

**Effects of STEAM-PBL on Calligraphy Vocational Skills and Artistic Creativity: Mediating Role of Learning Motivation**Enqi Tang¹, Mohamad Sattar Rasul^{2*}, Nur Atiqah Jalaludin³**ARTICLE INFO****ABSTRACT****Article History:**

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Keywords

STEAM-PBL, Vocational Skills, Artistic Creativity, Learning Motivation, Calligraphy

Background: The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) with Project-Based Learning (PBL) has been recognised as a means of addressing challenges associated with vocational competence and creativity. Within the context of calligraphy, STEAM-PBL provides a framework that combines technical proficiency with artistic innovation. **Objectives:** The present study seeks to evaluate the effectiveness of STEAM-PBL in fostering vocational calligraphy skills and enhancing

artistic creativity, while also investigating the mediating role of learning motivation in the relationship between STEAM-PBL and student outcomes. **Methods:** Data were collected through a structured questionnaire survey administered to 150 participants enrolled in vocational calligraphy courses. Responses were measured on a five-point Likert scale. Statistical analyses, including correlation, regression, and mediation testing, were conducted using SPSS. **Results:** The results demonstrated that STEAM-PBL significantly improved both vocational competencies and creative abilities in calligraphy instruction, with learning motivation serving as a mediator in this relationship. STEAM-PBL exerted a direct positive effect on both technical skills and creativity, and students with higher motivation exhibited enhanced precision and originality. **Conclusion:** The study highlights the potential of STEAM-PBL as an instructional model for developing vocational and creative skills in calligraphy education. Incorporating learning motivation into the teaching process strengthens the influence of STEAM-PBL, thereby offering valuable insights for educators in artistic and creative fields.

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Introduction

In recent years, growing attention has been directed towards the integration of STEAM into teaching strategies, particularly through PBL, as a means of strengthening creativity and vocational competence. The STEAM-PBL model presents considerable potential, as it promotes interdisciplinary learning by combining various fields into experiential problem-

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solving activities. This approach not only facilitates subject knowledge acquisition but also cultivates critical thinking and creative problem-solving abilities (Oner et al., 2016). In vocational education, such integration is especially valuable since it equips students with practical skills applicable in their future professions. Calligraphy, as an art form, provides a distinctive platform for STEAM-PBL because it unites creativity with structured techniques that require a scientific and methodological orientation (Chang et al., 2023).

According to Chang et al. (2023), STEAM-PBL enhances both problem-solving and creative thinking. Similarly, Kuo (2024) observed that students engaged in STEAM-based PBL demonstrated higher levels of creativity in task-oriented activities, as they generated original ideas, approached problems with flexibility, and developed solutions more effectively. These skills are particularly relevant in calligraphy, where technical accuracy and artistic creativity must be combined. The significance of learning motivation in this context has also been highlighted. Jazariyah et al. (2023) argued that motivation serves as a mediator in the success of STEAM-PBL. Motivated learners are more likely to engage deeply with tasks, thereby improving both their technical and creative competencies. Whether intrinsic or extrinsic, motivation plays a pivotal role in enabling students to apply their acquired knowledge in practical contexts. This underscores the importance of investigating how learning motivation influences skill acquisition in calligraphy within a STEAM-PBL framework, as suggested by Hehakaya et al. (2022).

Educational researchers have also sought to simplify the implementation of such innovative methods. Evidence indicates that embedding artistic elements into STEM-based courses enhances cognitive and creative outcomes (Pramashela et al., 2023). This is particularly important in vocational training, where the objective is to prepare learners with applicable workplace skills. The incorporation of arts into STEM activities has further been associated with improved creativity, executive function, problem-solving capabilities, and deeper understanding of theoretical and practical knowledge (Zhang & Jia, 2024). Despite these advancements, the application of STEAM-PBL in the enhancement of calligraphy-related vocational skills remains underexplored. Although previous studies have shown that PBL contributes to creativity and problem-solving in vocational education (García-Llamas et al., 2025), research is lacking on whether STEAM-PBL can effectively support both the technical precision and artistic creativity required in calligraphy. Furthermore, while learning motivation has been recognised as a crucial factor in student engagement and achievement (Indahwati et al., 2023), its mediating role in the relationship between STEAM-PBL, calligraphy skills, and artistic creativity has not been established. The present study aims to address these gaps by examining the impact of STEAM-PBL on calligraphy skills, values, and creative expression, while also assessing the mediating effect of learning motivation.

Research Objectives

1. To determine the effectiveness of STEAM-PBL in strengthening vocational calligraphy skills among students.
2. To analyse the influence of STEAM-PBL on the artistic creativity of calligraphy learners.
3. To investigate the mediating role of learning motivation in the relationship between STEAM-PBL, vocational calligraphy skills, and artistic creativity.

Integrating STEAM-PBL into vocational education represents a constructive approach to strengthening both creative and functional capabilities, particularly in artistic disciplines such as calligraphy. Previous studies indicate that STEAM encourages learners to engage in problem-solving processes that connect theoretical understanding with practical application [Jantakun et al. \(2024\)](#). It has also been shown to foster creativity and innovation, qualities that are fundamental to mastering calligraphy, where precision and artistry in letter formation are indispensable ([Hsiao et al., 2022](#)). Learning motivation is equally significant in this context, as it mediates the effectiveness of STEAM-PBL by maintaining student engagement and active participation in learning activities. Recognising the influence of motivation on integrated learning outcomes provides educators with guidance to design approaches that simultaneously advance creative and cognitive competencies. This research is also important for streamlining teaching practices in calligraphy and other vocational areas that demand both creativity and technical proficiency.

Literature Review

STEAM-PBL Implementation in Enhancing Calligraphy Vocational Skills among Students

STEAM education, when combined with PBL, has emerged as a pivotal approach for strengthening a range of vocational competencies, including those associated with calligraphy. The central aim of this approach is to evaluate the capacity of STEAM-PBL to enhance vocational proficiency, particularly in calligraphy training. STEAM promotes an interdisciplinary framework that fosters the acquisition of 21st-century skills, such as creativity, problem-solving, and critical thinking ([Pahmi et al., 2022](#)). According to [Lazić \(2024\)](#), this educational model has attracted considerable attention, particularly with reference to gifted learners, as it aligns closely with the development of skills considered vital for future labour markets. Extending such practices to vocational disciplines like calligraphy offers substantial potential for improving student learning and skill development. The use of PBL within STEAM learning has been widely documented. [Rizki et al. \(2022\)](#) suggest that PBL enhances learner engagement, facilitates critical analysis, and promotes scientific literacy. These qualities are particularly relevant in vocational contexts, where learners must acquire not only technical expertise but also the ability to synthesise and apply their knowledge in practical settings. In calligraphy, project-based approaches allow students to experience the art as a balance between technical mastery and creative exploration, a point supported by [Astriani et al. \(2023\)](#).

Broader educational initiatives also endorse this integration. [Manizia et al. \(2024\)](#) observe that incorporating the arts into scientific and technological education, as reflected in India's National Education Policy of 2020, has yielded positive outcomes in vocational training. This perspective is transferable to calligraphy, where learners are encouraged to merge traditional practices with contemporary technologies, thereby producing innovative and original outcomes. Interdisciplinary learning has additionally been recognised as a driver of 21st-century competencies. [Yang and Cheng \(2023\)](#) emphasise that transcending disciplinary boundaries equips learners with a global outlook, a vital aspect of professional training in calligraphy, which demands both precision and creativity. Likewise, [Sokolova et al. \(2025\)](#) underline that advances in STEM have increasingly acknowledged the

contribution of the arts, reinforcing the argument that STEAM is indispensable for the development of vocational disciplines such as calligraphy.

