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Developing a Pedagogical Model Integrating E-Learning, PAD Class, and Project-Based Learning for Innovation and Entrepreneurship Education Aligned with the Sustainable Development Goals (SDGs)

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ABSTRACT

This study aimed to develop a pedagogical model for innovation and entrepreneurship education that enhances students' creativity and attitudes, in alignment with Sustainable Development Goal 4 on quality education. The model (referred to as the E-Learning- Presentation-Assimilation-Discussion-Project-Based (EPP) Model) combines online learning, structured classroom interaction, and experiential projects. Grounded in Constructivism Theory, Educational Ecology Theory, and the Theory of Inventive Problem Solving (TRIZ), 9the model was developed using expert validation and implemented in a classroom setting. Students showed notable gains in creativity and learning attitudes after the intervention. These outcomes occurred because the model fosters active engagement, collaborative exploration, and reflective application. The impact of this integrated instructional design offers practical guidance for advancing student-centered, sustainable entrepreneurship education in higher learning institutions.

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1. INTRODUCTION

Innovation and entrepreneurship education has become a major focus in higher education, particularly in response to global calls for 21st-century skills and sustainable development. That is why many reports regarding this matter have been well-documented (Shaturaev, 2022; Adeoye *et al.,* 2022; Gatta *et al*., 2023; Yusof *et al*., 2023; Okebioru & Ige, 2024). In China, national policies have promoted "mass entrepreneurship and innovation" as a means to boost economic transformation, with the State Council urging universities and colleges to strengthen practical training and innovative capacity among students. Vocational colleges are expected to play a vital role in this agenda, yet many still rely on lecture-based approaches that limit student engagement and creative exploration (Zhang, 2023; Zhao & Wu, 2023). Students often lack motivation due to passive learning environments, and they struggle to connect theoretical knowledge with real-world entrepreneurial experiences. These issues directly hinder the achievement of Sustainable Development Goals (SDGs), which emphasizes inclusive, equitable, and quality education that fosters creativity, innovation, and lifelong learning.

To address these gaps, several studies advocate for active learning, blended instruction, and ecologically supportive learning environments that integrate real-life challenges (Li, 2022; Huang & Zhang, 2023). Theoretical insights from Constructivism suggest that knowledge is best constructed through learner interaction and reflection, while Educational Ecology Theory highlights the need to cultivate an interactive, resource-rich environment. Furthermore, the Theory of Inventive Problem Solving (TRIZ) provides systematic tools that can enhance students' creative thinking, especially in solving practical problems. However, prior research often isolates these strategies without integrating them into a cohesive model. A comprehensive, theoretically grounded teaching model that promotes both cognitive (creativity) and affective (attitudes) outcomes remains underdeveloped, particularly in vocational contexts.

The purpose of this study is to develop and evaluate a pedagogical model that enhances students' creativity and attitudes in innovation and entrepreneurship education. The model, designed for vocational college settings, integrates E-Learning, Presentation–Assimilation–Discussion (PAD) Class, and Project-Based Learning into a structured framework grounded in the principles of Constructivism, Educational Ecology, and TRIZ. The novelty of this approach lies in its synthesis of digital learning, interactive classroom practice, and systematic problem-solving to address both instructional effectiveness and student engagement. This study offers a replicable instructional design that supports SDG 4 by equipping students with the creative and entrepreneurial competencies needed in an innovation-driven economy.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

The growing emphasis on innovation and entrepreneurship education reflects a global shift toward equipping students with competencies relevant to economic development, employment, and sustainable futures. Within the framework of SDG 4, which promotes inclusive, equitable, and quality education, innovation and entrepreneurship education serves as a pathway to enhance critical thinking, creativity, and practical skills that support lifelong learning. In China, this educational transformation has been accelerated through policy interventions, particularly the 2015 guideline issued by the State Council to deepen reform in higher education and promote entrepreneurial capacity among students. Despite such initiatives, the implementation of effective pedagogical approaches remains uneven, especially in vocational colleges.

2.1 Innovation and Entrepreneurship Education in China

The push for innovation and entrepreneurship (I&E) education in China's higher education has grown rapidly over the past decade due to policy and economic imperatives. I&E education is

designed to equip students with the mindset and skills to initiate ventures, innovate within organizations, and respond to evolving economic demands. In vocational colleges, this education is typically delivered through standalone courses or embedded modules that include entrepreneurship theory, innovation strategies, and business planning. However, for such programs to be effective, they must move beyond passive content delivery and engage students in real-world, experiential learning environments that foster risk-taking and creativity (Fang *et al*., 2021; Sun & Anbarasan, 2021). Current evidence shows that many institutions still rely on conventional methods that limit student participation and do not meet the intended learning outcomes (Li, 2022).

