid	0.964	Reliable
3	Passage Planning Comprehension (Y)	PPC1	0.808	Valid	0.963	Reliable
		PPC2	0.818	Valid	0.963	Reliable
		PPC3	0.737	Valid	0.964	Reliable
		PPC4	0.890	Valid	0.962	Reliable
		PPC5	0.843	Valid	0.963	Reliable
4	Campus Environment (M)	CE1	0.567	Valid	0.966	Reliable
		CE2	0.682	Valid	0.964	Reliable
		CE3	0.826	Valid	0.963	Reliable
		CE4	0.787	Valid	0.963	Reliable
		CE5	0.727	Valid	0.964	Reliable

Source: SPSS Analysis Result (2026)

All items of the instrument showed r-calculated values ≥ 0.2319, indicating that all items were valid at $\alpha = 0.05$ significance level. Cronbach's Alpha coefficients for each construct were also highly satisfactory (≥ 0.962), indicating high internal consistency and that the instrument was reliable. Thus, the research instrument was suitable for use in the main data collection and subsequent SEM-PLS analysis.

Respondents Demography Result

The demographic distribution of respondents is presented based on campus, semester, gender, and competence level. The frequency and percentage of each category are shown in Table 3.

Table 3. Respondents Demography

Characteristics	Category	Frequency (n)	Percentage (%)
Campus	Poltekpel Sumbar	134	19.6
	PIP Semarang	550	80.4
Semester	2nd	337	49.27
	4th	347	50.73
Gender	Male	197	28.8
	Female	487	71.2
Competence level	D-IV	357	52.19
	D-III	327	47.81
	TOTAL	**684**	**100**

Source: Respondent Characteristics (2026)

Based on Table 3, it can be concluded that the respondents were dominated by students from PIP Semarang, totaling 550 people (80.4%), while respondents from Poltekpel Sumbar numbered 134 people (19.6%). In terms of semester, the distribution of respondents was relatively balanced between Semester 2 and Semester 4, so the data came from two representative learning levels. In terms of gender, the respondents were dominated by female students, totaling 487 people (71.2%), while male students numbered 197 people (28.8%). In addition, the majority of respondents were at the D-IV competence level, totaling 357 people (52.19%), while D-III students numbered 327 people (47.81%). Thus, the research sample showed a fairly diverse composition in terms of academic and demographic characteristics.

PLS Algorithm Test Result

Before testing the structural model, the PLS algorithm was calculated by examining the outer loading values. Outer loadings indicate how strongly each indicator reflects the latent construct, thereby serving as an initial check of indicator reliability and convergent validity. In other words, a high loading means that the item truly measures the intended construct. Ensuring that loadings meet the threshold, generally 0.50–0.70, is important. The outer loading values are shown in Table 4.

Table 4. Outer Loading Result

Indicator	Project-Based Learning (X1)	Learning Styles (X2)	Passage Planning Comprehension (Y)	Campus Environment (M)
PjBL1	0.807			
PjBL2	0.764			
PjBL3	0.774			
PjBL4	0.722			
PjBL5	0.836			
LS1		0.828		
LS2		0.851		
LS3		0.764		
LS4		0.771		
LS5		0.834		
PPC1			0.836	
PPC2			0.765	
PPC3			0.777	
PPC4			0.809	
PPC5			0.800	
CE1				0.719
CE2				0.770
CE3				0.808
CE4				0.816
CE5				0.811

Source: SEM-PLS Result Analysis (2026)

Based on Table 4, all indicators for Project-Based Learning, Learning Styles, Passage Planning Comprehension, and Campus Environment have outer loading values above 0.70, thus meeting the criterion for good convergent validity. This indicates that each statement item strongly and consistently reflects

the latent construct being measured. Therefore, no indicators needed to be eliminated because all exceeded the recommended minimum threshold in PLS analysis. These results confirm that the measurement model has satisfied the initial requirements for proceeding to the structural model test. Next, the values of composite reliability and AVE are presented in Table 5.

