

# **Effects of STEAM-PBL on Calligraphy Vocational Skills and Artistic Creativity: Mediating Role of Learning Motivation**

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**Abstract:** STEAM (Science, Technology, Engineering, Arts, and Mathematics) has been witnessed to integrate with the Project-Based Learning (PBL) in improving issues of concern with regard to vocational competencies and creativity. The broader meaning of STEAM-PBL in calligraphy is that it offers a platform to integrate technical knack and artistic ingenuity. The proposed study is intended to assess the efficacy of STEAM-PBL in the development of calligraphy vocational skills and the influence it has on artistic creativity, and to examine learning motivation as a mediator between STEAM-PBL and student outcomes. A structured questionnaire survey was adopted, and 150 respondents were enrolled in vocational calligraphy programs through a Likert scale (1-5). The statistical test used in data analysis included correlation, regression, and mediation analysis using SPSS. Findings showed that STEAM-PBL resulted in a significant improvement in vocational skills and artistic creativity in a calligraphic lesson, and learning motivation mediated this improvement. Both of those skills were directly and positively impacted by STEAM-PBL, and motivated students displayed greater creativity and technical accuracy. The article indicates how STEAM-PBL can be used to train vocational and artistic skills in the teaching of calligraphy. Learning motivation added to the teaching process may enhance the impact of STEAM-PBL and hence offer useful data to teachers in creative disciplines.

**Keywords:** STEAM-PBL, Vocational Skills, Artistic Creativity, Learning Motivation, Calligraphy.

## **1. Introduction**

In recent years, there has been a greater interest in the application of STEAM (Science, Technology, Engineering, Arts, and Mathematics) to teaching methods, particularly to Project-Based Learning (PBL), as a way to improve creativity and vocational competence. The STEAM-PBL course of study is rather promising since it allows interdisciplinary learning, integrating multiple disciplines into empirical problem-solving exercises, so that not only the material is learned but also critical thinking and creative problem-solving skills are developed (Oner et al., 2015). More specifically, within the vocational school such integration goes towards more practical skills that students can execute in their future employment. As art, Calligraphy offers a special environment to practice

STEAM-PBL, since it is a creative art, but with specific and organized strategies that demand a scientific and methodological attitude (Chang et al., 2023).

Chang et al. (2023) also discovered that problem-solving and creative thinking are significantly enhanced during STEAM-PBL. According to Kuo (2025), the learners who followed a STEAM based PBL showed more creativity in activities based on tasks, when they had to come up with their own ideas, were more flexible in solving problems, and developed their ideas more. These skills are especially relevant in creative initiatives such as calligraphy, where both technical and artistic expressions are vital.

Jazariyah et al. (2023) stated that learning motivation is significant because it mediates the effectiveness of STEAM-PBL. Learners have a greater chance of becoming immersed in tasks and developing both technical and creative abilities when motivated to learn. Motivation, whether intrinsic or extrinsic, plays a crucial role in the application of skills learned by students in practical situations. This predetermines the investigation of how the motivation to study affects the acquisition of skills for calligraphy work, based on the STEAM-PBL approach, as a valuable study direction, as stated by Hehakaya, Matdoan and Rumahlatu (2022).

As educational researchers and teachers also aimed to lower the complexity of implementing these educational innovations in the classroom, research indicates that introducing artistic aspects into STEM-based courses leads to better cognitive and creative performance, as discussed by Pramashela et al. (2023). In particular, when focusing on vocational educational practices, when the aim is to prepare students to acquire working skills, the given integration becomes even more vital. The use of the arts in STEM-related activities has also been associated with enhanced creativity, executive function, and novel solution achievements, as well as comprehension of both theoretical and practical concepts of the discipline, as stated by Zhang and Jia (2024).

Although STEAM-PBL has been identified to have the potential to promote creativity and critical thinking in several learning situations, in reality, it is yet to be used in the context of calligraphy-vocation skills enhancement. Despite literature supporting the view that Project-Based Learning (PBL) helps to develop problem-solving skills and creativity in vocational education, as stated by García-Llamas et al. (2025), no research is available on the efficacy of STEAM-PBL to influence both the technical and creative sides of calligraphy. Moreover, although learning motivation has been identified as an essential factor in boosting the involvement and performance of students, as noted by Indahwati, Rachmadiarti and Hariyono (2023), it is unknown if learning motivation mediates the relationship between STEAM-PBL and the calligraphy abilities and artistic creativity of students. This research is going to fill these gaps by examining the effects of STEAM-PBL on calligraphy ability, values, and artistic creativity, as well as the effects of learning motivation as a mediator.

