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How Steam-Based Learning Fosters Entrepreneurial Mindset: The Serial Mediating Roles of Creative Problem-Solving and Opportunity Recognition

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A B S T R A C T

This study examines how STEAM-based learning fosters entrepreneurial mindset through the serial mediating roles of creative problem-solving and opportunity recognition, offering a cognitive-process explanation of how interdisciplinary learning supports entrepreneurship education. Using a quantitative explanatory cross-sectional survey, data were collected from 103 second-semester Economic Education students after completing an entrepreneurship course and participating in project-, problem-, interdisciplinary-, or STEAM-related learning activities. STEAM-based learning, creative problem-solving, opportunity recognition, and entrepreneurial mindset were measured using five-point Likert scales and analysed with PLS-SEM. Results show that STEAM-based learning enhances creative problem-solving and entrepreneurial mindset, while creative problem-solving improves opportunity recognition, which subsequently strengthens entrepreneurial mindset. Serial mediation was confirmed, suggesting that entrepreneurship education should integrate interdisciplinary, problem-centred, and opportunity-oriented learning.

INTRODUCTION

Economic uncertainty, technological disruption, and rapidly changing labour market demands have intensified the need for graduates who are not only knowledgeable but also capable of thinking entrepreneurially. In higher education, this development has expanded the role of entrepreneurship education from the transmission of business knowledge toward the cultivation of adaptive, creative, proactive, and opportunity-oriented ways of thinking. Within this context, entrepreneurial mindset has emerged as an important educational outcome because it reflects students' capacity to recognise value-creation opportunities, tolerate ambiguity, respond proactively to uncertainty, and develop innovative responses to complex problems (Amalia & von Korflesch, 2021; Liszt-Rohlf et al., 2026). Developing such a mindset is increasingly important because graduates are expected not merely to enter existing labour markets, but also to identify emerging needs, create new forms of value, and adapt to changing social and economic conditions.

Despite its importance, the development of entrepreneurial mindset in higher education remains challenging. Entrepreneurship education is still frequently delivered through content-oriented and theory-driven approaches that emphasise business concepts, planning, and procedural knowledge while providing relatively limited opportunities for students to experience the cognitive processes involved in entrepreneurial thinking. Entrepreneurial mindset, however, is unlikely to develop solely through the acquisition of entrepreneurial knowledge. It is more effectively cultivated through experiential, interdisciplinary, and problem-centred learning environments that enable students to investigate authentic problems, generate and evaluate ideas, recognise opportunities, and translate those opportunities into potential value creation (Larsen & Warhuus, 2025; Mawson et al., 2023; Udeozor et al., 2025). This condition creates a pedagogical need to identify learning approaches that can foster entrepreneurial mindset through explicit cognitive mechanisms rather than assuming that exposure to entrepreneurship education automatically produces entrepreneurial ways of thinking.

STEAM-based learning offers a potentially relevant pedagogical response to this challenge. By integrating science, technology, engineering, arts, and mathematics, STEAM-based learning encourages students to connect knowledge across disciplinary boundaries, investigate authentic problems, experiment with alternative solutions, collaborate, and produce creative outcomes (Liu & Wu, 2025; Surur et al., 2025). These characteristics are closely aligned with entrepreneurial learning because entrepreneurial activity also requires integrative thinking, creativity, sensitivity to emerging needs, and the ability to transform problems into feasible solutions. Accordingly, STEAM-based learning may extend beyond its conventional application in science and technology education and function as a pedagogical foundation for entrepreneurship education.

The influence of STEAM-based learning on entrepreneurial mindset, however, may operate through a sequence of cognitive processes. Interdisciplinary learning situations require students to analyse problems from

different perspectives, combine technical and creative knowledge, and design workable responses. Such experiences can strengthen creative problem-solving, defined as the capacity to generate original, flexible, and practical solutions to complex problems (Bianchi & Verganti, 2021; Shahat et al., 2026; Van Hooijdonk et al., 2023). In entrepreneurship education, this capability is particularly relevant because entrepreneurial action often begins by reframing existing problems, identifying unmet needs, and imagining alternative possibilities for creating value.