Table 5. Reliability & Validity Result

Variabel	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted (AVE)
PjBL (X1)	0.840	0.844	0.887	0.611
LS (X2)	0.869	0.872	0.905	0.657
Moderating Effect 1	0.983	1.000	0.984	0.714
Moderating Effect 2	0.988	1.000	0.989	0.783
PPC (Y)	0.857	0.862	0.897	0.636
CE (M)	0.846	0.858	0.889	0.617

Source: SEM-PLS Result Analysis (2026)

Based on Table 5, it can be concluded that all research variables have Cronbach's Alpha, rho_A, and Composite Reliability values above the recommended minimum threshold, indicating that the instrument is reliable. In addition, all AVE values are greater than 0.50, which shows that each construct meets the criterion for convergent validity. These results confirm that the indicators in the model adequately and consistently explain the latent variables. Thus, the measurement model in this study is deemed suitable for continuation to the structural model testing stage. The next recommended step is to assess discriminant validity before evaluating the structural model and testing the hypotheses. The discriminant validity results are shown in Table 6.

Table 6. Fornell-Larcker Result

	Learning Styles (X2)	Passage Planning Comprehension (Y)	Campus Environment (M)	Project-Based Learning (X1)
LS (X2)	0.810			
PPC (Y)		0.798		
CE (M)			0.786	
PjBL (X1)				0.781

Source: SEM-PLS Result Analysis (2026)

Table 6 shows the square root of AVE for each construct is relatively high, ranging from 0.781 to 0.810, thereby meeting the criterion for discriminant validity. This means that each latent variable is capable of distinguishing itself well from the other constructs in the model. The indicators used are not only convergently valid, but also able to represent their respective constructs specifically without excessive overlap. Therefore, the measurement model in this study has met the discriminant validity requirement and is appropriate for structural model testing and hypothesis testing. The inner model analysis was conducted by examining the R-Square (R^2) value to assess whether the structural relationships provide meaningful practical contribution and to compare or evaluate model improvement. The R-Square (R^2) value is shown below.

Table 7. R-Square Result

	R Square	R Square Adjusted
Passage Planning Comprehension (Y)	0.823	0.822

Source: SEM-PLS Result Analysis (2026)

The R-Square result shows that Project-Based Learning, Learning Styles, and Campus Environment explain 82.3% of the variance in Passage Planning Comprehension ($R^2 = 0.823$). This value falls into the strong category, indicating that the structural model has excellent predictive power in explaining changes in the dependent variable. The remaining 17.7% is influenced by other factors outside this research model. Thus, the model used can be considered highly explanatory and suitable for analyzing the relationships among variables. Next, the F-Square values are shown in Table 8.

Table 8. F-Square Result

	Passage Planning Comprehension (Y)
Campus Environment (M)	0.038
Learning Styles (X2)	0.459
Project-Based Learning (X1)	0.023

Source: SEM-PLS Result Analysis (2026)

Based on Table 8, Learning Styles (X2) has an F-Square value of 0.459, indicating a large effect on Passage Planning Comprehension (Y). Meanwhile, Campus Environment (M) has a value of 0.038 and Project-Based Learning (X1) has a value of 0.023, both of which fall into the small and relatively weak effect categories. These results indicate that the most dominant contribution to changes in passage planning comprehension comes from students' learning styles. Thus, although Project-Based Learning and campus environment also exert influence, their strength is relatively small compared with Learning Styles.

Hypotheses Test Result

The path model from bootstrapping calculation clearly represents the structure of the research hypotheses and shows statistical evidence supporting the proposed theoretical relationships. Figure 1 presents below.

