

# **The effectiveness of the 5E-EDP model in STEAM education to develop the creativity of children aged 5-6 in preschool: A quasi-experimental study in Vietnam**

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## **Abstract**

Developing children's creativity is a central goal of preschool education programs worldwide. This study aimed to examine the effectiveness of the 5E model combined with the engineering design process (5E-EDP) within a STEAM education context in fostering creativity among preschool children. A quasi-experimental design was employed, involving two groups of children: an experimental group and a control group. The TCT-DP scale was used to assess children's creativity at both pre-test and post-test stages. The results indicate that the 5E-EDP model was more effective in enhancing creativity in 5-6-year-old children than the 5E model alone. The integration of the engineering design process within the 5E framework provided opportunities for children to generate and develop ideas, select materials, and create products in more innovative ways. Based on the findings, the study offers policy recommendations for implementing STEAM education to support educational innovation in the context of Vietnamese early childhood education.

**Keywords :** *STEAM education, Creativity, 5E-EDP model, Preschool children*

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## Introduction

Fostering creativity in children represents a foundational step in cultivating creative thinkers and innovators for adulthood. Creativity is recognized as a pivotal component of 21st-century education and is now at the forefront of human development when we face a rapid social and technological changing (Leggett, 2024). Education is critical in developing creativity (Blok, 2022). Integrating creativity into children's early educational experiences provides wealthy foundations to build future worlds (Leggett, 2017). Some researchers asserted that human creativity appears early in childhood, and preschool teachers are essential in promoting children's curiosity and creativity (Leggett, 2017; Gao & Hall, 2024). The lack of support from administrators and parents, along with inadequate training in teaching methods that enhance teachers' creativity can hinder the development of creativity in children (Gao & Hall, 2024).

STEM (Science, Technology, Engineering, and Mathematics) is an integrated approach to teaching and learning (Bybee, 2010). Related to STEM is STEAM, which also integrates different types of arts such as painting, drama, music, humanities, and design (Liao, 2016). Many studies have shown that the foundation of STEAM begins in childhood when children possess natural abilities to ask questions, be creative, investigate, and explore. STEAM experiences focus on real-life problems, are guided by creative queries or issues related to open, realistic discovery activities, and often require teamwork and collaboration (Wahyuningsih et al., 2020; Ng et al., 2022). Organizing educational activities according to the 5E model is consistent with STEAM education (Anggraeni & Suratno, 2021; Eroğlu & Bektaş, 2022). The 5E model by Bybee consists of five phases: engage, explore, explain, elaborate, and evaluate (Bybee et al., 2006).

Besides the commonly used 5E model, the engineering design process (EDP) is also used in STEAM education. The EDP is used to design and create solutions to problems. It is also known as the Design Thinking or Creative Problem Solving Process. It is a multi-step process, starting with an idea, followed by research and analysis, before arriving at a design solution. The EDP process encourages students to think creatively and critically (Xi et al., 2024). Some researchers propose that the 5E model combined with EDP in education for high school

students is called the 5E-EDP, and for preschool children, it is called the EDP-5E model. These studies show that the 5E-EDP model can be applied in science education to teach students and preschool children (Lottero-Perdue et al., 2015; Diep et al., 2023). Up to now, there have been no studies evaluating the effectiveness of the 5E-EDP model in early childhood education in developing the creativity of preschool children. This study contributes to filling this research gap by developing an innovative approach that integrates the EDP into the 5E model, forming the 5E-EDP framework, and evaluating its effectiveness in enhancing the creativity of preschool children aged 5-6 years.