### *1.1. Research Objectives*

1. To evaluate the effectiveness of STEAM-PBL implementation in enhancing calligraphy vocational skills among students
2. To assess the impact of STEAM-PBL on artistic creativity in calligraphy students
3. To examine the role of learning motivation as a mediator between STEAM-PBL and students' calligraphy vocational skills and artistic creativity

Incorporating STEAM-PBL into vocational learning is a positive initiative toward enhancing the development of both creative and functional abilities, including such artistic fields as calligraphy. STEAM education has also been proven to support the tendency of students to participate in problem-solving processes that bridge theoretical knowledge and practical practice, as discussed by Jantakun, Jantakoon and Laoha (2024). Furthermore, it has been identified to promote creativity and innovation, which are essential elements to commit to calligraphy practice involving precision and artistry in letter forming, as stated by Hsiao et al. (2022). Learning motivation also plays a massive role in this process because it mediates the effectiveness of the STEAM-PBL, ensuring that the students remain involved and intensely engaged in their learning activities. The impact of learning motivation on the performance of an integrated approach will enable teachers to design methods to improve both creative and cognitive abilities. The study is also vital to simplifying teaching techniques in calligraphy and other vocational subjects that require creativity as well as technical skills.

## 2. Literature Review

### 2.1. STEAM-PBL Implementation in Enhancing Calligraphy Vocational Skills among Students

STEAM (Science, Technology, Engineering, Arts, and Mathematics) education, combined with Project-Based Learning (PBL), has become a significant strategy to improve numerous vocational competencies, such as calligraphy. The goal of this objective is to assess the usefulness of STEAM-PBL as a way of enhancing vocational ability, in this case, calligraphy. STEAM education emphasizes an interdisciplinary approach that plays a central role in developing 21st-century skills, which include critical thinking, creativity, and problem-solving, as stated by Pahmi, Juandi and Sugiarni (2022). Lazić (2024) notes that this strategy has been widely discussed, particularly with gifted students in mind, as it is easily linked to the concept of honing the skills that are vital in the future labor market. Once extended to vocational skills, such as calligraphy, it can have a profound impact on educating students and developing skills.

The use of PBL in STEAM learning is well-discussed in the literature. As Rizki, Setyarsih and Suprpto (2022) explain, PBL enables students to engage with the subject, thereby developing critical thinking and enhancing their scientific literacy. The notion is instrumental in vocational training, where the students are not only likely to have to possess the technical knowledge necessary but also skills to analyze, integrate, and apply their knowledge into practice. Project-based learning can be used in teaching calligraphy to offer students a comprehensive perspective of one of the artistic approaches that combines both creativity and technical craft, as was found in the research by Astriani et al. (2023).

Moreover, national educational strategies and the STEAM Act collaborate toward the implementation of such programs. Manizia et al. (2024) suggest that integrating art into science and technology education, as emphasized by India's National Education Policy of 2020, is beneficial for vocational education. The same strategy may be adopted in the calligraphy sector, where students have been encouraged to integrate the old and new practice, meaning they have been using modern technology to achieve creative solutions.

Yang and Cheng (2023) also argue that interdisciplinary learning is effective in enhancing 21st-century skills. They emphasize that by crossing the boundaries of any discipline, students should obtain a global perspective on the learning process, a key aspect of professional training, such as calligraphy, where not only technical proficiency but also creativity is applied. Furthermore, Sokolova, Blaginina and Shatrova (2025) note that the progress of STEM education has also been associated with an appreciation of the role of art. Hence, the use of STEAM in vocational disciplines such as calligraphy is not only becoming acceptable but also essential for future development.

Additionally, Kangas, Sormunen and Korhonen (2022) highlight the innovative educational opportunities that incorporating technology into traditional STEAM learning presents, which can be applied to calligraphy in light of the increased use of digital tools and platforms, thereby improving practice and artistic creativity.

PBL and STEAM education provide an uninterrupted system of developing vocational competence. It was shown that the addition of PBL to STEAM has had successes in effectiveness by enhancing practical skills in various disciplines, and this can be applied in calligraphy research (Megawati, 2024). As a result, integrating STEAM-PBL into vocational training of calligraphy can improve technical and artistic skills required to work in the field.

The STEAM-PBL combination used in training calligraphy is consistent with the global trend in vocational education because a more dynamic aspect of teaching skills will support innovation and flexibility. Integrating interdisciplinary education with project-based learning is the key to enhancing vocational education, a fact that has already been asserted by Rajamanickam et al. (2024). This is an aspect of the old-fashioned means of education, whereby an overall and more effective mode of acquiring the vocational techniques needed in the modern industries.

## *2.2. STEAM-PBL on Artistic Creativity in Calligraphy Students*

It has been continually revealed in research that both project-based learning and STEAM education help develop creative thinking. As an example, Pramashela et al. (2023) point out that creative thinking and problem-solving are critical abilities that students who can study the arts, including calligraphy, must have, and STEAM in PBL can support those processes. The combination of the subject areas in STEAM allows the students to improve the work projects using the combined perspectives, which provides students with the opportunity to express their creativity in the form of the arts. Likewise, Aqilah Fauziah and Palennari (2024) model that the implementation of STEAM in project-based learning would create a positive impact on the potential of students to solve problems, who will therefore be more creative in producing art.