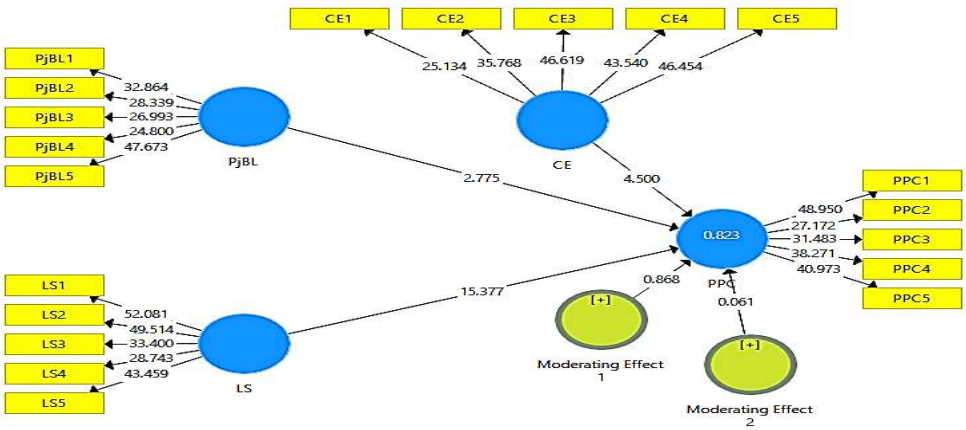

Figure 1. Research Path Model

The bootstrap figure shows that the direct relationship between Learning Styles and Passage Planning Comprehension is the strongest and most significant path, followed by Campus Environment and Project-Based Learning, which also show positive effects on passage planning comprehension. The t-statistics values for these three direct relationships exceed the common significance threshold, thus supporting the main hypotheses of the study. Meanwhile, the two interaction paths for the moderating effects show very small values, indicating that the moderating role of campus environment in the tested relationships was not strong in this model. Overall, the bootstrap model confirms that the hypothesis structure is supported primarily by direct effects, with the largest contribution coming from Learning Styles. To determine whether these relationships are statistically significant, the t-statistics or p-values from the bootstrap results must be examined by the hypothesis testing results.

Table 9. Hypotheses Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
PjBL – PPC	0.125	0.130	0.045	2.775	0.006
LS – PPC	0.628	0.626	0.041	15.377	0.000
CE - PPC	0.150	0.147	0.033	4.500	0.000
CE – PjBL – PPC	-0.046	-0.060	0.053	0.868	0.386
CE – LS - PPC	0.003	0.019	0.054	0.061	0.952

Source: SEM-PLS Result Analysis (2026)

Based on the hypothesis testing results, **H1 is accepted**, indicating that Project-Based Learning has a positive and significant effect on students' Passage Planning Comprehension. **H2 is also accepted**, showing that Learning Styles have a positive and significant effect on Passage Planning Comprehension, and this variable provides the strongest contribution among the predictors. **H3 is accepted**, which means that Campus Environment has a positive and significant effect on students' Passage Planning Comprehension. However, **H4 is rejected** because Campus Environment does not significantly moderate the effect of Project-Based Learning on Passage Planning Comprehension, and **H5 is also rejected** because Campus Environment does not significantly moderate the effect of Learning Styles on Passage Planning Comprehension. Thus, the findings confirm that Project-Based Learning, Learning Styles, and Campus Environment each directly influence Passage Planning Comprehension, but Campus Environment does not function as a moderating variable in the tested relationships.

Discussion

A Positive and Significant Effect of Project-Based Learning on Students' Passage Planning Comprehension

The results of this study show that Project-Based Learning has a positive and significant effect on students' passage planning comprehension, so the first hypothesis is accepted. This finding may occur because project-based learning encourages students to learn through direct experience, problem analysis, and

task completion that resembles real shipboard conditions (Rehman et al., 2024). In the context of nautical education, students not only receive theoretical explanations but also practice preparing voyage planning steps systematically (Kong & Roh, 2024). This process helps them understand the relationship between navigational concepts, decision-making, and maritime safety (Uddin & Siska, 2026). Thus, Project-Based Learning is a relevant approach to strengthening students' understanding of passage planning material. These results are consistent with previous studies showing that project-based learning can improve engagement, conceptual understanding, and the ability to apply knowledge in practical situations (Hasnur et al., 2026). The similarity lies in the finding that learning activities requiring active participation can generate deeper understanding than passive learning (Wart et al., 2025 and Tusher et al., 2026).

Based on this research findings, the authors argue that Project-Based Learning is an effective instructional approach for improving students' passage planning comprehension because it places learners in active, problem-solving situations that require them to connect navigational concepts with practical application. Through project tasks that resemble authentic shipboard conditions, students are encouraged to analyze problems, organize voyage-planning steps systematically, and make appropriate decisions based on maritime safety considerations. This learning process enables students to develop a deeper understanding of passage planning than conventional instruction, which often emphasizes theory without sufficient practice. Therefore, the authors conclude that Project-Based Learning is highly suitable for maritime education, particularly for passage planning material that demands the integration of theoretical knowledge and professional skills.