There remains a gap between curricular objectives and instructional delivery. Entrepreneurship education in vocational contexts often emphasizes theoretical frameworks without offering practice-based engagement, which results in decreased student motivation and weak skill development (Huang & Zhang, 2023). Students in these settings frequently struggle to connect their academic learning with entrepreneurial realities, and educators report difficulty in encouraging creative thinking in rigid, exam-oriented curricula (Zhang, 2023; Zhao & Wu, 2023). These challenges highlight the need for pedagogical innovation that supports SDG 4 by promoting creativity, learner agency, and contextually relevant instruction.

2.2. Constructivism and Active Learning

Constructivist theory offers a foundation for designing entrepreneurship education that encourages knowledge construction through experience and reflection. Rather than viewing students as passive recipients of information, constructivism positions them as active participants who interpret, organize, and apply knowledge in meaningful contexts. In entrepreneurship education, this approach is closely aligned with strategies such as project-based learning, problem-solving tasks, and classroom dialogue that encourage students to build understanding through doing. Research has shown that these approaches can significantly improve learners' motivation, engagement, and creativity (Blumenfeld *et al*., 1991; Hmelo-Silver, 2004).

While constructivism encourages autonomy, excessive learner freedom without guidance can be counterproductive. A structured environment that includes scaffolding and instructor support is often necessary to ensure learning is effective and goal-oriented (Kirschner *et al*., 2006). The Presentation-Assimilation-Discussion (PAD) class model addresses this concern by dividing classroom sessions into phases that guide the learning process while allowing for self-paced exploration and peer interaction. This balance between structure and autonomy is essential in vocational education, where students often benefit from explicit direction while developing independent learning skills.

Furthermore, constructivist pedagogy aligns with SDG 4's emphasis on quality education and lifelong learning by promoting skills such as inquiry, collaboration, and critical thinking. These competencies are essential for navigating uncertainty and complexity in entrepreneurship and innovation-driven work environments.

2.3 Educational Ecology Theory

Educational ecology theory extends the pedagogical lens beyond individual learners to consider the broader systems that shape learning environments. This approach views education as a dynamic ecosystem in which multiple interconnected layers (such as classroom practices, institutional policies, social relationships, and digital resources) jointly influence learning outcomes. The theory supports the idea that creative and entrepreneurial capacity is not solely the product of curriculum design but also of the conditions under which students learn.

A positive educational ecology includes access to mentorship, exposure to diverse perspectives, collaborative spaces, and a culture that values experimentation and innovation (Zhou, 2021; Zhang,

2023). In entrepreneurship education, such an ecology encourages students to test ideas, engage with peers, and interact with external stakeholders such as industry partners and community actors. Educators also play a critical role as facilitators who support exploration and foster trust. Technology-enhanced learning platforms further contribute to this ecology by providing flexible and accessible resources tailored to varied learning needs (Lin *et al*., 2022; Yang *et al*., 2024).

The proposed teaching model applies educational ecology theory by integrating online learning, collaborative classroom formats, and real-world project experiences into a cohesive system. These elements create a learning environment in which students are supported cognitively, socially, and emotionally. This system approach responds directly to SDG 4, which calls for inclusive and effective learning environments that promote equity and innovation.

2.4 TRIZ and Creativity Development

The TRIZ, developed from engineering contexts, provides structured techniques to enhance students' creative thinking. It introduces tools such as contradiction matrices, the 40 inventive principles, and ARIZ algorithms to help learners identify patterns in problems and generate novel solutions. When applied in education, TRIZ offers a systematic framework that fosters innovation while reducing the ambiguity often associated with creativity instruction.

Recent research shows that TRIZ-based instruction can lead to measurable improvements in problem-solving and idea generation across fields such as engineering, technology, and design (Zhu *et al*., 2024). Its application in entrepreneurship education helps students identify user needs, resolve design trade-offs, and innovate business models in a structured manner. When paired with project-based learning, TRIZ encourages disciplined creativity, where students learn not only to generate ideas but also to refine and implement them based on analytical reasoning (Jaramillo-Avila *et al*., 2024).

The proposed model incorporates TRIZ principles in the project-based learning phase, guiding students through structured problem-solving exercises that are grounded in real-world entrepreneurial challenges. This integration ensures that students acquire both the mindset and methodological tools for innovation, a critical component of entrepreneurship education aligned with SDG 4 targets on skills development and employability.

2.5 E-Learning in Blended Innovation and Entrepreneurship Education

The "E" component of the proposed model refers to e-learning, which encompasses asynchronous digital modules, multimedia content, and learning management systems that support flexible study. Blended learning, which combines online and face-to-face methods, has been shown to improve learning outcomes by increasing engagement and accommodating diverse learning preferences (Kimmons *et al*., 2020). In innovation and entrepreneurship education, e-learning enables students to access video lectures, case studies, and digital simulations that expose them to entrepreneurial practices and startup experiences.