Also, Suchikova and Kovachov (2024) discuss a framework in STEAM education that involves fusing artistic approaches to learning with scientific and technological knowledge. The process of researching STEAM-related nanoart implies that the aesthetic and scientific can be merged into a more innovative and versatile artistic output. This view may be especially advantageous for the study of calligraphy, as it presents possibilities for incorporating new technology into old calligraphic practices and provoking a new, possible art of expression.

Santi et al. (2021) claim that the interdisciplinary STEAM methodology can support creativity, not only by helping students prepare to solve real-life problems, but also by

teaching them to think critically and collaborate. To the students of calligraphy, such interdisciplinary attention implies that they will be able to integrate art with other field forms, increasing their creative potential and technical expertise. In the same way, Wei, Lin and Chen (2023) address the idea of the impact of teaching aids design in STEAM education on creativity, suggesting that creative thinking and learning are facilitated through the provision of innovative tools and methodologies that directly translate to the development of artistic abilities in calligraphy.

Additional support for the utility of technology in promoting creativity in STEAM education is that emerging technologies play a significant role in augmenting creativity practices, as noted by Leavy et al. (2023). This also aligns with Yilmaz's (2021) opinion, who believes that creative pedagogy is crucial in a technology-enhanced learning environment, where students have access to new tools and digital platforms that can expand their creative space. An example is that calligraphy students can use digital platforms to explore various calligraphic styles and techniques during practice, thereby broadening their creativity.

Additionally, Duong et al. (2024) highlight that STEAM education fosters the expression of creativity by providing students with opportunities to utilize their artistic talents within a multidisciplinary context. It aligns well with artistic education in vocational contexts because it challenges students to think creatively and develop innovative forms of artistic expression. Lestari (2021) discusses the role of 21st-century skills in STEAM education, including creativity, which is a focus of vocational education in calligraphy. Finally, Hussin et al. (2019) mention that project-based learning (including robotics lessons) has a positive impact on the development of creative approaches to solving problems among students. This model applies to calligraphy, where students apply problem-solving techniques as they refine their artwork, utilizing the critical thinking process.

### *2.3. Learning Motivation as a Mediator between STEAM-PBL and Students' Calligraphy Vocational Skills and Artistic Creativity*

Studies have revealed that intrinsic motivation significantly influences creative thinking, which is crucial for students of calligraphy, as it enhances their innovativeness and ability to showcase their talents in this art. Aditya and Suparman (2023) describes the role of motivation in developing creative thinking abilities in education through the lens that motivated students are more likely to bend rules or think profoundly about their craft. Likewise, the article by Aguirre et al. (2020) demonstrates that the STEAM methodology and its interdisciplinary approach are beneficial in fostering creativity, as a diverse range of tools and perspectives is offered to students. It may be immediately applied to calligraphy students because appropriate creativity is the main element of modern intentions to combine classical methods with contemporary styles of artistic representation.

As one of the primary components of STEAM, project-based learning (PBL) is a practical approach for enhancing both creative thinking and problem-solving skills. In vocational high schools, Herlambang, Rachmadi and Zulvarina (2024) compare the effectiveness of problem-based learning (PBL) and project-based learning (PBL, revealing that PBL enables students to enhance their creative abilities in a practical environment. In the case of calligraphy students, this approach will allow them to participate in projects that may require either artistic or technical skills, thereby improving their capacity to implement multi-faceted designs. In this regard, motivation works to energize students to be fully involved in the learning process, hence resulting in increased creativity.

Correlation of knowledge among the teacher, the motivation of the student, and the proficient learning result is another important one. As Abd Aziz et al. (2020) say, PBL methods learned by the teachers might also contribute to the determination of the effectiveness of project-based learning, as students who do not have closed attitudes towards the whole learning process will surely have a better experience with their teachers, who could help them in complicated creative tasks. Being an example of calligraphy, education implemented in STEAM concepts and personnel educating the student using the right equipment and instruction can serve as an additional source of inducement and learning to develop artistic skills.

Also, gamification in the STEAM curriculum has proved to boost motivation in the creative topics of education. T. In their article, Jantakoon et al. (2024) address the problem of gamification in the STEAM education system and its essentiality to the improvement of the student engagement level, which, in turn, raises their level of creativity and skill acquisition. Gamified goals can be beneficial to calligraphy learners because they help them to be adventurous, experiment with different styles, and expand their artistic abilities. According to Farantika, Dessy et al. (2024), a learning environment should be created on multiliteracy that stimulates motivation and creativity. Educators can strengthen students' innate motivation to explore artistic manifestations, such as calligraphy, by offering them a variety of learning experiences and resources. This, in turn, results in improved performance in both creative thinking and technical skills.

The use of project-based learning in STEM subjects is also mentioned by Rochman et al. (2024), who state its positive effect on students' ability to collaborate and think creatively. This applies to calligraphy students, as they are likely to take advantage of the collaborative characteristic of PBL, which allows them to share their ideas and techniques with others, thereby enhancing their artistic development. An argument in favor of this is that through problem-based learning, collaborative skills are enhanced, which is particularly applicable in calligraphy projects where students often collaborate to sharpen their skills and creativity, as noted by Nurwidodo et al. (2024).