## **Literature review**

### **Creativity and early children's creativity**

Creativity is explained from different angles, but the authors agree that creativity is an attribute, a unique intellectual quality of human beings. Creative activities can occur anytime, in any setting, and across various fields. At its essence, creativity involves discovering new, distinctive, and socially valuable ideas or solutions (Charyton & Snelbecker, 2007). It is widely regarded as a broad and complex concept that is challenging to define and measure. A comprehensive perspective defines creativity as the ability to produce original and meaningful ideas (Mumford, 2003), which empowers individuals to innovate in science, technology, and the arts and solve practical problems in daily life. Creativity encompasses the ability to perceive and address problems, deficiencies, or gaps in knowledge. It involves recognizing challenges, exploring potential solutions, proposing hypotheses, and implementing these ideas to address deficiencies (Almeida et al., 2008). The most fundamental expression of creativity is: (a) Fluency – the variety of ideas generated about a particular subject in response to a stimulus; (b) Flexibility – related to different types of ideas or the approach to a problem in different ways, (c) Originality – refers to thinking uniquely and creating unique actions (Weiss & Wilhelm, 2022; Leggett, 2024). “Creativity involves not only quantitative aspects but also quality elements such as ... unconventionality, affection,

and humor” (Urban, 2005). Urban (2005) emphasizes that creativity is a holistic concept and cannot be measured solely through traditional divergent thinking tests. He argues that creativity is not just about fluency (the number of ideas generated) but also involves structure, completeness, interconnections, unconventional thinking, and emotional expressiveness in the creative product.

In the early years of education, O'Connor (2012) emphasizes creativity as essential for enhancing children's thinking and problem-solving skills. She highlights that engaging in creative activities fosters idea generation, expression, challenge recognition, and solution-finding, making creativity a fundamental aspect of early learning and development. Some research shows that the creativity growth rate peaks between 4-6-year-old children, decreases gradually between the ages of seven and eleven, and then increases again in adolescence (Root-Bernstein, 2021). Nurturing the creativity of preschool children in general and children aged 5-6 years, in particular, involves providing materials to stimulate children's imagination, allowing children time to think without pressuring them or operating under conformism, and identifying new ideas to encourage creative thinking; accepting different points of view; appreciating children's individuality at work (Nikkola et al., 2020; O'Reilly et al., 2022). Gross et al. (2020) suggest cultivating curiosity, a sense of happiness, perseverance, and confidence, which are essential attributes of a child's mental health to learn and, more importantly, in this context, to develop children's creativity. Leggett (2024) interprets Malaguzzi's educational philosophy to outline principles that can help teachers foster children's creativity. These include ensuring children feel comfortable, promoting enjoyment, integrating multisensory learning, accepting the risk of failure, and creating a friendly classroom environment. Furthermore, children can unleash their creativity without distractions, stress, anxiety, or discomfort.

### **Developing early children’s creativity through STEAM education**

STEM is an acronym for Science, Technology, Engineering, and Mathematics. STEM education is an integrated approach to teaching and learning (Bybee, 2010). The goals of STEM education encompass students’ knowledge related to the fields of STEM, problem-

solving skills, and 21st-century competencies, including creativity, critical thinking, communication, and collaboration, as well as positive attitudes toward STEM, such as interest, engagement, and self-efficacy (Han et al., 2021; Thornhill-Miller et al., 2023). STEAM is a concept closely related to STEM, aiming to further integrate STEM with many types of arts, such as music, dance, drama, humanities, and design (Liao, 2016). Adding the word arts will allow children to describe concepts within the STEM field in creative and imaginative ways (Conradty & Bogner, 2018; Erol et al., 2023).

STEAM education, grounded in constructivism, is recognized as an effective pedagogical approach for fostering creativity in early childhood. Many studies have identified methods and conditions that enable STEAM education to enhance children's creativity. Research indicates that integrating STEAM-based learning enhances young learners' cognitive flexibility, innovative thinking, detailed exploration, and fluid reasoning (Atikah & Biru, 2024). Embedding STEAM into preschool curricula leverages children's natural curiosity, promoting engagement, collaboration, and problem-solving (DeJarnette, 2018). Additionally, incorporating loose media parts into STEAM activities encourages open-ended exploration and self-expression, further amplifying creativity and imagination (Sasongko et al., 2021). Providing children with the autonomy to select materials in STEAM activities also stimulates their creative potential (Üret & Ceylan, 2021). Moreover, studies highlight that STEAM topics significantly enhance the cognitive abilities of 5-6-year-olds, improving flexibility, fluency, originality, and elaboration in creative thinking (Che Abdul Aziz & Abu Bakar, 2021). Given these benefits, integrating STEAM education into early childhood programs is essential for nurturing creativity. However, its effectiveness depends on an exploratory and psychologically supportive learning environment that encourages active engagement and experimentation (Habibi, 2023).