From a constructivist perspective, e-learning allows students to acquire foundational knowledge independently before participating in higher-order learning tasks in class. This format aligns with the flipped classroom model, where instructional time is repurposed for deeper discussion, analysis, and application (Suanse & Yuenyong, 2021). In the proposed model, the e-learning phase is designed as a preparatory stage that introduces students to key concepts and triggers questions, which are then addressed during interactive in-person sessions. Studies have shown that well-structured online learning can enhance learner motivation and satisfaction when content is relevant and interactive (Kim & Keller, 2021). This supports SDG 4's objective of providing equitable access to quality education through digital innovation and inclusive learning technologies.

2.6 PAD Class Model

The PAD Class (standing for Presentation, Assimilation, and Discussion) is a structured instructional method developed to enhance classroom engagement. It divides the learning session into three phases: the teacher presents core content, students work independently or in small groups to process the information, and finally, all participants engage in a discussion to consolidate understanding and explore diverse perspectives (Zhang, 2017). This cycle aligns with constructivist principles by blending teacher guidance with student-centered exploration.

Research indicates that PAD classes improve learner participation, confidence, and interest, particularly by empowering students to form their own understanding before entering the group discourse (Huang & Zhang, 2023). In the proposed model, PAD is situated within the "while-class" stage, bridging the e-learning input and the project-based application. The format creates a learning rhythm that supports both cognitive assimilation and social learning through peer interaction. Moreover, the PAD structure directly supports SDG 4's emphasis on learner engagement and the development of transferable skills such as communication and collaboration.

2.7 Project-Based Learning

Project-Based Learning (PBL) is a cornerstone of experiential pedagogy that enables students to apply theoretical concepts to practical, often interdisciplinary challenges (Putra & Sajkti, 2022; Pratiwi *et al*., 2025; Lestari, 2024; Wahyuningasih *et al*., 2024). In entrepreneurship education, PBL typically involves long-term projects such as business proposals, market analysis, or product development. These experiences simulate real-world entrepreneurial processes and provide meaningful contexts for learning. PBL is consistent with experiential learning theory, which emphasizes cycles of experience, reflection, and action.

Numerous studies confirm that PBL enhances problem-solving, creativity, teamwork, and motivation (Blumenfeld *et al*., 1991). In the proposed model, the post-class phase is dedicated to project work, where students collaborate to develop entrepreneurial solutions to local or institutional needs. These activities reinforce not only knowledge application but also critical soft skills required in professional settings. Moreover, PBL addresses both individual and collective learning goals, encouraging students to take ownership of their learning. This aligns with SDG 4's call for relevant and effective learning outcomes that promote lifelong learning and employability.

2.8 Creativity in Education

Creativity is commonly defined as the capacity to generate ideas or solutions that are both novel and appropriate within a specific context. In educational settings, it includes cognitive abilities such as divergent thinking, flexibility, and originality, as well as affective traits like curiosity and risk tolerance. The Williams Creativity Disposition Test, used in this study, evaluates creativity based on dimensions such as imagination, adventurousness, curiosity, and preference for challenge.

Evidence supports the notion that creativity can be cultivated through targeted instructional strategies, including brainstorming, open-ended tasks, and interdisciplinary collaboration (Sternberg, 2021; Runco & Acar, 2012). Within entrepreneurship education, creativity is essential for identifying business opportunities, designing innovative products or services, and adapting to market dynamics. The proposed model promotes creativity through its integration of TRIZ, collaborative discussions, and project-based activities. This systematic and multifaceted approach ensures that creativity is not treated as a spontaneous outcome but as a skill that can be intentionally nurtured. Supporting creativity in education is directly related to SDG 4's goals of fostering inclusive and quality learning that empowers learners to become innovators and problem solvers.

2.9 Attitude and Motivation in Learning

Attitude plays a critical role in learning and can significantly influence a student's engagement, persistence, and academic success. The ARCS model of motivation outlines four key dimensions (Attention, Relevance, Confidence, and Satisfaction) that collectively shape a student's attitude toward learning. Positive attitudes arise when students are intellectually stimulated, see personal value in the learning content, feel capable of succeeding, and derive satisfaction from their accomplishments.

The Course Interest Survey (CIS), grounded in the ARCS model, is widely used to measure learning motivation and has shown strong predictive validity across different educational contexts (Kim & Keller, 2021). Research indicates that instructional approaches that are interactive, relevant, and supportive significantly improve student motivation and engagement (Sharifzadeh & Abdollahzadeh, 2021). In the proposed model, motivation is addressed through multiple channels: e-learning provides flexibility and access, PAD classes offer structure and reflection, and PBL introduces real-world relevance and collaborative satisfaction. These elements work together to build a learning environment that supports positive attitudes, as envisioned by SDG 4's focus on quality education and student empowerment.