Creative problem-solving may subsequently facilitate opportunity recognition. Students who can generate and evaluate alternative solutions are more likely to perceive problems not only as obstacles but also as potential opportunities. They may become better able to interpret changing needs, identify gaps, and assess possibilities that can be converted into entrepreneurial value. Opportunity recognition is therefore central to entrepreneurial cognition because it represents the ability to identify, interpret, and evaluate market gaps, social needs, or emerging possibilities that may become the foundation for entrepreneurial action (Schlichte & Junge, 2025; Zhu et al., 2025). From this perspective, creative problem-solving provides a cognitive bridge between interdisciplinary learning experiences and opportunity recognition.

Opportunity recognition, in turn, may strengthen entrepreneurial mindset by encouraging students to think proactively, respond constructively to uncertainty, and perceive changing conditions as potential sources of innovation and value creation. The development of entrepreneurial mindset can therefore be conceptualised as a sequential cognitive process in which STEAM-based learning strengthens creative problem-solving, creative problem-solving facilitates opportunity recognition, and opportunity recognition contributes to entrepreneurial mindset. This perspective provides a more specific explanation of how interdisciplinary learning may influence entrepreneurial thinking rather than treating the relationship as a simple direct effect.

Although previous studies have separately examined entrepreneurship education, STEAM pedagogy, creative problem-solving, opportunity recognition, and entrepreneurial outcomes, several gaps remain. Entrepreneurial mindset has often been treated as a broad outcome of entrepreneurship education without sufficient explanation of the cognitive mechanisms through which it develops. Similarly, STEAM-based learning has been extensively associated with creativity, STEM achievement, interdisciplinary competence, and twenty-first-century skills, but its role as an antecedent of entrepreneurial mindset remains comparatively underexplored. In addition, creative problem-solving and opportunity recognition have commonly been investigated as separate constructs rather than as sequential mechanisms linking learning experiences to entrepreneurial cognition. Consequently, limited empirical evidence explains whether STEAM-based learning initiates a serial process from creative problem-solving to opportunity recognition and ultimately to entrepreneurial mindset.

This study contributes to knowledge by integrating these constructs into a single explanatory model and positioning STEAM-based learning as a pedagogical antecedent of entrepreneurial mindset. The proposed model enriches entrepreneurship education literature by explaining not only whether STEAM-based learning influences entrepreneurial mindset but also how this influence occurs through the sequential cognitive mechanisms of creative problem-solving and opportunity recognition. It also extends the conceptual application of STEAM-based learning beyond its dominant science and technology context into entrepreneurship education. Empirically, the study focuses on second-semester Economic Education students who had completed an entrepreneurship course and had been exposed to project-based, problem-based, interdisciplinary, or STEAM-related learning experiences. This sample provides a relevant context for examining entrepreneurial mindset formation among students who have already encountered entrepreneurship education but are still in the relatively early stage of higher education.

Accordingly, this study aims to examine how STEAM-based learning contributes to entrepreneurial mindset through the serial mediating roles of creative problem-solving and opportunity recognition. Specifically, it investigates whether STEAM-based learning enhances creative problem-solving, whether creative problem-solving strengthens opportunity recognition, whether opportunity recognition contributes to entrepreneurial mindset, whether STEAM-based learning directly influences entrepreneurial mindset, and whether creative problem-solving and opportunity recognition sequentially mediate the relationship between STEAM-based learning and entrepreneurial mindset. By addressing these relationships, the study seeks to provide a clearer explanation of the pedagogical and cognitive processes through which interdisciplinary learning can foster entrepreneurial ways of thinking in higher education.

LITERATURE REVIEW

Entrepreneurial Mindset Theory

Entrepreneurial mindset reflects an individual's ability to think proactively, recognise opportunities, tolerate uncertainty, and create value through innovative action (Amalia & von Korflesch, 2021; Liszt-Rohlf et al., 2026). In higher education, entrepreneurial mindset develops not only through business knowledge but also through experiential, interdisciplinary, and problem-centred learning activities that stimulate creativity and opportunity-oriented thinking (Larsen & Warhuus, 2025; Mawson et al., 2023; Udeozor et al., 2025).

STEAM-Based Learning and Creative Problem-Solving

STEAM-based learning integrates science, technology, engineering, arts, and mathematics to encourage interdisciplinary thinking, experimentation, and the development of creative solutions (Liu & Wu, 2025; Surur et al., 2025). Such learning experiences require students to analyse complex problems from multiple perspectives and generate feasible alternatives, which are central characteristics of creative problem-solving (Bianchi & Verganti, 2021; Shahat et al., 2026; Van Hooijdonk et al., 2023). Therefore, the following hypothesis is proposed:

H1: STEAM-based learning has a positive and significant effect on creative problem-solving.