In addition, the study by Naufal, Dwikoranto and Rizki (2025) examines the usage of digital-based STEAM learning, with the researchers noting that digital tools have the potential to generate motivation and creativity. For students of calligraphy, exploring the domain of designs and techniques with the help of digital media can be of great benefit, as it develops their artistic ability and fosters creative thought. Another publication, Nuraini, Asri and Fajri (2023), also advocates for the inclusion of technology in project-based learning, which has demonstrated the ability to enhance student motivation and learning outcomes in the arts, including calligraphy. Hue (2021) emphasizes that incorporating flipped learning into PBL settings also enhances students' engagement and creativity, as students have the freedom to explore concepts and subsequently apply them in group projects. This practice is particularly beneficial for students of calligraphy because it encourages self-direction in the student and allows them to explore various techniques, thereby fostering creativity. Through the integration of motivation in these new learning approaches, students gain the capacity to build on their vocational training and refine their skills in the arts.

#### *2.4. Literature Gap*

Although STEAM-PBL has been extensively addressed in vocational education,

specifically about its contribution to both creativity and technical skill development, several areas have not been covered in the literature regarding its use in teaching calligraphy. Although Pahmi et al. (2022) and Lazić (2024) emphasize the role of STEAM in developing 21st-century skills, the literature lacks a specific exploration of how this construct can be applied to the vocational field of calligraphy. Additionally, although Rizki et al. (2022) and Astriani et al. (2023) offer some information on the role of PBL in fostering critical thinking and scientific literacy, little is known about the approaches required to meet the needs of calligraphy students within a STEAM-PBL context. The impact of new technologies on teaching calligraphy, as suggested by Leavy et al. (2023) and Naufal et al. (2025), remains underexplored, particularly in the area of artistic creativity facilitated by digital devices. Additionally, although motivation is recognized as a crucial mediator in PBL (Aditya & Suparman, 2023; Hue, 2021), further study is required to analyze the nature of its effect on the creative and vocational performance of calligraphy students.

### 2.5. 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.

### 2.6. Conceptual Framework

Figure 1: Conceptual Framework.

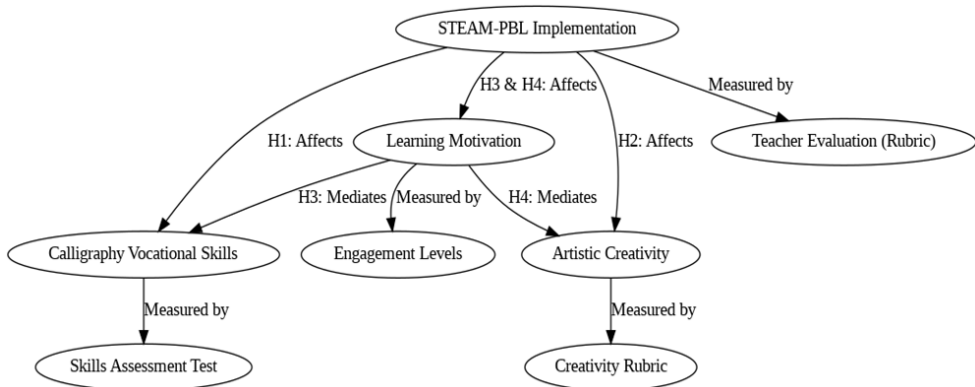


Figure 1 illustrates the relationships between STEAM-PBL, learning motivation, calligraphy vocational skills, and artistic creativity. It shows that STEAM-PBL positively impacts both skills and creativity (H1, H2), with learning motivation mediating these effects (H3, H4).

### 3. Methodology

#### 3.1. Research Methods and Design

In this research, a quantitative research design was utilized in order to explore how STEAM-PBL (Science, Technology, Engineering, Arts, and Mathematics - Project-Based Learning) affects vocational skills in calligraphy and artistic creativity. It was selected because it is possible to objectively measure the relationships between the independent variable (IV), application of STEAM-PBL, and the dependent variables (DVs), i.e., calligraphy vocational skills and artistic creativity. The survey was carried out with the help of a questionnaire, and with the help of this method, it was possible to arrange a full-fledged examination of the impact of the experience of participants whose work is based on STEAM-PBL on their calligraphic and creative experience and on their desire to engage in the learning process. The study used a Likert scale (1-5) to evaluate the subjective experience of the students with STEAM-PBL and their motivation to study.