The integration of technology into STEAM also generates innovative opportunities for education. Kangas et al. (2022) highlight that digital tools and platforms, when applied in this context, can enrich both practice and artistic creativity in calligraphy. In a similar vein, Megawati (2024) notes that incorporating PBL within STEAM has proven effective in enhancing practical skills across a variety of fields, a finding that can be extended to the study of calligraphy. Consequently, the adoption of STEAM-PBL within vocational calligraphy instruction may advance both the technical precision and creative artistry required in the profession. This model is consistent with global trends in vocational education, where dynamic teaching approaches are increasingly emphasised to support flexibility and innovation. Rajamanickam et al. (2025) affirm that combining interdisciplinary instruction with project-based learning strengthens vocational education by offering a more holistic and effective pathway to acquiring skills demanded in modern industries. In this respect, the application of STEAM-PBL to calligraphy represents both a continuation of traditional pedagogical principles and an evolution towards more adaptive and forward-looking educational practices.

STEAM-PBL on Artistic Creativity in Calligraphy Students

Extensive research consistently demonstrates that both project-based learning and STEAM contribute significantly to the development of creative thinking. Pramashela et al. (2023) emphasise that creativity and problem-solving are indispensable abilities for learners engaged in artistic fields such as calligraphy, and that STEAM within PBL provides an effective structure to support these skills. By integrating multiple subject areas, STEAM allows students to approach projects from varied perspectives, offering opportunities to express creativity through artistic forms. Similarly, Mf and Palennari (2024) illustrate that applying STEAM to PBL positively influences students' problem-solving capabilities, thereby fostering greater creativity in artistic production.

Suchikova and Kovachov (2024) propose a STEAM framework that blends artistic methods with scientific and technological understanding. Their exploration of nanoart demonstrates how aesthetic and scientific dimensions can converge to produce innovative and adaptable creative outcomes. This perspective is particularly relevant to calligraphy, where modern technologies may be integrated with traditional practices to expand expressive possibilities and generate new artistic directions. The interdisciplinary nature of STEAM also advances collaboration and real-world problem-solving. Santi et al. (2021) argue that STEAM encourages not only critical thinking but also cooperative learning, enabling calligraphy students to integrate artistic practices with knowledge from other domains, thereby strengthening both creative capacity and technical expertise. Wei et al. (2023) further note that the design of instructional aids in STEAM supports creativity by introducing innovative tools and methodologies, which can be directly applied to advancing artistic skill in calligraphy.

Technology has also been identified as a catalyst for creativity within STEAM. Leavy et al. (2023) contend that emerging technologies significantly enhance creative practice, a view echoed by Yilmaz (2021), who argues that creative pedagogy thrives in technology-enriched learning environments. Within calligraphy, digital platforms provide students with the means to explore diverse stylistic techniques and expand their creative repertoire.

Moreover, STEAM has been shown to encourage artistic expression within multidisciplinary learning. Duong et al. (2024) highlight that STEAM creates conditions for students to channel their creativity into innovative forms of artistic practice, which aligns well with vocational contexts. Lestari (2021) also identifies creativity as a central component of 21st-century skills promoted through STEAM, a priority in vocational education such as calligraphy. Finally, Hussin et al. (2019) demonstrate that PBL, even in fields such as robotics, enhances students' capacity to devise creative problem-solving strategies. This finding can be applied to calligraphy, where learners refine their artwork through iterative problem-solving and critical thinking processes.

Learning Motivation as a Mediator Between STEAM-PBL and Students' Calligraphy Vocational Skills and Artistic Creativity

Research has demonstrated that intrinsic motivation plays a crucial role in shaping creative thinking, a skill particularly important for calligraphy students as it enhances innovation and the ability to showcase artistic talent. Aditya and Suparman (2023) highlights that motivated learners are more inclined to challenge conventions and engage more profoundly with their craft, which contributes to the development of creative thinking in educational contexts. Similarly, Santillán Aguirre et al. (2020) point out that the interdisciplinary nature of the STEAM methodology supports creativity by exposing learners to a wide array of tools and perspectives. This approach can be applied to calligraphy education, where creativity is central to integrating traditional methods with contemporary artistic expression.

Within STEAM, PBL emerges as a particularly effective strategy for developing creativity and problem-solving skills. A comparative study by Herlambang et al. (2024) demonstrates that PBL fosters creativity more effectively than problem-based learning, as it allows learners to cultivate creative abilities through practical engagement. For calligraphy students, participation in project-based tasks that demand both artistic and technical skills can significantly strengthen their ability to create complex, multi-dimensional designs. Motivation acts as a driving force in this context, encouraging learners to invest deeply in their projects and enhancing their creative performance. The interaction between teacher expertise, student motivation, and learning outcomes also deserves attention. Abd Aziz et al. (2020) argue that the teacher's mastery of PBL strategies influences the effectiveness of its implementation, as motivated learners with open attitudes towards the process benefit more from guided support in creative tasks. In calligraphy education, this relationship becomes evident when educators apply STEAM concepts using appropriate instructional methods and resources, thereby motivating learners and fostering the growth of artistic skills.

Gamification has also been identified as a valuable tool for strengthening motivation in STEAM-based creative disciplines. Jantakoon et al. (2024) emphasise the role of gamified approaches in enhancing student engagement, which subsequently leads to higher levels of creativity and skill development. For calligraphy learners, gamified objectives encourage experimentation with diverse styles and techniques, supporting both risk-taking and artistic growth. In a related perspective, Farantika et al. (2024) recommend the design of multiliteracy-oriented learning environments that stimulate both motivation and creativity. By offering varied resources and experiences, educators can enhance students' intrinsic drive to explore artistic practices such as calligraphy, ultimately leading to improved creative and technical outcomes. The contribution of PBL to collaboration and

creative expression has also been recognised in STEM contexts. Rochman et al. (2024) highlight that this method strengthens both teamwork and creativity, qualities that are equally relevant to calligraphy education, where peer collaboration enriches the artistic process. Nurwidodo et al. (2024) further support this by noting that problem-based approaches also cultivate collaborative abilities, which are essential for students engaged in joint calligraphy projects aimed at advancing creativity and skill.

Furthermore, the integration of digital tools into STEAM learning has been shown to promote creativity and motivation. Naufal et al. (2025) demonstrate that digital platforms can broaden students' opportunities for artistic exploration, which is particularly advantageous for calligraphy students working with diverse designs and techniques. In support of this, Nuraini et al. (2023) argue for the use of technology in PBL, showing its capacity to increase motivation and improve learning outcomes within artistic education. Additionally, Hue (2021) notes that flipped learning, when embedded within PBL, enhances creativity by granting students greater autonomy in concept exploration and subsequent application in collaborative projects. For calligraphy learners, this approach fosters self-directed learning, enabling them to experiment with varied techniques and expand their artistic capabilities. By combining motivation with innovative pedagogical strategies such as PBL, gamification, and digital integration, learners not only strengthen their vocational training but also refine the artistic and creative skills necessary for excellence in calligraphy.