Creative Problem-Solving and Opportunity Recognition

Creative problem-solving enables individuals to reframe problems, identify unmet needs, and develop alternative solutions. These cognitive processes may help students perceive problems as potential entrepreneurial opportunities. Opportunity recognition involves identifying and evaluating market gaps, social needs, or emerging possibilities that can be transformed into value-creating activities (Schlichte & Junge, 2025; Zhu et al., 2025). Therefore:

H2: Creative problem-solving has a positive and significant effect on opportunity recognition.

Opportunity Recognition and Entrepreneurial Mindset

The ability to recognise opportunities encourages students to interpret uncertainty as a potential source of innovation and value creation. As students become more sensitive to emerging opportunities, they are more likely to develop proactive, adaptive, and entrepreneurial ways of thinking (Amalia & von Korflesch, 2021; Schlichte & Junge, 2025; Zhu et al., 2025). Therefore:

H3: Opportunity recognition has a positive and significant effect on entrepreneurial mindset.

STEAM-Based Learning and Entrepreneurial Mindset

STEAM-based learning promotes interdisciplinary thinking, creativity, experimentation, and problem-oriented action, which are closely related to entrepreneurial cognition. Through authentic and interdisciplinary learning experiences, students may develop a stronger capacity to respond creatively to uncertainty and identify possibilities for value creation (Liu & Wu, 2025; Surur et al., 2025). Therefore:

H4: STEAM-based learning has a positive and significant effect on entrepreneurial mindset.

Serial Mediation of Creative Problem-Solving and Opportunity Recognition

STEAM-based learning may influence entrepreneurial mindset through a sequential cognitive process. Interdisciplinary learning first strengthens creative problem-solving, which subsequently enhances students' ability to recognise opportunities. Opportunity recognition then contributes to the development of entrepreneurial mindset. This sequence integrates the roles of creative problem-solving and opportunity recognition as mechanisms connecting STEAM-based learning with entrepreneurial thinking (Bianchi & Verganti, 2021; Schlichte & Junge, 2025; Van Hooijdonk et al., 2023; Zhu et al., 2025). Therefore:

H5: Creative problem-solving and opportunity recognition serially mediate the relationship between STEAM-based learning and entrepreneurial mindset.