2.10 Related Empirical Research

A growing body of empirical studies highlights the benefits of integrating blended and active learning methods in entrepreneurship education. For example, TRIZ-based instructional interventions have been shown to improve students' self-efficacy, innovation capacity, and problem-solving skills in engineering and business domains. Similarly, the use of digital learning platforms combined with face-to-face workshops has resulted in greater student engagement and stronger project outcomes in entrepreneurship courses (Chen, 2020).

However, few studies have comprehensively combined constructivist pedagogy, educational ecology, and TRIZ into a single teaching model validated through both expert review and empirical testing. The proposed model fills this gap by offering a theoretically grounded and practically tested approach to innovation and entrepreneurship education. Its development and implementation in a vocational college setting adds to its significance, especially in light of the urgent need for scalable educational solutions that align with global development goals. As such, this model contributes to advancing SDG 4 by demonstrating how blended, learner-centered pedagogy can enhance both cognitive and affective outcomes in higher education.

3. METHOD

3.1. Research Design

This study employed a research and development (R&D) design with three main phases: (i) context and needs analysis, (ii) model development and validation, and (iii) model implementation and evaluation. Detailed information regarding this method is explained elsewhere (Susilawati *et al*., 2025).

The methodology was designed to ensure that the proposed teaching model is both theoretically grounded and empirically tested. Data collection involved both quantitative and qualitative methods, including questionnaires, expert reviews, and experimental intervention. The design allowed for iterative refinement of the model through expert feedback and student learning outcomes, ensuring that it is responsive to contextual challenges in vocational education and aligned with the learning needs of the students.

3.2. Model Development and Validation

Figure 1 presents the structure of the proposed pedagogical model, referred to as the EPP Teaching Model, which integrates E-Learning, Presentation–Assimilation–Discussion (PAD) Class, and Project-Based Learning within a constructivist and ecological framework. The model is designed around six components: theoretical foundations, learning objectives, instructional syntax, social system, principles of action, and support system.

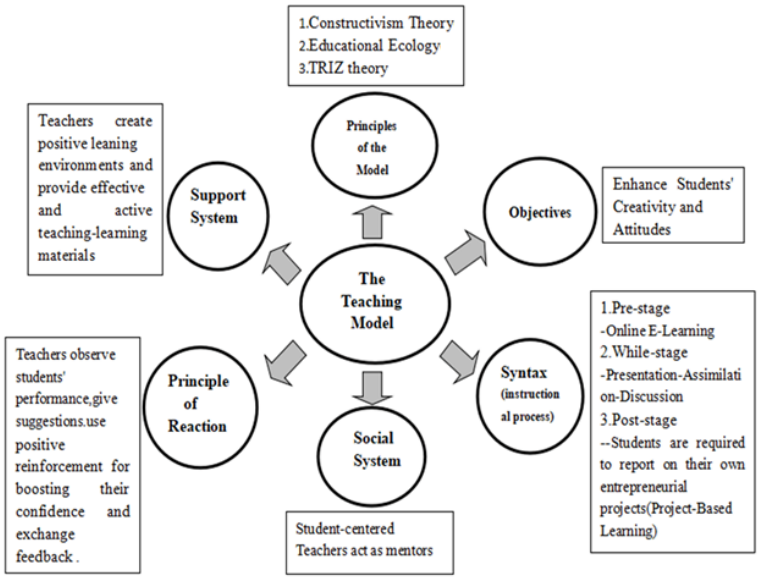

Figure 1. The structure of the teaching model.

The model was developed in response to the findings from the initial phase, which revealed students' lack of motivation and creativity in traditional entrepreneurship courses. It draws from Constructivism Theory, Educational Ecology Theory, and the Theory of Inventive Problem Solving (TRIZ), integrating these perspectives into a coherent instructional system. The syntax of the model is divided into three stages: pre-class (E-Learning), while-class (PAD Class), and post-class (Project-Based Learning), with each phase designed to scaffold learners' understanding and engagement.

To validate the model's structure and content, five experts in education and entrepreneurship were consulted. The evaluation used a four-point Likert scale assessing relevance, clarity, and applicability. The item-level content validity index (I-CVI) ranged from 0.80 to 1.00, with the average scale-level content validity index (S-CVI/Ave) reaching 0.94, indicating excellent agreement among reviewers. The social system component received the lowest score (I-CVI = 0.80), suggesting a need for further clarification on participant roles, while the syntax and support system components received perfect consensus.

3.3. Implementation of the Teaching Model

After validation, the EPP Teaching Model was implemented over eight weeks in a classroom of 45 students from the Department of Finance and Economics. The students were in their second year of study and had no prior experience with TRIZ or project-based learning. The model was embedded into the course "Innovation and Entrepreneurship Education" and delivered through three integrated stages.