Literature Gap

While STEAM-PBL has been widely examined in vocational education, particularly in relation to creativity and technical skill development, certain gaps remain concerning its application in calligraphy instruction. Although Pahmi et al. (2022) and Lazić (2024) highlight the significance of STEAM in cultivating 21st-century competencies, the literature provides limited insight into how these principles can be tailored to the vocational context of calligraphy. Similarly, the contributions of PBL to enhancing critical thinking and scientific literacy, as noted by Rizki et al. (2022) and Astriani et al. (2023), do not sufficiently address the pedagogical strategies necessary to meet the specific needs of calligraphy learners within a STEAM-PBL framework. The integration of emerging technologies into calligraphy education also remains insufficiently explored. Although Leavy et al. (2023) and Naufal et al. (2025) recognise the potential of digital tools in shaping learning, there is little investigation into their influence on artistic creativity when applied to calligraphic practice. Furthermore, while motivation has been acknowledged as a key mediating factor in PBL (Aditya & Suparman, 2023; Hue, 2021), further research is required to clarify how it shapes both creative development and vocational outcomes for students engaged in calligraphy.

Hypothesis Development

H1: STEAM-PBL implementation has a positive effect on the development of calligraphy vocational skills among students.

H2: STEAM-PBL implementation has a positive effect on artistic creativity in calligraphy students.

H3: Learning motivation mediates the relationship between STEAM-PBL implementation and students' calligraphy vocational skills.

H4: Learning motivation mediates the relationship between STEAM-PBL implementation and students' artistic creativity.

Conceptual Framework

Figure 1 presents the conceptual framework linking STEAM-PBL, learning motivation, calligraphy vocational skills, and artistic creativity. The model proposes that STEAM-PBL exerts a positive influence on both vocational skills and creativity (H1, H2), while learning motivation functions as a mediating factor in these relationships (H3, H4).

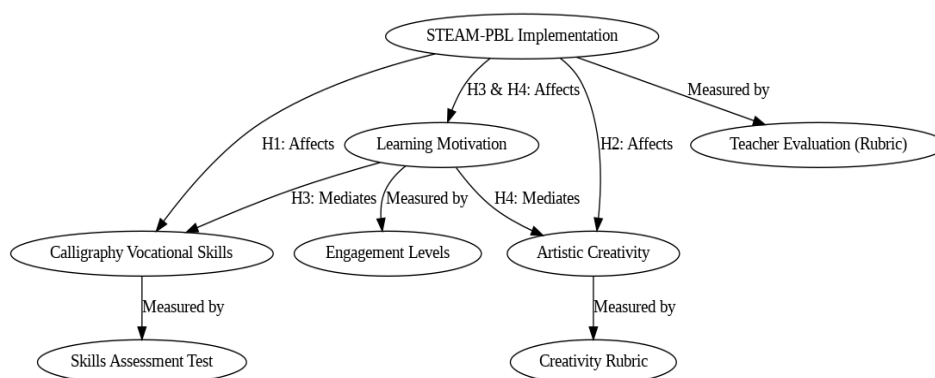


Figure 1: Conceptual Framework

Methodology

Research Methods and Design

This study employed a quantitative research design to examine the influence of STEAM-PBL on vocational calligraphy skills and artistic creativity. This approach was chosen because it enables an objective assessment of the relationships between the independent variable (application of STEAM-PBL) and the dependent variables (vocational calligraphy skills and artistic creativity). Data were collected through a questionnaire survey, which facilitated a comprehensive evaluation of participants' experiences with STEAM-PBL, their development of calligraphic and creative abilities, and their level of engagement in the learning process. A five-point Likert scale was applied to measure students' perceptions of STEAM-PBL and their motivation to learn.

Data Collection Methods

The principal data collection instrument was a structured questionnaire designed to address four central constructs: STEAM-PBL implementation, learning motivation, calligraphy vocational competence, and artistic creativity. The instrument employed a Likert scale format, enabling participants to express graded levels of agreement or disagreement with statements reflecting these domains. The items were formulated to capture students' evaluations of STEAM-PBL practices within calligraphy instruction, their motivational engagement during the learning process, perceived enhancement of technical

calligraphic ability, and the extent of creativity expressed in project-based outputs. To ensure alignment with the research objectives, participants were selected through purposive sampling, focusing exclusively on those engaged in STEAM-PBL-oriented calligraphy curricula. This approach generated empirically grounded data that facilitated a rigorous quantitative assessment of STEAM-PBL's effectiveness in shaping student outcomes.

Sampling Technique

A purposive sampling strategy was employed to recruit 150 participants enrolled in vocational calligraphy programmes that explicitly integrated STEAM-PBL. This sampling approach was deemed appropriate as it facilitated the deliberate selection of individuals possessing characteristics directly aligned with the research objectives, namely prior engagement with STEAM-PBL within calligraphy instruction. Such targeted selection ensured that respondents possessed the requisite experiential background to provide meaningful insights into the study's focal constructs. The sample size of 150 was considered methodologically robust, offering sufficient statistical power to produce reliable findings and enabling a degree of generalisability to the wider population of vocational calligraphy learners.

Samples

The study sample comprised 150 students enrolled in vocational calligraphy programmes where STEAM-PBL was systematically incorporated into instructional practice. Participants were drawn from multiple educational institutions offering calligraphy within their vocational curricula, ensuring representation across diverse learning environments. The cohort included both male and female students spanning a range of age groups, thereby enhancing the representativeness of the responses and supporting the generalisability of the findings. Eligibility criteria required prior exposure to STEAM-PBL, with participants having completed at least one academic term under this instructional approach. Consequently, the sample was considered an appropriate reflection of the broader population undertaking vocational calligraphy training through STEAM-PBL.

Data Analysis Technique

The relationships between the independent variable (STEAM-PBL implementation), the mediating variable (learning motivation), and the dependent variables (calligraphy vocational skills and artistic creativity) were examined using data derived from the questionnaires and analysed with the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were employed to summarise the demographic characteristics of the participants, thereby providing an overview of the dataset. To establish the internal consistency of the measurement instruments, reliability analysis was performed, with Cronbach's alpha computed to confirm the adequacy of the administered scales. Pearson's correlation analysis was applied to assess the strength, direction, and significance of associations among the study variables. The influence of STEAM-PBL implementation on the dependent variables was further evaluated through multiple regression analysis, while

mediation analysis was conducted to determine the extent to which learning motivation mediated the observed relationships.

Ethical Consideration

The study was conducted in full compliance with established ethical standards. Participants were informed of the research objectives, assured that their involvement was entirely voluntary, and notified that confidentiality would be maintained throughout. Informed consent was secured prior to participation, with guarantees of anonymity and the use of responses exclusively for academic purposes. Participants were also informed of their right to withdraw from the study at any stage without consequence. Overall, the research process adhered to recognised ethical guidelines, thereby safeguarding the dignity, privacy, and rights of all respondents.

Findings

Data from 150 participants were obtained through a structured questionnaire to investigate the interrelationships among STEAM-PBL implementation, learning motivation, and calligraphy vocational skills. Descriptive statistical analysis demonstrated moderately positive associations among the variables. Regression results indicated that STEAM-PBL exerted a significant effect on learning motivation, which subsequently influenced calligraphy vocational skills. Mediation analysis further confirmed that learning motivation served as a significant intermediary in the relationship between STEAM-PBL and calligraphy vocational skills. All statistical procedures were performed using SPSS, ensuring robustness, reliability, and accuracy in the findings.