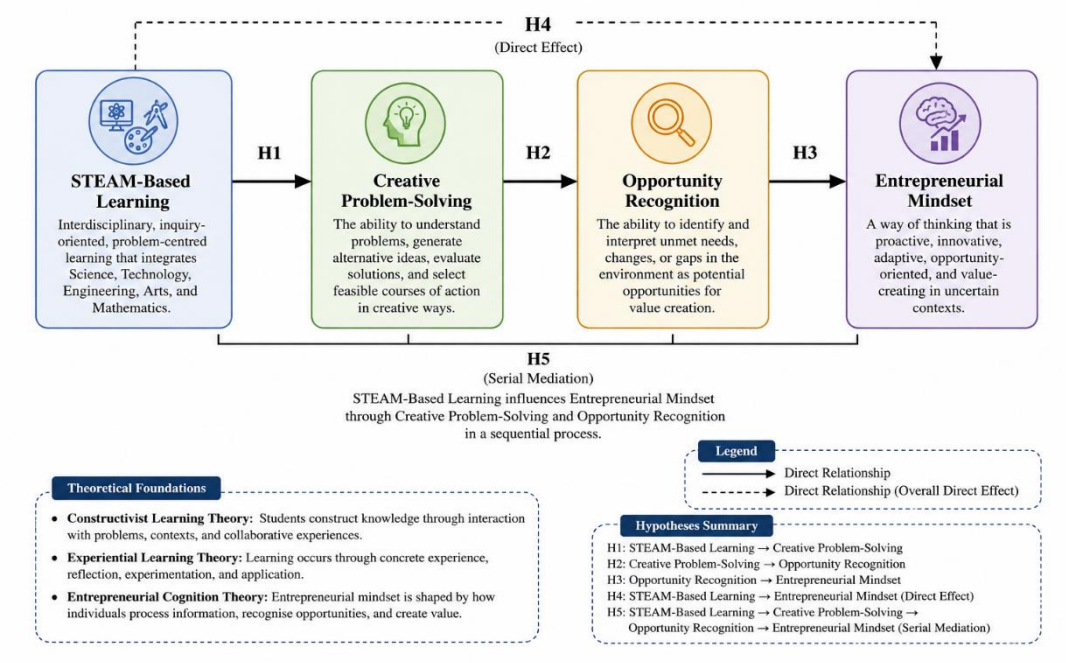


Figure 1. Conceptual Framework

METHODOLOGY

This study employed a quantitative explanatory survey design to examine the effect of STEAM-based learning on entrepreneurial mindset through creative problem-solving and opportunity recognition as serial mediators. The study involved second-semester Economic Education students who had completed an entrepreneurship course and experienced project-based, problem-based, interdisciplinary, or STEAM-related learning activities. The population consisted of 138 students. Using Slovin's formula with a 5% margin of error, 103 respondents were selected through purposive sampling based on the study criteria. Data were collected through a structured questionnaire using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The instrument measured STEAM-based learning, creative problem-solving, opportunity recognition, and entrepreneurial mindset.

The structural model examined the following pathway:

$$SBL \rightarrow CPS \rightarrow OR \rightarrow EM$$

where SBL represents STEAM-based learning, CPS represents creative problem-solving, OR represents opportunity recognition, and EM represents entrepreneurial mindset. The model also examined the direct effect of SBL on EM. Data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The measurement model was assessed through outer loadings, Cronbach's alpha, composite reliability, average variance extracted, discriminant validity, and variance inflation factor. The structural model was evaluated using path coefficients, t-statistics, p-values, R^2, effect size, predictive relevance, and bootstrapping. Statistical significance was determined at $p < 0.05$, including the serial indirect effect of SBL → CPS → OR → EM.

RESEARCH RESULT

This section presents the results of the data analysis conducted to examine the relationships among opportunity recognition, innovation orientation, creative problem solving, STEAM-based learning, and entrepreneurial mindset.

Table 1. Respondent Characteristics (n = 103)

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	29	28.2
	Female	74	71.8
Age	18 years	21	20.4
	19 years	57	55.3
	20 years	20	19.4
	21 years	5	4.9
Semester	Second semester	103	100.0
Study Program	Economic Education	103	100.0

Table 1 shows that the respondents in this study consisted of 103 second-semester students from the Economic Education study program. The majority of respondents were female (71.8%), while male students accounted for 28.2%. In terms of age, most respondents were 19 years old (55.3%), followed by 18 years old (20.4%), 20 years old (19.4%), and 21 years old (4.9%). These results indicate that the respondents were relatively homogeneous in terms of academic background and semester level.

Table 2. Measurement Model Evaluation

Construct	Loading Range	AVE	Cronbach's Alpha	Composite Reliability
STEAM-Based Learning	0.826–0.852	0.709	0.864	0.907
Creative Problem-Solving	0.834–0.861	0.721	0.871	0.911
Opportunity Recognition	0.801–0.839	0.676	0.842	0.893
Entrepreneurial Mindset	0.845–0.872	0.742	0.884	0.920

Table 2 presents the evaluation of the measurement model. The results indicate that all constructs met the recommended criteria for convergent validity and reliability. The loading values for all indicators ranged from 0.801 to 0.872, exceeding the minimum threshold of 0.70. This suggests that the indicators adequately represented their respective latent constructs. In addition, the average variance extracted values ranged from 0.676 to 0.742, which were above the recommended value of 0.50, confirming satisfactory convergent validity. The Cronbach's alpha values ranged from 0.842 to 0.884, while the composite reliability values ranged from 0.893 to 0.920. These values exceeded the recommended threshold of 0.70, indicating strong internal consistency reliability. Overall, the measurement model

demonstrated adequate validity and reliability for further structural model analysis.

Table 3. Direct Effects and Hypothesis Testing

Hypothesis	Path	Path Coefficient β	t-value	p-value	Decision
H1	STEAM-Based Learning → Creative Problem-Solving	0.612	8.214	<0.001	Supported
H2	Creative Problem-Solving → Opportunity Recognition	0.547	6.938	<0.001	Supported
H3	Opportunity Recognition → Entrepreneurial Mindset	0.419	4.882	<0.001	Supported
H4	STEAM-Based Learning → Entrepreneurial Mindset	0.311	3.764	<0.001	Supported

Table 3 presents the results of the direct effects and hypothesis testing. The findings show that all proposed direct relationships were positive and statistically significant. STEAM-based learning had a significant positive effect on creative problem-solving ($\beta = 0.612$, $t = 8.214$, $p < 0.001$), indicating that students who experienced stronger STEAM-based learning were more likely to develop creative problem-solving ability. Creative problem-solving also had a significant positive effect on opportunity recognition ($\beta = 0.547$, $t = 6.938$, $p < 0.001$), suggesting that students with stronger creative problem-solving ability were more capable of identifying and evaluating entrepreneurial opportunities.