A Positive and Significant Effect of Learning Styles on Students' Passage Planning Comprehension

The results of this study prove that learning styles have a positive and significant effect on students' passage planning comprehension, so the second hypothesis is accepted. This finding indicates that students understand the material more easily when the learning method matches their learning preferences, whether visual, verbal, auditory, or hands-on (Pascu, 2024 and Xu & Soares, 2026). In maritime vocatioal education, learning style compatibility is important because students must process theoretical material and apply it in simulation and practical activities (Plooy et al., 2024; Siska et al., 2025). When learning styles align with learning demands, students tend to be more focused, understand concepts more quickly, and remember important information better (Riyanto et al., 2026). Therefore, learning style is an important internal factor determining the success of passage planning comprehension. These results are similar to several previous studies showing that learning preferences are related to learning outcomes, especially when the teaching process accommodates different ways of receiving information (Guo, 2025). The similarity lies in the finding that learning becomes more effective when the delivery method matches students' characteristics (Sayed et al., 2025 and Kanchon et al., 2024)

The authors state that learning styles significantly influence students' passage planning comprehension because students are able to understand the material more effectively when the learning activities are aligned with their preferred ways of learning. In maritime vocational education, where students must combine theoretical understanding with practical application, the suitability between instructional delivery and individual learning preferences helps students focus better, process information more quickly, and retain important concepts more effectively. This finding shows that learning styles are an important internal factor in supporting the successful comprehension of passage planning, particularly in contexts that require both conceptual knowledge and practical navigational skills. However, this study differs because it places learning styles in the context of maritime education, which requires a greater proportion of practical than theoretical learning. This contextual difference is important because nautical students need a combination of learning styles that are not only reading- and listening-based, but also observation-, practice-, and reflection-oriented in relation to navigational procedures.

A Positive and Significant Effect of Campus Environment on Students' Passage Planning Comprehension

The results of this study indicate that campus environment has a positive and significant effect on students' passage planning comprehension, so the third hypothesis is accepted. This may occur because a supportive campus environment provides facilities, atmosphere, and learning resources that help students understand the material more concretely (Makaremi et al., 2024). In the nautical context, the presence of simulators, navigation laboratories, learning devices, and adequate practice spaces helps students connect theory with real shipboard conditions (Heilporn et al., 2024 and Stavroulakis et al., 2025). A comfortable learning environment also increases students' concentration, motivation, and engagement during the learning process (Rabby et al., 2026). Thus, campus environment functions as an external factor that strengthens students' learning experiences in understanding passage planning. This finding is in line with previous studies emphasizing that the quality of the learning environment has a positive relationship with academic engagement and student learning outcomes (Moges et al., 2025). The similarity lies in the recognition that good facilities and a supportive learning atmosphere encourage better understanding of the material (Munim et al., 2025 and Houweling et al., 2024).

Based on this research finding, the authors state that the campus environment has a significant positive influence on students' passage planning comprehension because a supportive learning environment provides the facilities, atmosphere, and resources needed to help students understand the material more effectively. In maritime vocational education, the availability of simulators, navigation laboratories, practical equipment, and adequate learning spaces enables students to connect theoretical concepts with real operational conditions at sea. A comfortable and well-supported campus environment also increases students' concentration, motivation, and active participation in

learning. Therefore, the campus environment is an important external factor that contributes to the successful comprehension of passage planning. This study is distinctive because campus environment was tested in maritime vocational education, where simulation facilities play a very important role in building learning experience. In other words, the campus environment in this study is not merely a physical space, but also a means of developing professional competence.

The Non-Significant Moderating Effect of Campus Environment on the Relationship between Project-Based Learning and Students' Passage Planning Comprehension

The results show that the moderating effect of campus environment on the relationship between Project-Based Learning and passage planning comprehension is not significant, so the fourth hypothesis is not supported. This may occur because the effect of Project-Based Learning on students' comprehension is already strong directly, so the additional role of campus environment does not further strengthen the relationship statistically variables (Riyadi & Erliyani, 2025; Nazarwin et al., 2025). Another possibility is that the learning projects were designed in such a way that students could understand them even when campus support varied only slightly (Hamidani et al., 2025; Tan et al., 2025). In this context, campus environment functions more as a general supporting factor rather than as a factor that changes the strength of the relationship between PjBL and comprehension (Assefa et al., 2025; Bauer et al., 2025 and Phanphichit & Bartusevičienė, 2025). Thus, campus environment appears to serve as a supporting condition rather than a decisive moderator. This finding is similar to some previous studies showing that contextual variables do not always moderate the relationship between active learning and learning outcomes, especially when the learning method itself is already strong and applied (Tetzlaff et al., 2025). The similarity lies in the fact that core learning factors are often more dominant than environmental factors in explaining learning outcomes (Prichard et al., 2025).