Demographics

Table 1 presents data from 150 valid respondents, with no cases of missing values. The demographic variables examined include gender, educational background, place of origin, and age group. As shown in Table 2, 34 percent of respondents identified as male, 32 percent as female, while 34 percent chose not to disclose their gender. The overall sample size remained 150, with no missing responses, and the percentages cumulatively accounted for 100 percent. Table 3 indicates that 36.7 percent of respondents reported a high school level of education, 35.3 percent were graduates, and 28 percent were undergraduates. Similar to the gender distribution, the total sample consisted of 150 respondents, with complete data coverage and percentages summing to 100 percent.

Table 1

Frequency Distribution of the Respondents

		Statistics			
		Gender	Educational Background	Place of Origin	Age Group
N	Valid	150	150	150	150
	Missing	0	0	0	0

Table 2

Frequency Distribution of Gender of the Respondent

		Gender			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	48	32.0	32.0	32.0
	Male	51	34.0	34.0	66.0
	Prefer not to Say	51	34.0	34.0	100.0
	Total	150	100.0	100.0	

Table 3

Frequency Distribution of Education Background of the Respondents

		Educational Background			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Graduate	53	35.3	35.3	35.3
	High School	55	36.7	36.7	72.0
	Undergraduate	42	28.0	28.0	100.0
	Total	150	100.0	100.0	

Table 4 indicates that 32 percent of the respondents originated from the Western region, 24 percent from the Northern region, 22.7 percent from the Eastern region, and 21.3 percent from the Southern region. The total number of participants was 150, with complete data and no missing responses. Table 5 demonstrates that 31.3 percent of respondents were aged 46 years and above, 25.3 percent fell within the 26–35 age group, 22 percent were between 36–45 years, and 21.3 percent were within the 18–25 age group. As with the other demographic variables, the total sample comprised 150 participants, all data were valid, and percentages added up to 100 percent.

Table 4

Frequency Distribution of the Place of Origin of the Respondents

		Place of Origin			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Eastern	34	22.7	22.7	22.7
	Northern	36	24.0	24.0	46.7
	Southern	32	21.3	21.3	68.0
	Western	48	32.0	32.0	100.0
	Total	150	100.0	100.0	

Table 5

Frequency Distribution of the Age Group of the Respondents

		Age Group			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-25	32	21.3	21.3	21.3
	26-35	38	25.3	25.3	46.7
	36-45	33	22.0	22.0	68.7
	46 and above	47	31.3	31.3	100.0
	Total	150	100.0	100.0	

Reliability Analysis

The Cronbach's alpha coefficient of 0.743 demonstrates an acceptable level of internal consistency across the 20 questionnaire items, confirming that the scale employed in this study is a reliable measure of the targeted constructs (Table 6).

Table 6

Reliability Test

Reliability Statistics	
Cronbach's Alpha ^a	N of Items
.743	20

Correlation Analysis

Table 7 demonstrates that all variables exhibit moderate positive correlations, with statistical significance at $p = .000$. The implementation of STEAM-PBL shows a moderate positive relationship with calligraphy vocational skills ($r = .436$) and artistic creativity ($r = .518$). Learning motivation is likewise positively correlated with all three constructs, reflecting a strong degree of interconnectedness. These findings provide empirical support for the proposed hypotheses concerning the relationships among the variables (Table 7).

Table 7

Correlation Analysis

	STEAM-PBL Implementation	Calligraphy Vocational Skills	Artistic Creativity	Learning Motivation
STEAM-PBL Implementation	Pearson Correlation	1	.436	.518
	Sig. (2-Tailed)		.000	.000
Calligraphy Vocational Skills	Pearson Correlation	.436	1	.379
	Sig. (2-Tailed)	.000		.000
Artistic Creativity	Pearson Correlation	.518	.379	1
	Sig. (2-Tailed)	.000	.000	
Learning Motivation	Pearson Correlation	.472	.332	.410
	Sig. (2-Tailed)	.000	.000	.000

Regression Analysis

Model 1

The model summary reveals a strong positive correlation between STEAM-PBL implementation and the outcome variable ($R = 0.690$). The model accounts for 47.6 percent of the variance ($R^2 = 0.476$), with an adjusted R^2 value of 0.472, indicating a stable and reliable model fit. Furthermore, the standard error of 0.7100 suggests a satisfactory level of predictive accuracy (Table 8). The ANOVA results indicate that the regression model is

statistically significant ($F = 59.24, p = .000$), demonstrating that STEAM-PBL implementation is a significant predictor of calligraphy vocational skills. The high F-value, coupled with the extremely low p-value, confirms that the model accounts for a substantial proportion of the variance in vocational skill development (Table 9). The coefficients analysis demonstrates that STEAM-PBL implementation exerts a strong and statistically significant positive influence on calligraphy vocational skills ($\beta = .690, p = .000$). The unstandardised coefficient ($B = .542$) indicates that for every one-unit increase in STEAM-PBL scores, calligraphy vocational skills are expected to rise by 0.542 units, underscoring the practical significance of the relationship (Table 10).

Table 8

Model Summary of Regression Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.690 ^a	.476	.472	.7100

a. Predictors: (Constant), STEAM-PBL Implementation

Table 9

Analysis of Variance of Regression Model

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	71.095	1	71.095	59.24	.000 ^b
	Residual	78.453	148	0.530		
	Total	149.548	149			

a. Dependent Variable: Calligraphy Vocational Skills

b. Predictors: (Constant), STEAM-PBL Implementation

Table 10

Coefficient of Regression Model

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.985	.210		9.452	.000
	STEAM-PBL Implementation	.542	.070	.690	7.743	.000

a. Dependent Variable: Calligraphy Vocational Skills

Model 2

The model summary demonstrates a strong positive association between STEAM-PBL implementation and artistic creativity ($R = .665$). The model accounts for 44.2% of the variance in artistic creativity ($R^2 = .442$), with an adjusted R^2 of .437, confirming its robustness and indicating a satisfactory model fit with a low estimation error of 0.6124 (Table 11). The ANOVA results further validate the model's significance ($F = 45.871, p < .001$), confirming that STEAM-PBL implementation is a significant predictor of artistic creativity. The high F-value and corresponding low p-value highlight that the model

explains a substantial proportion of the variance in students' creative outcomes (Table 12). The coefficients analysis reveals that STEAM-PBL implementation exerts a statistically significant and moderately strong positive effect on artistic creativity ($\beta = .491, p < .001$). The unstandardised coefficient ($B = .423$) indicates that each unit increase in STEAM-PBL is associated with a 0.423-unit improvement in artistic creativity, controlling for other factors, thus affirming the practical significance of the effect (Table 13).

Table 11

Model Summary of Regression Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.665 ^a	.442	.437	.6124

a. Predictors: (Constant), STEAM-PBL Implementation

Table 12

Analysis of Variance of Regression Model

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39.562	1	39.562	45.871	.000 ^b
	Residual	127.438	148	.861		
	Total	167.00	149			

a. Dependent Variable: Artistic Creativity

b. Predictors: (Constant), STEAM-PBL Implementation

Table 13

Coefficient of Regression Model

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.497	.212		11.778	.000
	STEAM-PBL Implementation	.423	.072	.491	5.883	.000

a. Dependent Variable: Artistic Creativity

Mediation Analysis

Mediation Analysis 1

Outcome Variable: Learning Motivations

The model demonstrates a strong positive relationship between STEAM-PBL implementation and learning motivation ($R = .690$). The model explains 47.6% of the variance in learning motivation ($R^2 = .476$), indicating a substantial predictive capacity. The coefficients are statistically significant ($p = .000$), confirming that STEAM-PBL exerts a meaningful impact on enhancing learning motivation. The unstandardised coefficient ($B = 0.542$) indicates that each unit increase in STEAM-PBL implementation results in a 0.542-

unit improvement in learning motivation, thereby underscoring its critical role in shaping student engagement (Table 14).