Furthermore, opportunity recognition significantly influenced entrepreneurial mindset ($\beta = 0.419$, $t = 4.882$, $p < 0.001$). This indicates that students who were more capable of recognising opportunities tended to demonstrate a stronger entrepreneurial mindset. In addition, STEAM-based learning had a significant direct effect on entrepreneurial mindset ($\beta = 0.311$, $t = 3.764$, $p < 0.001$). Therefore, H1, H2, H3, and H4 were supported.

Table 4. Indirect Effects and Serial Mediation Testing

Hypothesis	Indirect Path	Indirect Effect β	t-value	p-value	Mediation Result
H5	STEAM-Based Learning → Creative Problem-Solving → Opportunity Recognition → Entrepreneurial Mindset	0.140	3.911	<0.001	Supported, Partial Mediation

Table 4 presents the indirect effects and serial mediation testing. The results show that the serial indirect effect of STEAM-based learning on entrepreneurial mindset through creative problem-solving and opportunity recognition was positive and statistically significant ($\beta = 0.140$, $t = 3.911$, $p < 0.001$). This finding supports H5 and confirms that creative problem-solving and opportunity recognition sequentially mediate the relationship between STEAM-based learning and entrepreneurial mindset.

The result indicates that STEAM-based learning enhances entrepreneurial mindset not only directly but also indirectly by first strengthening students' creative problem-solving ability, which subsequently improves their opportunity recognition and finally contributes to entrepreneurial mindset. Since the direct effect of STEAM-based learning on entrepreneurial mindset remained significant, the mediation can be classified as partial mediation. This suggests that STEAM-based learning contributes to entrepreneurial mindset through both direct and indirect mechanisms.

Table 5. Structural Model Summary

Endogenous Variable	**R^2**	**Q^2**	**Interpretation**
Creative Problem-Solving	0.375	0.257	Moderate
Opportunity Recognition	0.299	0.205	Moderate
Entrepreneurial Mindset	0.521	0.356	Moderate to Substantial

Table 5 presents the structural model summary. The R^2 value for creative problem-solving was 0.375, indicating that 37.5% of the variance in creative problem-solving was explained by STEAM-based learning. This suggests that STEAM-based learning provided a moderate explanation of students' creative problem-solving ability. The R^2 value for opportunity recognition was 0.299, meaning that 29.9% of the variance in opportunity recognition was explained by creative problem-solving. This indicates that creative problem-solving played an important role in shaping students' ability to recognise entrepreneurial opportunities.

Meanwhile, the R^2 value for entrepreneurial mindset was 0.521, indicating that 52.1% of the variance in entrepreneurial mindset was explained by STEAM-based learning and opportunity recognition. This value suggests that the model had moderate to substantial explanatory power. In addition, all Q^2 values were greater than zero, indicating that the model had acceptable predictive relevance. Overall, the structural model demonstrated adequate explanatory and predictive power in explaining how STEAM-based learning fosters entrepreneurial mindset through creative problem-solving and opportunity recognition.

DISCUSSION

The findings of this study provide empirical support for the proposed serial mediation model explaining how STEAM-based learning fosters entrepreneurial mindset through creative problem-solving and opportunity recognition. The results show that STEAM-based learning positively influences creative problem-solving, creative problem-solving positively influences opportunity recognition, and opportunity recognition positively influences entrepreneurial mindset. In

addition, STEAM-based learning has a direct positive effect on entrepreneurial mindset, while creative problem-solving and opportunity recognition sequentially mediate the relationship between STEAM-based learning and entrepreneurial mindset. These findings suggest that the development of entrepreneurial mindset is not a spontaneous outcome of entrepreneurship education, but a gradual cognitive process shaped by interdisciplinary learning experiences, creative reasoning, and opportunity-oriented interpretation.