From this finding, the authors state that campus environment does not significantly moderate the relationship between Project-Based Learning and students' passage planning comprehension because the influence of Project-Based Learning appears to be strong enough on its own to improve student understanding. This suggests that the effectiveness of Project-Based Learning is not highly dependent on variations in campus facilities, learning atmosphere, or other environmental conditions. In this context, campus environment functions more as a general supporting factor that contributes to learning, rather than as a variable that changes the strength of the relationship between Project-Based Learning and passage planning comprehension. Therefore, the findings indicate that the direct impact of Project-Based Learning is more dominant than its interaction with the campus environment. This study differs because it examines this moderation among maritime students who have practical and simulation-based learning characteristics. This difference in results indicates that in nautical

education, the direct effect of the learning method may be more prominent than its interaction with campus environment. Future studies are recommended to test moderation using more specific indicators of campus environment, such as simulator quality, intensity of laboratory use, or more measurable practical facility support.

The Non-Significant Moderating Effect of Campus Environment on the Relationship between Learning Styles and Students' Passage Planning Comprehension

The results show that campus environment does not moderate the effect of learning styles on passage planning comprehension, so the fifth hypothesis is also not supported. This may occur because learning style is an internal student characteristic that is relatively stable and tends to work directly on comprehension without being too dependent on campus environment variations (Efranto & Anindita, 2025). In addition, students may already be able to adjust their own learning methods even if campus facilities or atmosphere differ (Fortuna et al., 2025). In this context, campus environment is more likely to act as a standalone factor rather than as a modifier of the relationship between learning styles and comprehension (Chernikova et al., 2025). This result is similar to previous research showing that learning styles often have a direct effect on learning outcomes, but are not always influenced by contextual variables as moderators. The similarity is seen in the tendency for students' learning preferences to work consistently across various learning situations (Keyserlingk et al., 2025; Tlais et al., 2025 and Christopoulos & Stylios, 2024). Therefore, the influence of learning styles appears to be more independent than dependent on campus environmental conditions.

The campus environment does not significantly moderate the relationship between learning styles and students' passage planning comprehension because learning style is an internal characteristic that influences comprehension directly and remains relatively stable across different learning conditions. This indicates that students are generally able to use their preferred learning approaches regardless of variations in campus facilities, atmosphere, or other environmental factors. In this context, campus environment functions more as a general supporting condition than as a variable that changes the strength of the relationship between learning styles and comprehension. Therefore, the findings suggest that the effect of learning styles on passage planning comprehension is more independent than dependent on campus environmental conditions. This study differs because it was conducted in a maritime education context that requires a simultaneous combination of practical and theoretical abilities. This contextual difference may explain why campus environment is not strong enough to alter the relationship between learning styles and passage planning comprehension.

Overall, this study contributes to maritime education by providing empirical evidence that Project-Based Learning, Learning Styles, and Campus Environment each have a significant direct effect on students' passage planning

comprehension, while Campus Environment does not function as a moderating variable in the tested relationships. These findings enrich the literature on nautical learning by showing that passage planning can be improved through active and student-centered instruction, attention to individual learning preferences, and the provision of a supportive academic environment. The results indicate that maritime institutions and lecturers should strengthen project-based and simulation-oriented learning, optimize instructional strategies, and create an effective learning atmosphere to support students' readiness for professional navigation practice.

CONCLUSION

This study demonstrates that Project-Based Learning, Learning Styles, and Campus Environment each have a positive and significant effect on students' understanding of passage planning, while the moderating role of campus environment on the relationships between Project-Based Learning and Learning Styles with passage planning comprehension is not supported. The most important lesson from this research is that maritime students' comprehension of navigation planning is strengthened not only by student-centered instruction but also by the alignment between learning preferences and the learning environment, especially in vocational maritime education where practice and theory must be integrated. Scientifically, this study has an implication to the literature by extending the understanding of passage planning learning through a structural model that combines instructional strategy, learner characteristics, and campus context, while practically it provides evidence for maritime institutions to design more experiential, adaptive, and facility-supported learning environments. However, the findings of this research are limited by the concentration on a specific program, semester level, and geographic context, which may restrict broader generalization. Future research should involve larger and more diverse maritime populations, incorporate additional psychological and instructional variables such as motivation, self-regulated learning, and teaching quality, and explore alternative moderating mechanisms to better explain how passage planning comprehension can be optimized in vocational maritime education.

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