#### 3.2. Data Collection Methods

A structured questionnaire with four significant variables, including STEAM-PBL implementation, learning motivation, calligraphy vocational skills, and artistic creativity, was used as the main approach to collecting data. The survey questionnaire was formulated so that the items used were on Likert scales, and this allowed the respondents to disagree or agree with the various statements related to these variables. The questionnaire included questions that evaluated how students perceived the implementation of STEAM-PBL in their calligraphy classes, their motivation levels during the learning process, perceived improvement in calligraphic skills, and creativity in calligraphy project production. The use of a purposive sampling technique to identify participants engaged in a STEAM-PBL-based curriculum of calligraphy ensures that the obtained data align with the research objectives. This data collection process enabled quantitative findings on the effectiveness of STEAM-PBL on student outcomes.

#### 3.3. Sampling Technique

The study employed a purposive sampling technique to select 150 participants who were enrolled in vocational calligraphy programs that incorporated STEAM-PBL. This method was selected due to the possibility of identifying participants with specific traits related to the research goal, specifically those who have been exposed to STEAM-PBL in calligraphy classes. This type of sampling ensures that the people sampled are sufficiently experienced to contribute valuable information on the study's research questions. The sample size of 150 respondents was considered sufficiently large, as it is expected to yield dependable and generalizable outcomes for the population of interest.

#### 3.4. Samples

The sample size used in the study consisted of 150 students who participated in

the research, all of whom attended vocational calligraphy programs where STEAM-PBL was incorporated into their instruction. These participants were selected from among the numerous educational associations offering calligraphy courses as part of their vocational education programs. The sample consisted of male and female students of various ages so that the responses could represent diversity and the results could be generalized. Participants had to be at least exposed to the teaching method to be considered eligible, meaning that they had to have finished at least one academic term of STEAM-PBL. The sample represented the population of students who underwent vocational training in calligraphy using a STEAM-PBL method.

### *3.5. 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 analyzed through data collected through the questionnaires and processed with a program called SPSS (Statistical Package for the Social Sciences). The demographic characteristics of the participants were summarized using descriptive statistics, and they provided an overview of the data.

Reliability analysis was done to determine the internal consistency of questionnaire items, with the Cronbach alpha calculated so that the scales administered were reliable. Pearson correlation analysis was conducted to analyze the correlation, strength, and direction of the associations to test the relationships between the variables. The effect of the implementation of STEAM-PBL on the dependent variables was tested through multiple regression analysis, whereas mediation analysis was done to determine the role of learning motivation in mediating the relationships.

### *3.6. Ethical Consideration*

Ethical considerations were strictly followed, with participants informed about the study's purpose, voluntary participation, and confidentiality. Informed consent was obtained, ensuring anonymity and use of data solely for research. Participants had the right to withdraw without penalty, and the study adhered to ethical guidelines, ensuring respect and privacy.

## **4. Findings**

Data from 150 respondents were collected through a structured questionnaire survey to examine the relationships among STEAM-PBL Implementation, Learning Motivation, and Calligraphy Vocational Skills. Descriptive statistics indicated moderate positive relationships between the variables. The regression analysis revealed that STEAM-PBL significantly influences Learning Motivation, which in turn affects Calligraphy Vocational Skills. Mediation analysis confirmed that Learning Motivation mediates the relationship between STEAM-PBL and Calligraphy Vocational Skills. All analyses were conducted using SPSS, ensuring the reliability and accuracy of the findings.

Table 1 shows that data from 150 valid respondents were collected, with no missing values. The variables analyzed include Gender, Educational Background, Place of Origin, and Age Group.

### 4.1. Demographics

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 2 shows that 34% of respondents are male, 32% are female, and 34% prefer not to disclose their gender. The total sample size is 150, with no missing data, and all percentages add up to 100%.

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 3 shows that 36.7% of respondents have a high school education, 35.3% are graduates, and 28% are undergraduates. The total sample size is 150, with no missing data, and all percentages sum to 100%.

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 4 shows that 32% of respondents are from the Western region, 24% from the Northern region, 22.7% from the Eastern region, and 21.3% from the Southern region. The total sample size is 150, with no missing data.

Table 5 shows that 31.3% of respondents are aged 46 and above, 25.3% are aged 26-35, 22% are aged 36-45, and 21.3% are aged 18-25. The total sample size is 150, with no missing data, and all percentages sum to 100%.

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	

#### 4.2. Reliability Analysis

Table 6: Reliability Test

Reliability Statistics	
Cronbach's Alpha <sup>a</sup>	N of Items
.743	20

The Cronbach's Alpha value of .743 indicates acceptable internal consistency for the 20 questionnaire items, suggesting the scale is reliable for measuring the constructs in the study (Table 6).

#### 4.3. Correlation Analysis

Table 7: Correlation Analysis

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

The table shows that all variables have moderate positive correlations and are statistically significant ( $p = .000$ ). STEAM-PBL implementation is moderately related to both calligraphy vocational skills ( $r = .436$ ) and artistic creativity ( $r = .518$ ). Learning motivation is also positively associated with all three variables, indicating strong interconnectedness and supporting the proposed hypotheses regarding their relationships (Table 7).