The positive effect of STEAM-based learning on creative problem-solving can be explained by the nature of STEAM pedagogy itself. STEAM-based learning integrates science, technology, engineering, arts, and mathematics into learning experiences that are interdisciplinary, inquiry-based, and problem-centred (Stenard, 2023). This type of learning exposes students to complex problems that cannot be solved through a single disciplinary perspective. As a result, students are encouraged to combine analytical thinking, technical reasoning, creative imagination, and design-oriented approaches when developing solutions. This explains why students who experience stronger STEAM-based learning tend to demonstrate stronger creative problem-solving ability.

This finding is consistent with constructivist learning theory, which argues that learners actively construct knowledge through interaction with problems, contexts, and experiences (Sriarun et al., 2025). In STEAM-based learning, students do not merely receive information from lecturers; they engage with authentic problems, test ideas, collaborate with peers, and refine solutions (Quigley et al., 2017). These processes create the conditions for creative problem-solving because students are required to interpret problems, generate alternatives, evaluate possibilities, and produce workable solutions. Therefore, the significant relationship between STEAM-based learning and creative problem-solving indicates that creativity in problem-solving is strengthened when learning activities provide space for exploration, experimentation, and interdisciplinary knowledge construction (Perignat & Katz-Buonincontro, 2019).

The finding that creative problem-solving positively influences opportunity recognition can be understood through the cognitive logic of entrepreneurship. Opportunity recognition is not simply the act of discovering an existing opportunity; rather, it involves interpreting problems, unmet needs, environmental changes, and constraints as possibilities for value creation (Farrokhnia et al., 2022; Ohlert et al., 2025). Creative problem-solving supports this process because it enables students to reframe problems and imagine alternative ways to address them. When students are able to generate creative and feasible solutions, they become more capable of seeing problems as entrepreneurial opportunities.

This result addresses an important theoretical issue in entrepreneurship education. Many studies discuss opportunity recognition as a key entrepreneurial capability, but fewer explain how this capability is formed through prior cognitive processes. The present finding suggests that creative problem-solving serves as a cognitive antecedent of opportunity recognition. Students first learn to analyse and solve problems creatively; through this

process, they begin to recognise that problems may contain opportunities for innovation, improvement, or value creation. Thus, opportunity recognition emerges not only from market awareness but also from the ability to creatively interpret problems (Nguyen & Thi Thu Le, 2024; White & Hertz, 2022).

The positive effect of opportunity recognition on entrepreneurial mindset can be explained by the central role of opportunity-oriented thinking in entrepreneurship. Entrepreneurial mindset reflects the tendency to think proactively, creatively, adaptively, and in a value-creating manner (Hasan et al., 2026; Lynch & Corbett, 2023). These characteristics are closely connected to opportunity recognition because students who can identify and evaluate opportunities are more likely to perceive uncertainty as manageable and problems as potential sources of innovation. In this way, opportunity recognition strengthens the cognitive foundation of entrepreneurial mindset.

This finding also clarifies why entrepreneurial mindset cannot be developed merely through exposure to entrepreneurship concepts or business knowledge. Students may understand entrepreneurship theoretically, but entrepreneurial mindset requires the ability to connect knowledge with real-world possibilities. Opportunity recognition provides this connection by helping students translate problems, needs, and changes into potential entrepreneurial action (Hou et al., 2022; White & Hertz, 2022). Therefore, the significant effect of opportunity recognition on entrepreneurial mindset indicates that entrepreneurial ways of thinking become stronger when students are able to interpret their environment in terms of opportunity and value creation.

The direct effect of STEAM-based learning on entrepreneurial mindset further shows that interdisciplinary learning experiences can shape entrepreneurial thinking even without relying entirely on the mediating variables. This result can be explained by the fact that STEAM-based learning contains several elements that overlap with entrepreneurial mindset, such as creativity, experimentation, collaboration, adaptability, and solution orientation. Students involved in STEAM-based learning are repeatedly exposed to situations that require them to explore uncertainty, combine ideas, and produce meaningful outcomes (Gu et al., 2023; Perales & Aróstegui, 2024; Quigley et al., 2017). These experiences are similar to the cognitive demands of entrepreneurship, where individuals must act under uncertainty, identify possibilities, and create value from limited resources.