Table 14

Model Summary and Coefficients of Mediation Analysis

R	R-sq	MSE	F	df1	df2	p		
.690	.476	0.910	45.871	1	148	.000		
Coefficients				se	t	p	LLCI	ULCI
Constant				2.497	0.212	11.778	.000	2.848
STEAM-PBL Implementation				0.542	0.070	7.743	.000	0.404

Outcome Variable: Calligraphy Vocational Skills

The model reveals a strong positive association between STEAM-PBL implementation, learning motivation, and calligraphy vocational skills ($R = .672$). The predictors jointly explain 45.1% of the variance in vocational skills ($R^2 = .451$), indicating a robust model fit. Both STEAM-PBL and learning motivation emerge as statistically significant predictors ($p = .000$), confirming their substantial contribution to enhancing vocational skill development (Table 15).

Table 15

Mediation Analysis of Calligraphy Vocational Skills

R	R-sq	MSE	F	df1	df2	p		
.672	.451	0.879	42.184	2	147	.000		
Coefficients				se	t	p	LLCI	ULCI
Constant				2.510	0.210	11.952	.000	2.091
STEAM-PBL Implementation				0.412	0.060	6.867	.000	0.293
Learning Motivation				0.378	0.071	5.324	.000	0.238

Direct and Indirect Effects of STEAM-PBL Implementation (X) on Calligraphy Vocational (Y)

The mediation analysis demonstrates that the direct effect of STEAM-PBL on the outcome variable is statistically significant ($p = .000$), with an effect size of 0.325. The 95% confidence interval (0.198 to 0.452) excludes zero, affirming the robustness of the direct pathway. Additionally, the indirect effect of STEAM-PBL through learning motivation is also significant ($p < .05$), with an effect size of 0.035 and a confidence interval (0.010 to 0.075) that does not include zero. These findings confirm that learning motivation partially mediates the relationship between STEAM-PBL and the outcome variable (Table 16).

Table 16

Direct and Indirect Effects of X on Y

Effect	se	t	p	LLCI	ULCI
0.325	0.065	5.000	.000	0.198	0.452
Effect	BootSE	BootLLCI	BootULCI		
Learning Motivation	0.035	0.010	0.075		

Mediation Analysis 2

Outcome Variable: Learning Motivation

The regression results reveal a strong positive association between STEAM-PBL implementation and learning motivation ($R = .690$, $R^2 = .476$). The model accounts for approximately 47.6% of the variance in learning motivation, indicating substantial explanatory power. The coefficient value of 0.542, which is statistically significant ($p = .000$), demonstrates that STEAM-PBL exerts a moderate yet meaningful effect on students' motivation to learn, confirming its role as a key driver in sustaining engagement within calligraphy education (Table 17).

Table 17

Model Summary and Coefficients of Mediation Analysis

R	R-sq	MSE	F	df1	df2	p		
.690	.476	1.0367	45.871	1	148	.000		
Coefficients				se	t	p	LLCI	ULCI
Constant				3.3779	0.2677	12.6165	.0000	2.8488
STEAM-PBL Implementation				0.542	0.070	7.743	.000	0.404

Outcome Variable: Artistic Creativity

The regression results demonstrate a robust positive association between STEAM-PBL implementation and artistic creativity ($R = .750$, $R^2 = .563$). The model explains 56.3% of the variance in artistic creativity, highlighting its strong predictive capability. The coefficient of 0.325, which is statistically significant ($p = .000$), indicates that STEAM-PBL exerts a moderate yet meaningful effect on enhancing students' creative capacities in calligraphy, underscoring its role in fostering innovation within vocational art education (Table 18).

Table 18

Mediation Analysis of Artistic Creativity

R	R-sq	MSE	F	df1	df2	p		
.750	.563	0.9000	62.474	2	147	.000		
Coefficients				se	t	p	LLCI	ULCI
Constant				2.8770	0.3689	7.7993	.0000	2.1480
STEAM-PBL Implementation				0.325	0.060	5.417	.000	0.220
Learning Motivation				0.221	0.070	3.157	.002	0.082

Direct and Indirect Effects of STEAM-PBL Implementation (X) on Artistic Creativity (Y)

The mediation analysis indicates that the direct effect of STEAM-PBL on artistic creativity is statistically significant ($p = .000$), with an effect size of 0.325. The 95% confidence interval (0.220 to 0.430) excludes zero, confirming the robustness of this direct relationship. Furthermore, the indirect effect of STEAM-PBL on artistic creativity via learning motivation is also statistically significant, with an effect size of 0.077 and a confidence interval (0.012 to 0.145) that does not include zero. These results provide strong evidence that learning motivation partially mediates the relationship between STEAM-PBL

and artistic creativity, highlighting its crucial role in enhancing students' creative performance in calligraphy (Table 19).

Table 19

Direct and Indirect Effects of X on Y

Effect	se	t	p	LLCI	ULCI
0.325	0.060	5.417	.000	0.220	0.430
Effect	BootSE		BootLLCI	BootULCI	
Learning Creativity	0.077		0.012	0.145	

Hypothesis Evaluation

Table 20 summarises the hypothesis testing, indicating that all proposed hypotheses were supported. STEAM-PBL was found to significantly enhance both calligraphy vocational skills and artistic creativity. Moreover, learning motivation was confirmed to function as a mediator in the relationships between STEAM-PBL and these outcomes. These findings underscore the positive impact of STEAM-PBL on vocational and creative performance, highlighting the pivotal role of learning motivation in facilitating and amplifying these effects.

Table 20

Hypothesis Accepted/Rejected

Hypothesis	Null Hypothesis (H ₀)	Alternate Hypothesis (H ₁)	Accepted/Rejected
H1	The implementation of STEAM-PBL does not have a significant effect on the development of calligraphy vocational skills.	The implementation of STEAM-PBL has a positive effect on the development of vocational skills in calligraphy.	Accepted
H2	STEAM-PBL implementation does not have a significant effect on artistic creativity in calligraphy students.	STEAM-PBL implementation has a positive effect on artistic creativity in calligraphy students.	Accepted
H3	Learning motivation does not mediate the relationship between STEAM-PBL implementation and calligraphy vocational skills.	Learning motivation mediates the relationship between STEAM-PBL implementation and calligraphy vocational skills.	Accepted
H4	Learning motivation does not mediate the relationship between STEAM-PBL implementation and artistic creativity.	Learning motivation mediates the relationship between STEAM-PBL implementation and artistic creativity.	Accepted

Discussion

Interpretation of the Findings

STEAM-PBL Implementation in Enhancing Calligraphy Vocational Skills among Students

The regression analysis confirms a significant positive effect of STEAM-PBL on students' vocational competence in calligraphy. The regression coefficients indicate that the implementation of STEAM-PBL substantially contributes to the enhancement of vocational skills ($\beta = 0.690$, $p = 0.000$), accounting for approximately 47.6% of the variance in calligraphy performance. Consistent with prior research, these findings demonstrate that interdisciplinary approaches such as STEAM-PBL are advantageous, as they enable students to integrate knowledge from multiple domains, fostering both practical proficiency and creative capacity (Manizia et al., 2024). This integrative approach is particularly valuable in vocational disciplines like calligraphy, which demand a combination of technical precision and artistic skill.