In the pre-class stage, students accessed digital materials through a learning management system. These included video lectures, entrepreneurship case studies, and interactive quizzes. This

asynchronous phase aimed to prepare students with foundational knowledge and stimulate curiosity before face-to-face instruction.

The while-class stage applied the PAD model. Instructors began by presenting key concepts in innovation and entrepreneurship, followed by student assimilation activities where learners independently analyzed concepts and engaged with reflective prompts. The class concluded with open discussions where students exchanged perspectives, received feedback, and connected ideas to real-world scenarios.

In the post-class stage, students worked in small teams to complete entrepreneurial projects. These included idea generation, market research, business model development, and final presentations. Instructors facilitated group coaching sessions, and students applied TRIZ principles to solve challenges encountered during their projects.

Formative assessment strategies were used throughout the intervention, including participation tracking, peer reviews, project rubrics, and reflection journals. The final assessment combined group project scores with individual post-tests measuring creativity and attitude outcomes.

3.4. Research Instruments

Two validated instruments were used to measure the effectiveness of the teaching model:

(i) The Williams Creativity Disposition Test (WCDT), which includes subscales for imagination, curiosity, adventurousness, and challenge. Each item was rated using a 5-point Likert scale, with higher scores indicating greater creative disposition.

(ii) The Course Interest Survey (CIS), based on Keller's ARCS model, was used to assess learning motivation. It includes subscales for attention, relevance, confidence, and satisfaction. This survey also uses a 5-point Likert scale.

Both instruments were translated and piloted with a small group of students to ensure clarity and contextual suitability. Internal consistency reliability scores (Cronbach's alpha) for the translated versions exceeded 0.85 for all subscales.

Demographic data were collected through a general background questionnaire completed by 200 students in the initial needs analysis phase. The purpose was to understand the learner profile and identify contextual variables that might affect implementation.

3.5. Data Analysis Techniques

Quantitative data from the pre-test and post-test instruments were analyzed using IBM SPSS. We analyzed statistics to get a better understanding of the results. Detailed information on how to analyze using statistical analysis is reported elsewhere (Fiandini *et al*., 2024).

First, descriptive statistics were calculated for all subscales. Then, the Shapiro-Wilk test was used to examine the normality of score distributions. As shown in later sections, all p-values were above 0.05, confirming that the data met the assumptions for parametric testing.

Paired sample t-tests were conducted to determine whether the differences between pre- and post-test scores were statistically significant. Effect sizes were calculated using Cohen's d, interpreted as small (0.2), medium (0.5), or large (0.8+). The significance level was set at $p < 0.05$.

Qualitative data from student reflections and expert feedback were analyzed thematically. Key themes included increased learner autonomy, improved teamwork, enhanced problem-solving, and positive perception of structured innovation strategies. This mixed-methods analysis allowed for triangulation of findings and deeper insight into how and why the model achieved its outcomes. It also enabled the research team to make evidence-based revisions for future scaling and adaptation.

4. RESULTS AND DISCUSSION

4.1. Baseline Data for Developing the Teaching Model

Table 1 presents the demographic data of participants who were surveyed during the first phase of the study. The respondents included 200 students from the Faculty of Finance and Economics, who completed a questionnaire measuring their baseline attitudes and creativity dispositions related to innovation and entrepreneurship education. The data show that 54% of the respondents were female, and the majority of participants came from rural backgrounds and had completed an ordinary high school education. Most students were in their first or second year of study.

The demographic findings suggest that the sample was relatively diverse in terms of background, though heavily weighted toward early-year students. This aligns with the institutional context of vocational education, where students often come directly from secondary school and may lack prior exposure to entrepreneurial experiences.

The initial creativity scores revealed moderate self-perceptions in areas such as imagination (M ≈ 3.3) and curiosity, with lower scores in adventurousness (M ≈ 2.9). Meanwhile, students' attitudes toward entrepreneurship learning (measured through the CIS) also revealed modest levels, particularly in dimensions such as confidence and satisfaction, where average scores hovered around 3.1. Qualitative interviews with 10 students and 5 faculty members further contextualized these findings. Students expressed a general sense of disengagement with traditional lecture formats and described classes as overly theoretical with few opportunities for practical exploration. Instructors reported that curriculum constraints and assessment pressures hindered the inclusion of project-based or interactive tasks. These insights reinforced the need for a pedagogical model that fosters creative engagement, peer collaboration, and motivational support.

Table 1. The Basic information of the questionnaire participants.