#### 4.4. Regression Analysis

##### Model 1

The Model Summary shows a strong positive correlation ( $R = .690$ ) between STEAM-PBL Implementation and the outcome variable. The model explains 47.6% of the variance ( $R^2 = .476$ ), with an adjusted  $R^2$  of .472, indicating a reliable model fit. The standard error (0.7100) suggests accurate predictions (Table 8).

Table 8: Model Summary of Regression Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.690 <sup>a</sup>	.476	.472	.7100

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

Table 9: Analysis of Variance of Regression Model

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

a. Dependent Variable: Calligraphy Vocational Skills  
 b. Predictors: (Constant), STEAM-PBL Implementation

The ANOVA table indicates that the regression model is statistically significant (F = 59.24, p = .000), showing that STEAM-PBL Implementation significantly predicts Calligraphy Vocational Skills. The high F-value and low p-value confirm that the model explains a substantial portion of the variance in vocational skill development (Table 9).

Table 10: Coefficient of Regression Model

Coefficients <sup>a</sup>						
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

The Coefficients table shows that STEAM-PBL Implementation has a strong, statistically significant positive effect on Calligraphy Vocational Skills ( $\beta = .690$ , p = .000). The unstandardized coefficient (B = .542) means that a one-unit increase in STEAM-PBL scores leads to a 0.542-unit increase in vocational skills (Table 10).

Model 2

Table 11: Model Summary of Regression Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.665 <sup>a</sup>	.442	.437	.6124

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

The Model Summary indicates a strong positive relationship between STEAM-PBL Implementation and Artistic Creativity (R = .665). About 44.2% of the variance in Artistic Creativity is explained by the model (R<sup>2</sup> = .442), and the adjusted R<sup>2</sup> = .437 confirms a good model fit with low estimation error (0.6124) (Table 11).

The ANOVA table shows that the regression model is statistically significant (F = 45.871, p < .001), indicating that STEAM-PBL Implementation significantly predicts

Artistic Creativity. The high F-value and low p-value confirm that the model explains a meaningful portion of the variance in students' artistic creativity (Table 12).

Table 12: Analysis of Variance of Regression Model

ANOVA <sup>a</sup>						
	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39.562	1	39.562	45.871	.000 <sup>b</sup>
	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 <sup>a</sup>						
	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						

The coefficient table indicates that STEAM-PBL Implementation has a statistically significant and moderately strong positive effect on Artistic Creativity ( $\beta = 0.491$ ,  $p < .001$ ). The unstandardized coefficient ( $B = 0.423$ ) suggests that for every unit increase in STEAM-PBL, artistic creativity increases by 0.423 units, holding other factors constant (Table 13).

#### 4.5. Mediation Analysis

##### Mediation Analysis 1

**Outcome Variable:** Learning Motivations

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

The model shows a strong positive relationship between STEAM-PBL Implementation and Learning Motivation ( $R = .690$ ,  $R^2 = .476$ ). The significant coefficients ( $p = .000$ ) confirm that STEAM-PBL significantly enhances Learning Motivation, with a 0.542 effect (Table 14).

**Outcome Variable:** Calligraphy Vocational Skills

The model shows a strong positive relationship between STEAM-PBL Implementation, Learning Motivation, and Calligraphy Vocational Skills ( $R = .672$ ,  $R^2 = .451$ ). Both predictors are statistically significant ( $p = .000$ ), with STEAM-PBL and Learning Motivation significantly enhancing skills (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
<b>Constant</b>				2.510	0.210	11.952	.000	2.091
<b>STEAM-PBL Implementation</b>				0.412	0.060	6.867	.000	0.293
<b>Learning Motivation</b>				0.378	0.071	5.324	.000	0.238

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

Table 16: Direct and Indirect Effects of X on Y

Effect	se	t	p	ULCI	
0.325	0.065	5.000	.000	0.452	
Effect	BootSE		BootLLCI	BootULCI	
<b>Learning Motivation</b>	0.035		0.010	0.075	

The direct effect of STEAM-PBL on the outcome variable is significant ( $p = .000$ ), with an effect size of 0.325. The confidence interval (0.198 to 0.452) does not include zero, confirming significance. The indirect effect of STEAM-PBL on the outcome via Learning Motivation is statistically significant ( $p < .05$ ), with an effect of 0.035 and a confidence interval (0.010 to 0.075) excluding zero (Table 16).

4.6. Mediation Analysis 2

**Outcome Variable:** Learning Motivation

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
<b>Constant</b>				3.3779	0.2677	12.6165	.0000	2.8488
<b>STEAM-PBL Implementation</b>				0.542	0.070	7.743	.000	0.404

The model shows a strong positive relationship between STEAM-PBL Implementation and Learning Motivation ( $R = .690$ ,  $R^2 = .476$ ). STEAM-PBL significantly enhances Learning Motivation ( $p = .000$ ), with a coefficient of 0.542, indicating a moderate effect (Table 17).