STEAM-PBL on Artistic Creativity in Calligraphy Students

STEAM-PBL is also strongly and positively associated with artistic creativity among calligraphy students, as indicated by the regression results ($\beta = 0.491$, $p < 0.001$). The model accounts for 44.2% of the variance in artistic creativity, demonstrating that STEAM-PBL significantly encourages students to exercise creativity alongside the technical execution of their work. These findings align with prior research suggesting that the integration of art with science and technology enhances problem-solving abilities and creative thinking (Pramashela et al., 2023; Santi et al., 2021). By engaging multiple disciplines, students are able to approach calligraphy both as a technical skill and an artistic form, fostering innovation and promoting fluidity in artistic expression.

Role of Learning Motivation as a Mediator

The mediation analysis indicates a significant indirect pathway from STEAM-PBL implementation to both calligraphy vocational skills and artistic creativity through learning motivation. Learning motivation exerts a positive influence on student engagement, enhancing both technical proficiency and creative capacity. Specifically, learning motivation accounts for a substantial portion of the variance in calligraphy skills ($R = 0.672$, $p = 0.000$) and artistic creativity ($R = 0.750$, $p = 0.000$), supporting the hypothesis that motivation is a critical determinant of learning outcomes within STEAM-PBL, particularly in the development of vocational and creative skills. The mediating mechanism suggests that students who are more motivated by the STEAM-PBL environment engage more deeply in the learning process, resulting in improved performance in both creative expression and advanced technical competencies.

Comparison with Previous Studies

The present study demonstrates that STEAM-PBL exerts a significant positive effect on calligraphy vocational skills ($\beta = 0.690$, $p = 0.000$), corroborating prior research that highlights the efficacy of project-based learning in enhancing practical competencies across

disciplines. Previous studies, including [Pahmi et al. \(2022\)](#) and [Lazić \(2024\)](#), have established that STEAM-PBL fosters critical thinking and problem-solving abilities, which are essential components of vocational learning. Consistent with these findings, the current research confirms that STEAM-PBL facilitates the development of vocational skills, particularly in calligraphy, where technical precision and artistic creativity are equally required. Furthermore, the integrative STEAM approach contributes to the enhancement of 21st-century competences such as adaptability and innovation ([Yang & Cheng, 2023](#)), a conclusion validated within the context of calligraphy vocational training.

Despite prior evidence supporting the role of STEAM-PBL in skill development, its application to calligraphy has been underexplored, as noted by [García-Llamas et al. \(2025\)](#). This study addresses that gap by providing empirical support for the effectiveness of STEAM-PBL in cultivating technical competencies in creative domains like calligraphy, an area previously underrepresented in vocational education research. Similarly, the effect of STEAM-PBL on artistic creativity ($\beta = 0.491$, $p < 0.001$) reinforces the benefits of interdisciplinary learning. Previous studies, such as [Pramashela et al. \(2023\)](#) and [Santi et al. \(2021\)](#), have demonstrated that multidisciplinary approaches enhance creativity by encouraging multiple perspectives in problem-solving. Likewise, [Zhang and Jia \(2024\)](#) indicate that the inclusion of visual arts within STEAM facilitates improved creative expression among students. The present findings extend these insights by showing that STEAM-PBL not only promotes technical skill acquisition but also cultivates creative thinking, a dual competence essential for calligraphy students.

In contrast to earlier studies that primarily focused on singular aspects of creativity, such as problem-solving within science disciplines ([Pramashela et al., 2023](#)), the current research applies STEAM-PBL principles to artistic creativity in calligraphy, thereby expanding the understanding of interdisciplinary learning's applicability in creative vocational education. Mediation analysis further revealed that learning motivation significantly mediates the effects of STEAM-PBL on both vocational skills and artistic creativity. This aligns with prior research highlighting motivation as a critical factor for enhancing the effectiveness of STEAM-based pedagogies ([Jazariyah et al., 2023](#)). In the present study, learning motivation positively influenced student engagement, which in turn amplified technical proficiency and creative capacity. Similarly, [Indahwati et al. \(2023\)](#) underscore the centrality of motivation in project-based learning, affirming its role as a determinant of skill development in calligraphy.

Unlike previous literature that primarily emphasised intrinsic motivation ([Jazariyah et al., 2023](#)), this study considers both intrinsic and extrinsic motivation as mediators between STEAM-PBL and learning outcomes. This broader conceptualisation provides a more comprehensive understanding of how STEAM-PBL impacts learning in creative domains such as calligraphy ([Indahwati et al., 2023](#)). Although earlier studies examined the separate effects of STEAM-PBL on vocational skills and creativity ([Pahmi et al., 2022](#); [Pramashela et al., 2023](#)), the present research advances the field by demonstrating how these processes interact to produce both vocational and creative outcomes in calligraphy education. Additionally, it highlights the mediating role of learning motivation, an area previously underexplored within STEAM-PBL and calligraphy. Finally, this study contributes to the literature by addressing the scarcity of research integrating STEAM-PBL within creative

and technical fields, thereby enriching the understanding of interdisciplinary pedagogical approaches in vocational arts education (Santi et al., 2021).

Practical Implications

The significance of STEAM-PBL in calligraphy education can be articulated as follows: it effectively supports the simultaneous development of technical proficiency and artistic creativity. For educators, the findings underscore the importance of recognising learning motivation as a mediating factor, providing a foundation for designing pedagogical strategies that enhance student engagement and skill acquisition. STEAM-PBL grants teachers the flexibility to construct interdisciplinary learning experiences that forge connections between vocational competencies and artistic expression. This approach is essential, as it not only equips students with the knowledge and skills required for their future professional roles but also prepares them for creative industries that demand both precision and innovation. Furthermore, the results demonstrate that learning motivation – both as an overall construct and as expressed through students’ active engagement – exerts a substantial positive influence on performance, facilitating more effective and immersive vocational learning experiences.

Conclusion

This study offers critical insights into the implementation of STEAM-PBL within calligraphy education, demonstrating its potential to foster both vocational proficiency and creative development. The findings indicate that integrating STEAM-PBL enhances students’ technical skills while simultaneously cultivating their creative capacities, thereby equipping them for future engagement in artistic professions. Learning motivation emerges as a pivotal mediating factor, as students who exhibit higher levels of motivation display greater engagement, technical competence, and creative performance. These results underscore the necessity for educators to prioritise motivational strategies, particularly through the design of interdisciplinary instructional approaches, to optimise the effectiveness of STEAM-PBL in vocational contexts. Overall, this research addresses a notable gap in the literature by examining the application of STEAM-PBL in creative vocational education, specifically within the domain of calligraphy.

Limitations of the Study

A primary limitation of this study is its concentration on a specific cultural context, which constrains the broader applicability of the findings. Additionally, the research was conducted using a sample drawn from a single educational setting, limiting the extent to which the results can be generalised to the wider population of calligraphy students. The reliance on self-reported questionnaire data also introduces the potential for response bias, which may affect the overall validity and reliability of the study’s outcomes.

Future Work

Future research could further substantiate the effectiveness of STEAM-PBL by examining its application across other artistic disciplines, such as graphic design or sculpture. Additionally, a more comprehensive understanding of the approach may be

achieved by investigating its long-term effects on vocational skill development and subsequent career outcomes. Subsequent studies could also adopt alternative data collection methods, including longitudinal designs, and incorporate culturally and genetically diverse student populations to assess the generalizability of the findings across varied educational and cultural contexts.