Item	Category	Number of People	Percentage (%)
Gender	Male	92	46.00
	Female	108	54.00
Place of Origin	Urban	83	41.50
	Rural	117	58.50
Education Background	Vocational High School	44	22.00
	Ordinary High School	156	78.00
Grade Level	Freshman	82	41.00
	Sophomore	88	44.00
	Junior	30	15.00

4.2 Development and Validation of the Teaching Model

Table 2 outlines the structural components of the proposed teaching model, which was developed in response to the contextual challenges identified. The model consists of six integrated components: theoretical principles, objectives, instructional syntax (pre-, while-, and post-stages), social system, principles of action, and support system. The syntax includes a blend of E-Learning, PAD Class, and Project-Based Learning, offering a scaffolded learning experience from concept acquisition to practical application.

To ensure content validity, five experts evaluated the model using a rating scale and qualitative feedback. Each component received high scores on relevance and clarity, with item-level Content Validity Index (I-CVI) values ranging from 0.80 to 1.00. Notably, the syntax and support system components achieved perfect agreement among experts. This confirms that the model's structure is

well-aligned with pedagogical theory and practical demands. The slightly lower score (I-CVI = 0.80) in the social system component may suggest the need for clearer role delineation between instructors, students, and external mentors, which is a common challenge in collaborative learning environments.

The model reflects a student-centered design grounded in Constructivism, Educational Ecology, and TRIZ. Its emphasis on structured interaction and real-world relevance supports both creative development and affective engagement. This is particularly significant in vocational education, where motivation and self-efficacy are critical to learning persistence. The strong expert endorsement further positions the model as a robust framework for broader application.

Table 2. The structure of the teaching model.

Component	Content
Theoretical Basis	Constructivism Theory, Educational Ecology Theory, TRIZ Theory
Teaching Objectives	To enhance students' creativity and attitude in innovation and entrepreneurship education
Instructional Syntax	Pre-Class: E-Learning While-Class: PAD Class (Presentation–Assimilation–Discussion) Post-Class: Project-Based Learning
Social System	Teachers act as facilitators; Students as active learners; Emphasis on peer collaboration and mutual support
Principles of Action	Centered on learner participation, problem-solving, and experiential reflection

4.3. Implementation Results: Entrepreneurial Project Performance

Table 3 summarizes the results from students' entrepreneurial project work during the implementation phase of the study. Over eight weeks, 45 students formed small groups to develop and present original business proposals. Their performance was evaluated across five dimensions: creativity and innovation, problem-solving, feasibility, team collaboration, and communication skills. The assessment used a 5-point Likert scale and compared pre- and post-intervention scores.

The results show substantial improvements across all criteria. The creativity and innovation dimension improved by 51.6%, while problem-solving showed a 47.4% increase. Similarly, gains in feasibility (44.7%), team collaboration (42.9%), and presentation skills (43.6%) reflect the positive impact of the teaching model. These improvements suggest that students were better able to integrate theoretical knowledge with practical application, demonstrating enhanced confidence in expressing and refining their ideas. These outcomes support the model's emphasis on experiential learning and structured creativity. The inclusion of TRIZ tools likely contributed to students' capacity to approach problems methodically while maintaining openness to original solutions. Moreover, the collaborative nature of the project work likely improved students' interpersonal skills and group management abilities, essential components of entrepreneurial competence. These findings align with previous research that links project-based learning with elevated levels of creative confidence and task ownership.

Table 3. Summary of students' entrepreneurial project performance.

Dimension	Pre-Test Score	Post-Test Score	Improvement (%)
Creativity and Innovation	2.36	3.58	51.60
Problem-Solving	2.47	3.64	47.40
Feasibility	2.58	3.73	44.70
Team Collaboration	2.67	3.81	42.90
Presentation Skills	2.73	3.92	43.60

4.4. Gains in Creativity and Attitudes

Table 4 presents descriptive statistics for both the Williams Creativity Disposition Test and the CIS, comparing pre-test and post-test scores. All subcomponents showed meaningful improvements. For example, in the CIS, attention increased by +1.13 points, relevance by +1.07, confidence by +1.15, and satisfaction by +1.17. In the creativity test, the largest gains occurred in imagination and adventurousness (both +1.27), with curiosity (+1.10) and challenge (+1.14) also improving significantly. The overall gain in creativity score was +1.20.

These results indicate that the EPP Teaching Model successfully enhanced both cognitive and affective learning outcomes. The significant growth in imagination and adventurousness suggests that the model encouraged students to think beyond familiar boundaries and embrace uncertainty as key attributes in entrepreneurial contexts. The improvement in satisfaction and confidence implies that students perceived value in the learning process and felt more capable of succeeding within it. The magnitude of these changes is particularly relevant for vocational learners, who may begin with lower self-confidence in academic or innovation-related domains. The scaffolded nature of the model (starting with e-learning, moving through guided class discussion, and culminating in real-world application) appears to build competence progressively, aligning with the ARCS motivation framework. Furthermore, the integration of digital tools and feedback mechanisms likely reinforced learner autonomy and engagement, directly supporting SDG 4's call for inclusive, effective, and student-centered education.