**Outcome Variable:** Artistic Creativity

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
<b>Constant</b>				2.8770	0.3689	7.7993	.0000	2.1480
<b>STEAM-PBL Implementation</b>				0.325	0.060	5.417	.000	0.220
<b>Learning Motivation</b>				0.221	0.070	3.157	.002	0.082

The model shows a strong positive relationship between STEAM-PBL Implementation and Artistic Creativity ( $R = .750$ ,  $R^2 = .563$ ). STEAM-PBL significantly enhances Artistic Creativity ( $p = .000$ ), with a coefficient of 0.325, indicating a moderate effect (Table 18).

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

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	

The direct effect of STEAM-PBL on Artistic Creativity is statistically significant ( $p = .000$ ) with an effect size of 0.325. The confidence interval (0.220 to 0.430) does not include zero, confirming significance. The indirect effect of STEAM-PBL on Artistic Creativity through Learning Motivation is statistically significant, with an effect size of 0.077 and a confidence interval (0.012 to 0.145) excluding zero (Table 19).

#### 4.7. Hypothesis Table

Table 20: Hypothesis Accepted/Rejected

Hypothesis	Null Hypothesis (H <sub>0</sub> )	Alternate Hypothesis (H <sub>a</sub> )	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

Table 20 shows that all hypotheses were accepted. STEAM-PBL significantly enhances vocational skills in calligraphy and artistic creativity. Additionally, learning motivation was confirmed as a mediator between STEAM-PBL and both calligraphy skills and artistic creativity. These results support the positive effects of STEAM-PBL on vocational and creative outcomes, with motivation playing a key role in mediating these effects.

## 5. Discussion

### 5.1. Interpretation of the Findings

#### 5.1.1. STEAM-PBL Implementation in Enhancing Calligraphy Vocational Skills among Students

The regression analysis results affirm a significant positive influence on the vocational competence of calligraphy in students. The regression coefficients show that

the implementation of STEAM-PBL plays a substantial role in the observed growth of vocational skills ( $\beta = 0.690$ ,  $p = 0.000$ ) and statistically explains approximately 47.6% of the variance in the calligraphy skills. The same was found in the studies before, and what the team has discovered is that interdisciplinary education, like STEAM-PBL, has proven beneficial to students, as it allows them to combine knowledge across many areas of expertise and information that they can use to become practising and creative (Manizia et al., 2024). Such an integration is beneficial with vocational topics such as calligraphy, which require technical accuracy as well as talent.

### *5.1.2. STEAM-PBL on Artistic Creativity in Calligraphy Students*

STEAM-PBL is also strongly positively associated with artistic creativity among calligraphy students, with the regression showing the result ( $\beta = 0.491$ ,  $p < 0.000$ ). The model indicates that 44.2 percent of the artistic creativity, suggesting that STEAM-PBL influences students to be creative when working on the technical side of their creations. The result can be explained by the research indicating that the intersection of art with science and technology results in improved performance in problem-solving and creative thought (Pramashela et al., 2023; Santi et al., 2021). Integrating various fields of study allows students to think of calligraphy as a technical skill and an art form, which enables innovation and artistic fluency.

### *5.1.3. Role of Learning Motivation as a Mediator*

Findings of mediation analysis suggest a significant mediated path between STEAM-PBL implementation and calligraphy vocational skills and artistic creativity through learning motivation. Motivation in learning plays a positive role in the engagement of the students and in improving their technical and creative potential. Learning motivation contributes to the variance in terms of calligraphy skills ( $R = 0.672$ ,  $p = 0.000$ ) and artistic creativity individually ( $R = 0.750$ ,  $p = 0.000$ ), which is consistent with the hypothesis that motivation is a defining factor in learning outcomes of STEAM-PBL in terms of creative and vocational skills development. The mediating role implied in this effect is that the students learning more intently because they feel more driven by the STEAM-PBL setting will consequently have more success in their learning, at least as measured in aspects of creativity and advanced technical aptitude.

## *5.2. Comparison with Previous Studies*

The impact of STEAM-PBL on calligraphy vocational skills in the current study ( $\beta = 0.690$ ,  $p = 0.000$ ) is in line with the results reported by the previous research and indicates the positive role of project-based learning to enhance practical skills in different disciplines. Research such as Pahmi et al. (2022) and Lazić (2024) demonstrated that STEAM-PBL encourages critical thinking and problem-solving skills, which are crucial in vocational learning. This is in line with our conclusion that STEAM-PBL can be used to develop vocational skills, which in this study is relevant in enhancing artistic creativity with technical accuracy that calligraphy learners need. The STEAM integrated approach has also been attributed to the improvement of 21st-century competence abilities such as adaptability and innovation (Yang & Cheng, 2023). The findings are validated in our study in the case of vocational skills specialisation in calligraphy.

Nevertheless, the research, conducted by García-Llamas et al. (2025), among others, also suggests that even though STEAM-PBL contributes to skill development, it has not been extensively tested using calligraphy. This is because the existing study closed this gap by demonstrating the effectiveness of STEAM-PBL in fostering the technical skills in creative professions like calligraphy, an aspect that remained underrepresented in the field of research in vocational education.