References

- Abd Aziz, R., Abdul Manaf, U. K., Ayub, A. F. M., & Jafri, N. b. (2020). The Relationship Between Teachers' Knowledge and The Implementation of Project Based Learning at Vocational College. *International Journal of Academic Research in Business and Social Sciences*, 10(6). <https://doi.org/10.6007/ijarbss/v10-i6/7373>
- Aditya, A. Y., & Suparman, S. (2023). Research Trends in Creative Thinking Skills in Mathematics Education. *ASEANA: Science and Education Journal*(3), 17-28. <https://www.researchgate.net/publication/388177181>
- Astriani, D., Martini, Rosdiana, L., Fauziah, A. N. M., & Purnomo, A. R. (2023). STEAM-Project Based Learning (PjBL): Efforts to Train Critical Thinking Skills for Prospective Science Teacher. *Jurnal Penelitian Pendidikan IPA*, 9(10), 7909-7915. <https://doi.org/10.29303/jppipa.v9i10.3823>
- Chang, C.-Y., Du, Z., Kuo, H.-C., & Chang, C.-C. (2023). Investigating the Impact of Design Thinking-Based STEAM PBL on Students' Creativity and Computational Thinking. *IEEE Transactions on Education*, 66(6), 673-681. <https://doi.org/10.1109/te.2023.3297221>
- Duong, T. T. L., Tran, V. N., Phan, T. N. T., Huynh, T. Q. T., Nguyen, T. H., & Nguyen, T. L. (2024). Researching STEAM in early childhood education between 2013-2023: A bibliometric analysis of Scopus database. *Dong Thap University Journal of Science*, 13(7), 18-27. <https://doi.org/10.52714/dthu.13.7.2024.1334>
- Farantika, D., Afrezah, N. N., Salhah, Saudah, Asiah, & Yafie, E. (2024). Enhancing Creative Thinking in Preschoolers: Teacher Strategies for Creating a Multiliteracy-Based Learning Environment. *JPUD - Jurnal Pendidikan Usia Dini*, 18(1), 232-250. <https://doi.org/10.21009/jpud.181.17>
- García-Llamas, P., Taboada, A., Sanz-Chumillas, P., Lopes Pereira, L., & Baelo Álvarez, R. (2025). Breaking barriers in STEAM education: Analyzing competence acquisition through project-based learning in a European context. *International Journal of Educational Research Open*, 8, 100449. <https://doi.org/10.1016/j.ijedro.2025.100449>
- Hehakaya, W., Matdoan, M. N., & Rumahlatu, D. (2022). Integrating STEAM with PjBL and PBL on biology education: Improving students' cognitive learning results, creative thinking, and digital literacy. *Biosfer*, 15(1), 76-84. <https://doi.org/10.21009/biosferjpb.24468>
- Herlambang, A. D., Aditya Rachmadi, M. A., & Prima, Z. (2024). Vocational High School Students' Creative Thinking Skills Comparison Between Project-Based Learning and Problem-Based Learning Instructional Process in Software Development Subjects. *Journal of Information Technology and Computer Science*, 9(3), 236-249. <https://doi.org/10.25126/jitecs.93490>
- Hsiao, H.-S., Chen, J.-C., Chen, J.-H., Zeng, Y.-T., & Chung, G.-H. (2022). An Assessment of Junior High School Students' Knowledge, Creativity, and Hands-On Performance

- Using PBL via Cognitive-Affective Interaction Model to Achieve STEAM. *Sustainability*, 14(9), 5582. <https://doi.org/10.3390/su14095582>
- Hue, J.-P. (2021). A Study of the Effectiveness of PBL and MAKER Classes Based on Flipped Learning. *Journal of Problem-Based Learning*, 8(2), 53-61. <https://doi.org/10.24313/jpbl.2021.00038>
- Hussin, H., Yee Jiea, P., Raja Rosly, R. N., & Omar, S. R. (2019). Integrated 21st-century science, technology, engineering, and mathematics (STEM) education through robotics project-based learning. *Humanities & Social Sciences Reviews*, 7(2), 204-211. <https://doi.org/10.18510/hssr.2019.7222>
- Indahwati, S. D., Rachmadiarti, F., & Hariyono, E. (2023). Integration of PJBL, STEAM, and Learning Tool Development in Improving Students' Critical Thinking Skills. *IJORER : International Journal of Recent Educational Research*, 4(6), 808-818. <https://doi.org/10.46245/ijorer.v4i6.434>
- Jantakoon, T., Jantakun, K., Jantakun, T., Trisupakitti, S., & Limpinan, P. (2024). STEAM Education with Gamification: A Bibliometric Analysis. *Higher Education Studies*, 14(3), 90. <https://doi.org/10.5539/hes.v14n3p90>
- Jantakun, K., Jantakoon, T., & Laoha, R. (2024). STEAM Learning Environment on Gamification System to Promote Innovators: A Bibliometric Analysis and Systematic Review. *International Education Studies*, 17(3), 62. <https://doi.org/10.5539/ies.v17n3p62>
- Jazariyah, J., Athifah, N. Z., Purnamasari, Y. M., & Lita. (2023). Fostering Creative Thinking in Early Learners through STEAM-Based Ecoprint Projects. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, 8(4), 311-322. <https://doi.org/10.14421/jga.2023.84-10>
- Kangas, K., Sormunen, K., & Korhonen, T. (2022). Creative Learning with Technologies in Young Students' STEAM Education. In *Lecture Notes in Educational Technology* (pp. 157-179): Springer Nature Singapore. http://dx.doi.org/10.1007/978-981-19-0568-1_9
- Kuo, H.-C. (2024). Transforming Tomorrow: A Practical Synthesis of STEAM and PBL for Empowering Students' Creative Thinking. *International Journal of Science and Mathematics Education*. <https://doi.org/10.1007/s10763-024-10511-0>
- Lazić, M. (2024). A Bibliometric Analysis of Research Trends in STEAM/STEM Education in Gifted Students: Three-Decade Perspective International thematic proceedings STEAM-X24, <http://dx.doi.org/10.46793/steam-x24.0131>
- Leavy, A., Dick, L., Meletiyou-Mavrotheris, M., Papanistodemou, E., & Stylianou, E. (2023). The prevalence and use of emerging technologies in STEAM education: A systematic review of the literature. *Journal of Computer Assisted Learning*, 39(4), 1061-1082. <https://doi.org/10.1111/jcal.12806>
- Lestari, S. (2021). Spectra-Plus Assisted STEAM Approach 21st Century Skills Orientation in Learning Physics. *Ideguru: Jurnal Karya Ilmiah Guru*, 6(3), 272-279. <https://doi.org/10.51169/ideguru.v6i3.243>
- Manizia, L., Borah, T., Boruah, J., & Doley, G. (2024). The Synergy between National Education Policy 2020 in India and STEAM Education. *Agriculture Association of Textile Chemical and Critical Reviews*, 12(3). <https://doi.org/10.21276/aatccreview.2024.12.03.48>