Table 4. Descriptive statistics of creativity and attitudes scores before and after implementation.

Variable	Pre-Test Mean	Post-Test Mean	Mean Difference
Attention	2.91	4.04	+1.13
Relevance	3.01	4.08	+1.07
Confidence	3.11	4.26	+1.15
Satisfaction	3.06	4.23	+1.17
Imagination	3.30	4.57	+1.27
Curiosity	3.18	4.28	+1.10
Adventurousness	2.90	4.17	+1.27
Challenge	3.14	4.28	+1.14

4.5. Normality Test and Hypothesis Testing

Table 5 shows the results of the Shapiro–Wilk test conducted to assess the normality of pre-test and post-test data distributions for both the CIS and the Williams Creativity Disposition Test (WCDT). The p-values for all variables were greater than 0.05, indicating that the assumption of normality was met. This allowed for the use of parametric statistical tests, specifically paired sample t-tests, to compare pre- and post-intervention scores. The confirmation of normality ensures the reliability of further statistical analysis. The WCDT and CIS instruments have been previously validated for use in educational research, and the adherence to distribution assumptions adds credibility to the significance testing. Establishing data normality is essential in measuring learning gains accurately and ensuring that improvements observed in students' creativity and attitudes are not artifacts of sampling bias or distribution anomalies.

Table 6 presents the results of the paired sample t-tests conducted to determine whether the observed differences in creativity and attitude scores before and after the implementation of the EPP Teaching Model were statistically significant. All variables showed p-values less than 0.001, indicating highly significant improvements. The effect sizes (Cohen's d) ranged from 1.52 to 1.87, reflecting strong educational impacts across all dimensions.

The improvements in the CIS subscales (attention, relevance, confidence, and satisfaction) demonstrate that the instructional approach effectively enhanced students' motivation and engagement. The largest gains in creativity occurred in imagination and adventurousness, suggesting that the model encouraged both free exploration and risk-taking. These outcomes affirm that the integration of TRIZ, PAD class interaction, and real-world projects provided a learning ecosystem where students could both imagine and act upon novel ideas.

From a motivational perspective, these gains align well with the ARCS framework. The e-learning component captured students' attention; the PAD structure emphasized relevance and confidence-building through discussion; and the project work offered satisfying outcomes. The cognitive dimension of creativity, enhanced through guided application of TRIZ tools, contributed to students' willingness to engage in innovation. Collectively, these improvements demonstrate the model's potential to foster sustainable learning attitudes and competencies, contributing meaningfully to the goals of SDG 4.

Table 5. Shapiro–Wilk test for normality.

Variable	W Statistic	Significance (p-value)
Attention	0.972	0.153
Relevance	0.976	0.215
Confidence	0.964	0.072
Satisfaction	0.961	0.061
Imagination	0.959	0.052
Curiosity	0.971	0.148
Adventurousness	0.967	0.096
Challenge	0.962	0.065

Note: All p-values > 0.05 indicate that the data follows a normal distribution.

Table 6. Paired sample t-test results for creativity and attitudes.

Variable	t-value	df	Significance (p-value)	Effect Size (Cohen's d)
Attention	15.23	44	0.000	1.63
Relevance	14.17	44	0.000	1.52
Confidence	16.01	44	0.000	1.71
Satisfaction	16.28	44	0.000	1.74
Imagination	18.73	44	0.000	1.87
Curiosity	13.66	44	0.000	1.47
Adventurousness	17.56	44	0.000	1.83
Challenge	14.89	44	0.000	1.61

Note: All results are statistically significant at p < 0.001.

4.6. Educational Significance and Model Validation

The statistical and qualitative results together affirm the success of the EPP Teaching Model in achieving its intended outcomes. The strong effect sizes across both creativity and attitude variables reflect more than surface-level improvements—they suggest transformative shifts in how students engage with learning. This is particularly important in vocational education, where learners often face challenges related to self-efficacy, limited exposure to innovation, and constrained learning environments.

The structured yet flexible design of the model (consisting of pre-class e-learning, interactive classroom dialogue, and hands-on project development) addressed these challenges by providing

multiple entry points for engagement. Each stage is built upon the previous one, allowing students to progressively develop understanding, confidence, and creative competence. The use of TRIZ added an important layer of methodological discipline to creativity, making the process accessible and less intimidating, especially for students new to entrepreneurial thinking.

The alignment of the model with Constructivist Theory supports its effectiveness in knowledge construction through active participation. Its ecological framing ensures that social and technological elements reinforce learning, while TRIZ supports systematic creativity. These theoretical foundations not only justify the model's design but also explain the success observed in practice. The combination of cognitive and affective gains reflects a holistic development process, consistent with the objectives of higher-order entrepreneurship education and aligned with SDG 4's emphasis on quality learning outcomes and life skills.