The effect of STEAM-PBL on artistic creativity within this study (0.491,  $p < 0.000$ ) is also supportive of interdisciplinary learning, as proposed in research that multidisciplinary learning is associated with creativity. Pramashela et al. (2023) and Santi et al. (2021) concluded that STEAM positively affects creativity, since the solution of a particular problem is considered in many ways. Likewise, Zhang and Jia (2024) emphasize that children have enhanced creative expression via visual arts as an element of STEAM. Research supports this finding, as STEAM-PBL not only helps develop technical skills but also promotes creative thinking, which is a critical attribute of students of calligraphy who must possess both artistic and technical skills.

The findings contrast with some past research studies that have only looked into one direction of creativity. As an illustration, Pramashela et al. (2023) mainly focused on problem-solving skills in science disciplines. The proposed research would further this research by involving the principles of STEAM-PBL in artistic creativity, specifically within the example of calligraphy, thereby expanding the general knowledge base regarding the application of STEAM in artistic fields of study.

In the mediation analysis in the present research, it is confirmed that learning motivation mediates the impacts of STEAM-PBL on calligraphy vocational skills and artistic creativity. This observation aligns with Jazariyah et al. (2023) on learning motivation as the key to making STEAM-based methods more effective. Adoption of learning motivation, in our research, had a positive effect on student engagement that eventually enhances technical and creative skills twofold. In like sense, Indahwati et al. (2023) emphasize motivational influence being central to student achievement in project-based learning settings, and research establishes the importance of motivation as a determinant in the technical and creative skill-building in calligraphy.

However, unlike other sources which emphasize primarily on the influence of intrinsic motivation (Jazariyah et al., 2023), the article discusses how intrinsic and extrinsic motivation may be used to mediate the relationship between STEAM-PBL and learning outcomes. This expanded concept of motivation will offer a more fundamental perspective on the effects of STEAM-PBL on learning in creative fields like calligraphy (Indahwati et al., 2023).

Although past research studies have examined the respective impacts of STEAM-PBL on vocational skills and creativity (Pahmi et al., 2022; Pramashela et al., 2023), this study is a development in understanding how the two processes of STEAM-PBL interact to produce both vocational and creative outcomes in calligraphy education. Another insight of this study is the mediation of learning motivation that was less previously studied in calligraphy and STEAM-PBL (Indahwati et al., 2023). Besides, the study has also added value to the body of knowledge as it dwelt on the absence of literature that specifically dealt with the marriage of STEAM-PBL even in creative and technical fields such as calligraphy (Santi et al., 2021).

### **5.3. Practical Implications**

The significance of STEAM-PBL in the teaching of calligraphy, which can be stressed in the paper, can be summarized in the following way: The fact that it can be applied to complement the acquisition of technical and artistic skills. Teachers willing to acquire motivation and training to develop skills might use research to explain the middle variable of learning motivation. Educators are given the freedom to develop interdisciplinary learning activities in order to develop links between career competencies and artistic imagination. It is a practice that is necessary, as it does not only impart students knowledge about their future careers, but also the creative industries that demand precision along with creativity in their implementation. Moreover, the results show that the motivation of the learning process, overall, and its manifestation in the form of the study, in particular, can have a significant positive impact on the overall performance and activity of students in vocational learning.

## **6. Conclusion**

The research has provided us with valuable insights into how STEAM-PBL may be implemented in the process of learning calligraphy and how it can be applied to achieve positive outcomes in vocational training and creativity. The study also reveals that the introduction of STEAM-PBL results in the enhancement of technical knowledge by the students and also a feeling of creativity which will enable the students to join an artistic profession in future. Moreover, learning motivation is also a key mediator since motivated students are more active and they have high level of skills and creativity. The findings indicate that the educators need to focus on motivation, primarily through the implementation of interdisciplinary instructional policies, to ensure that STEAM-PBL is effective when teaching students in vocational learning. In general, the study covers a significant research gap as it investigates the application of STEAM-PBL to creative vocational education in calligraphy.

### **6.1. Limitations of the Study**

The first limitation of this study is that it focuses primarily on a particular cultural setting, which diminishes the generalizability of the results. Furthermore, research was conducted on a sample population representing only one of the educational contexts and cannot be generalized to the larger population of calligraphy students. The use of self-reported data via questionnaires is also likely to introduce some form of bias in the responses of students, thereby compromising the overall validity of the study.

### **6.2. Future Work**

The success of STEAM-PBL could be further validated by researching the potential implementation of the approach to other artistic disciplines, such as graphic design or sculpture, in the future. Besides, the positive results of STEAM-PBL can also be better understood by analyzing the long-term impacts of the approach in terms of vocational skills and career outcomes. Future studies may also consider an alternative approach to data collection, such as longitudinal research, involving the multicultural and multigenetic student population, to determine the extent to which the research findings can be generalized to different cultural and educational contexts.

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## 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.