However, the direct effect alone does not fully explain how STEAM-based learning becomes entrepreneurial mindset. The serial mediation result provides a deeper explanation. The significant pathway from STEAM-based learning to entrepreneurial mindset through creative problem-solving and opportunity recognition indicates that STEAM-based learning works through a sequential cognitive mechanism. First, interdisciplinary and problem-centred learning strengthens students' ability to solve problems creatively. Second, creative problem-solving helps students reinterpret problems as entrepreneurial opportunities. Third, opportunity recognition develops students' entrepreneurial mindset by orienting their thinking toward value creation.

This serial pathway is the central analytical contribution of the study because it responds directly to the research gap. Previous studies have often examined STEAM-based learning, creative problem-solving, opportunity recognition, and entrepreneurial mindset as separate constructs. As a result, the mechanism explaining how STEAM-based learning contributes to entrepreneurial mindset formation has remained insufficiently developed. The present findings address this gap by showing that the relationship is not merely direct but sequential. STEAM-based learning fosters entrepreneurial mindset because it first develops creative problem-solving and then enables opportunity recognition.

The partial mediation result is also theoretically meaningful. Since the direct effect of STEAM-based learning on entrepreneurial mindset remains significant while the serial indirect effect is also significant, the findings suggest that STEAM-based learning influences entrepreneurial mindset through more than one pathway. On the one hand, STEAM-based learning directly cultivates entrepreneurial ways of thinking through interdisciplinary, experiential, and solution-oriented activities. On the other hand, it indirectly strengthens entrepreneurial mindset by developing students' creative problem-solving ability and opportunity recognition. This dual pathway explains why STEAM-based learning is an important pedagogical antecedent in entrepreneurship education.

From the perspective of experiential learning theory, the results can be interpreted as evidence that entrepreneurial mindset develops through experience, reflection, experimentation, and application (Chavan & Carter, 2018; Motta & Galina, 2023; Perusso et al., 2020). STEAM-based learning provides concrete experiences through problem-based and project-based activities. Creative problem-solving represents the reflective and experimental stage, where students analyse problems, generate alternatives, and test solutions. Opportunity recognition represents the interpretive stage, where students connect creative solutions with potential value creation. Entrepreneurial mindset then emerges as the outcome of this learning cycle.

From the perspective of entrepreneurial cognition theory, the findings indicate that entrepreneurial mindset is shaped by how students process information and interpret problems (Tahir et al., 2025). STEAM-based learning provides rich learning stimuli, but these stimuli must be cognitively processed before they become entrepreneurial thinking. Creative problem-solving enables students to process problems creatively, while opportunity recognition enables them to interpret those problems entrepreneurially. Therefore, the serial mediation result demonstrates that entrepreneurial mindset is formed through a cognitive transformation process: from interdisciplinary learning experience, to creative solution generation, to opportunity interpretation, and finally to entrepreneurial thinking.

Overall, the findings show that the formation of entrepreneurial mindset depends on the connection between learning design and cognitive development. STEAM-based learning provides the pedagogical foundation, creative problem-solving functions as the mechanism for generating solutions, and opportunity

recognition functions as the mechanism for interpreting those solutions as value-creating possibilities. This explanation moves beyond a simple direct-effect model and offers a deeper understanding of why STEAM-based learning can foster entrepreneurial mindset. The study therefore solves the identified gap by demonstrating that entrepreneurial mindset formation is best understood as a serial process in which interdisciplinary learning first develops creative problem-solving, then strengthens opportunity recognition, and ultimately fosters entrepreneurial mindset.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that STEAM-based learning strengthens entrepreneurial mindset both directly and indirectly through creative problem-solving and opportunity recognition. The serial mediation pathway indicates that interdisciplinary and problem-centred learning first develops students' creative problem-solving ability, which subsequently improves opportunity recognition and entrepreneurial mindset. These findings suggest that entrepreneurship education should integrate authentic problems, interdisciplinary projects, experimentation, creativity, and opportunity exploration to strengthen students' entrepreneurial thinking and value-creation capabilities.

ADVANCED RESEARCH

This study is limited by its cross-sectional design, purposive sampling, relatively small sample of 103 Economic Education students, and reliance on self-reported data. Future research should employ longitudinal, experimental, or mixed-method approaches, involve larger and more diverse samples, and examine additional variables such as entrepreneurial self-efficacy, innovation orientation, digital competence, institutional support, and prior entrepreneurial experience. Further studies may also test the proposed serial mediation model across different disciplines, universities, and cultural contexts.

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