4.7. Alignment with SDG 4 and Broader Implications

The EPP Teaching Model directly supports the vision of SDG 4, particularly target 4.4, which aims to increase the number of youth and adults with relevant skills for employment, decent jobs, and entrepreneurship. By fostering creativity, problem-solving, teamwork, and confidence through structured instruction, the model prepares students for participation in innovation-driven economies.

Furthermore, the blended instructional approach addresses educational equity by enabling flexible access to learning resources, especially through the e-learning component. This is crucial for institutions serving diverse and geographically dispersed student populations. The model also promotes lifelong learning by encouraging self-directed inquiry and resilience (traits that extend beyond the classroom). In broader terms, the EPP Model offers a replicable template for vocational colleges and other higher education institutions seeking to improve the quality and relevance of their entrepreneurship education. It bridges the gap between theory and practice, integrates multiple pedagogical approaches into a coherent structure, and yields measurable improvements in both cognitive and motivational domains. This study adds new information regarding SDGs, as reported elsewhere (**Table 4**).

Table 4. Previous studies on SDGs.

No	Title	Ref
1	Sustainable development goals (SDGs) in engineering education: Definitions, research trends, bibliometric insights, and strategic approaches	Ragadhita *et al*. (2026)
2	Sustainable packaging: Bioplastics as a low-carbon future step for the SDGs	Basnur *et al*. (2024)
3	Production of wet organic waste ecoenzymes as an alternative solution for environmental conservation supporting SDGs	Sesrita *et al*. (2025)
4	HIRADC for workplace safety in manufacturing: A risk-control framework and bibliometric review to support SDGs	Henny *et al*. (2025)
5	Techno-economic analysis of production ecobrick from plastic waste to support SDGs	Syahrudin *et al*. (2026)
6	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia's green tourism policy and the SDGs	Apriliani *et al*. (2026)
7	Definition and role of sustainable materials in reaching global SDGs completed with bibliometric analysis	Ragadhita *et al*. (2026)
8	Bibliometric insight into materials research trends and innovation to support SDGs	Al-Obaidi, (2026)
9	Physical adaptation of college students in high-altitude training to support SDGs	Xing *et al*. (2025)
10	Enhancing professional readiness in vocational education aligned with SDGs	Khamdamovna, (2025)
11	School feeding program and SDGs in education: Linking food security to learning outcomes	Ximenes, (2025)

Table 4 (Continue). Previous studies on SDGs.

No	Title	Ref
12	Influence of eco-friendly packaging on consumer interest to meet SDGs	Haq *et al*., (2024)
13	SDG 12 implementation through lemon commodities and waste reduction	Maulana *et al*., (2023)
14	Mediterranean diet patterns and sustainability to support SDGs	Nurnabila *et al*., (2023)
15	Education on food diversification through infographic to improve SDGs	Awalussillmi *et al*., (2023)
16	Safe food treatment technology to achieve SDG zero hunger and optimal health	Rahmah *et al*., (2024)
17	Student awareness of sustainable diet and carbon footprint reduction to support SDGs 2030	Keisyafa *et al*., (2024)
18	Techno-economic analysis of eco-friendly bamboo-based paper production for child-friendly school media and Sustainable Development Goals (SDGs)	Kholik *et al*., (2025)
19	Harnessing biomass for sustainable development goals (SDGs): Definition, bibliometric, application, opportunities, and challenges	Nandiyanto *et al*. (2025a)
20	Harnessing biomass waste for value-added products in achieving sustainable development goals (SDGs): A systematic review of low-carbon transition, bibliometric, technical insights, and challenges.	Nandiyanto *et al*. (2025b)
21	Sustainable development goals (SDGs) in science education: Definition, literature review, and bibliometric analysis	Maryanti *et al.* (2022)
22	Experiment design and laboratory activities on heat transfer to teaching Black principle topic in science to vocational student for supporting Sustainable Development Goals (SDGs).	Ragadhita *et al.* (2025)
23	Enhancing vocational students' understanding of macromolecules properties: A practical approach through laboratory activities to support Sustainable Development Goals (SDGs)	Tohe *et al.* (2025)
24	Assessing the impact of laboratory activities on the topic of viscosity and fluidity in the classroom through practical applications on everyday objects for vocational students to support Sustainable Development Goals (SDGs).	Wahyuni *et al*., (2025)

5. CONCLUSION

This study developed and implemented a pedagogical model integrating E-Learning, PAD Class, and Project-Based Learning to enhance vocational college students' creativity and attitudes in innovation and entrepreneurship education. The model significantly improved students' motivation and creative disposition because it provided structured, student-centered, and experiential learning aligned with Constructivism, Educational Ecology, and TRIZ. These outcomes demonstrate that the model offers a scalable and effective approach for fostering innovation competencies in alignment with SDG4 on quality education.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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