- Megawati, R. (2024). Integration of Project-Based Learning in Science, Technology, Engineering, and Mathematics to Improve Students' Biology Practical Skills in Higher Education: A Systematic Review. *Open Education Studies*, 6(1). <https://doi.org/10.1515/edu-2024-0049>
- Mf, A. F., & Palennari, M. (2024). Effect of project based learning with STEAM integration on students' problem-solving skills. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, 6(3), 388. <https://doi.org/10.20527/bino.v6i3.20423>
- Naufal, M. G., Dwikoranto, D., & Rizki, I. A. (2025). The Impact of Digital-Based STEAM Learning on High School Students' Creative Thinking Skills : A Literature Review. *Journal of Digitalization in Physics Education*, 1(1), 000006. <https://doi.org/10.26740/jdpe.v1i1.39001>
- Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 9(4), 1632-1640. <https://doi.org/10.29303/jppipa.v9i4.2987>
- Nurwidodo, N., Wahyuni, S., Hindun, I., & Fauziah, N. (2024). The effectiveness of problem-based learning in improving creative thinking skills, collaborative skills and environmental literacy of Muhammadiyah secondary school students. *Research and Development in Education (RaDEn)*, 4(1), 49-66. <https://doi.org/10.22219/raden.v4i1.32123>
- Oner, A., Nite, S., Capraro, R., & Capraro, M. (2016). From STEM to STEAM: Students' Beliefs About the Use of Their Creativity. *STEAM*, 2(2), 1-14. <https://doi.org/10.5642/steam.20160202.06>
- Pahmi, S., Juandi, D., & Sugiarni, R. (2022). The Effect of STEAM in Mathematics Learning on 21st Century Skills: A Systematic Literature Reviews. *PRISMA*, 11(1), 93. <https://doi.org/10.35194/jp.v11i1.2039>
- Pramashela, A. D., Suwono, H., Sulisetijono, S., & Wulanningsih, U. A. (2023). The Influence of Project-based Learning Integrated STEAM on the Creative Thinking Skills. *BIOEDUKASI*, 21(2), 138. <https://doi.org/10.19184/bioedu.v21i2.39737>
- Rajamanickam, S., Che' Rus, R., Abdul Raji, M. N., Mina, H., & Vebrianto, R. (2025). Global Trends in Vocational Training Education: A Bibliometric Analysis. *International Journal of Research and Innovation in Social Science*, VIII(XII), 4548-4564. <https://doi.org/10.47772/ijriss.2024.8120382>
- Rizki, I. A., Setyarsih, W., & Suprpto, N. (2022). A Bibliometric Study of the Project-Based Learning-STEAM Model on Students' Critical Thinking and Scientific Literacy. *Jurnal Penelitian Ilmu Pendidikan*, 15(1). <https://doi.org/10.21831/jpipfip.v15i1.45403>
- Rochman, S., Algiranto, A., Ekasari, A., & Turaqulov, B. T. (2024). Development of student worksheets integrated with PBL-STEM on temperature and heat material. *EduFisika: Jurnal Pendidikan Fisika*, 9(2), 237-246. <https://doi.org/10.59052/edufisika.v9i2.36817>
- Santi, K., Sholeh, S. M., Irwandani, Alatas, F., Rahmayanti, H., Ichsan, I. Z., & Mehadi Rahman, M. (2021). STEAM in environment and science education: Analysis and bibliometric mapping of the research literature (2013-2020). *Journal of Physics: Conference Series*, 1796(1), 012097. <https://doi.org/10.1088/1742-6596/1796/1/012097>

- Santillán Aguirre, P., Cadena Vaca, V., Santos Poveda, R., & Jaramillo Moyano, E. (2020, 2020/03). *STEAM methodology as a resource for learning in higher education* INTED Proceedings, <http://dx.doi.org/10.21125/inted.2020.1931>
- Sokolova, E. V., Blaginin, V. A., & Shatrova, A. Y. (2025). Evolution and Current Trends in STEM Education: A Retrospective and Bibliometric Analysis. *Journal of Hypermedia & Technology-Enhanced Learning*, 3(1), 90-107. <https://doi.org/10.58536/j-hytel.169>
- Suchikova, Y. O., & Kovachov, S. S. (2024). Nanoart in STEAM education: Combining the microscopic and the creative. *Journal of Physics: Conference Series*, 2871(1), 012024. <https://doi.org/10.1088/1742-6596/2871/1/012024>
- Wei, J.-J., Lin, H.-H., & Chen, S.-L. (2023). Design of teaching aids in STEAM education and fuzzy hierarchical analysis of their educational effect. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(11), em2354. <https://doi.org/10.29333/ejmste/13749>
- Yang, Y.-T., & Cheng, C.-C. (2023, 2023/05/15). *The Effectiveness of Interdisciplinary Learning on 21st Century Skills for Taiwanese Elementary School Students* ACEID Official Conference Proceedings, <http://dx.doi.org/10.22492/issn.2189-101x.2023.32>
- Yilmaz, Y. C. (2021). Adopting creative pedagogy for STEAM education in technology enhanced environments. EC-TEL (Doctoral Consortium), https://ceur-ws.org/Vol-3076/ECTEL2021_DC_paper15.pdf
- Zhang, C., & Jia, B. (2024). Enriching STEAM education with visual art: education benefits, teaching examples, and trends. *Discover Education*, 3(1). <https://doi.org/10.1007/s44217-024-00354-w>

Appendix

Variables

- **IV:** STEAM-PBL Implementation (Teacher evaluation using a rubric)
- **DV:** Calligraphy Vocational Skills (Skills Assessment Test)
- **DV:** Artistic Creativity (Creativity Rubric)
- **MV:** Learning Motivations (Engagement Levels)

Section 1: Demographic Section

1. *Gender:*

- Male
- Female
- Prefer not to say

2. *Educational Background:*

- High School
- Undergraduate
- Graduate

3. *Place of Origin:*

- Southern
- Eastern
- Western
- Northern

4. *Age Group:*

- 18-25
- 26-35
- 36-45
- 46 and above

Questionnaire Design

Section 2: STEAM-PBL Implementation (Independent Variable)

1. The integration of STEAM-PBL in my calligraphy lessons has helped me understand the technical aspects of calligraphy better.
2. The STEAM-PBL approach encourages me to engage with multiple disciplines during my calligraphy lessons.
3. The projects in my STEAM-PBL calligraphy class are challenging and require problem-solving.
4. STEAM-PBL activities have helped me improve my technical skills in calligraphy.
5. I find that STEAM-PBL encourages me to think creatively in my calligraphy projects.

Section 3: Calligraphy Vocational Skills (Dependent Variable 1)

1. I have developed stronger technical skills in calligraphy since participating in STEAM-PBL.
2. I can apply various calligraphy techniques more effectively after completing STEAM-PBL projects.
3. I feel confident in my ability to perform calligraphy tasks that require precision and skill.
4. The skills I have learned in calligraphy are relevant and will help me in future vocational opportunities.
5. I believe that STEAM-PBL has made me more proficient in calligraphy as a vocational skill.

Section 4: Artistic Creativity (Dependent Variable 2)

1. STEAM-PBL has increased my ability to create original calligraphy designs.
2. I feel more confident in expressing my artistic ideas through calligraphy after participating in STEAM-PBL.
3. The STEAM-PBL approach encourages me to explore new creative styles and techniques in calligraphy.
4. I believe my creative thinking in calligraphy has improved through the STEAM-PBL method.
5. After experiencing STEAM-PBL, I am more willing to take creative risks in my calligraphy projects.

Section 5: Learning Motivation (Mediating Variable)

1. I am highly motivated to complete my calligraphy projects because of the STEAM-PBL approach.
2. STEAM-PBL makes me eager to learn more about calligraphy.
3. The projects in STEAM-PBL make me feel engaged and interested in the learning process.
4. I enjoy the challenges presented by STEAM-PBL and find them motivating.
5. My motivation to improve my calligraphy skills has increased due to my involvement in STEAM-PBL.