### **5E-EDP model**

In STEAM education, the 5E teaching model is very commonly used by teachers (Koyunlu & Dökme, 2022; Zhou, 2022). The 5E model, developed in 1987 based on the scientific research method of the Biological Science Curriculum Study, is widely used in exploratory

teaching (Bybee et al., 2006). The 5E model consists of five stages: engage, explore, explain, elaborate, and evaluate, each designed to build on the previous phase. Activities stimulate curiosity and connect prior knowledge with new concepts in the engagement phase. The explore phase encourages hands-on investigation, where students use scientific process skills to discover knowledge. During the explain phase, learners articulate their findings and clarify their understanding through discussions and teacher input. In the elaborate phase, students apply their knowledge to new contexts, deepening understanding and fostering critical thinking. The evaluation phase involves assessing learning outcomes through various methods to identify progress and address misconceptions (Anggraeni & Suratno, 2021). These stages provide a structured framework for connecting prior knowledge to new learning experiences. The 5E model allows children to participate in learning actively, relate to daily life, experience as scientists, and solve problems as engineers. Using arts to explore and express scientific knowledge can lead children to deepen their understanding of scientific concepts (Beisly & Moffitt, 2024).

Dym et al. (2005) defined the EDP as a systematic approach that involves applying concepts and principles to create a device or system capable of achieving specific objectives within certain constraints. These EDP processes have been synthesized from various studies, as presented in the article (Lin et al., 2021). For example, the EDP proceeds as follows: problem definition, information gathering, idea generation, modeling, feasibility analysis, evaluation, decision, communication, implementation, and design revision. Similarly, a slightly different EDP is to identify the need or problem, research the need or problem, develop possible solutions, select the best possible solution, construct a prototype, test and evaluate the solution, communicate the solution, and redesign (Lin et al., 2021).

In early childhood education, by emphasizing engineering design as a flexible process, children take on the role of designers, engaging in practical problem-solving and learning how to apply their knowledge to real-life situations (Isabelle, 2021; Arifin & Mahmud, 2021). The EDP encourages children to participate, learn from peers, and build confidence. While 4- and 5-year-olds generally adapt well to this process, 3-year-olds may face challenges in sharing responsibilities, collaborating in teams, and fulfilling roles (Yalçın, 2022). The Engineering is Elementary (EiE) project introduced a simplified five-step EDP tailored for

young learners: Ask, Imagine, Plan, Create, and Improve. This model was designed to make the design process accessible and age-appropriate for children (Cunningham & Kelly, 2017).

A limited body of research integrates the 5E model and the EDP in teaching science and mathematics across the preschool and general education levels. Diep et al. (2023) introduced a framework combining the EDP steps—problem identification, construction, testing, evaluation, and redesign—into the 5E model. Their findings indicated that Grade 6 students demonstrated significantly improved knowledge acquisition and scientific creativity compared to using only the EDP (Diep et al., 2023). Similarly, Lottero-Perdue et al. (2015) proposed the EDP-5E approach, where the 5E framework remains a cornerstone in science education, with one adaptation replacing the exploration phase with a comprehensive EDP cycle. Research applying this approach in early childhood education has shown promising results, with young children demonstrating enhanced problem-solving skills and creativity through structured engagement in engineering design activities. The 5E-EDP model integrates inquiry-based science and mathematics learning with engineering design. It facilitates progression from foundational to advanced concepts and transitions from theoretical understanding to practical application. This model establishes strong mathematical and scientific foundations by aligning with national educational standards while actively engaging students in hands-on design activities (Diep et al., 2023).

This study introduces an innovative application of the 5E-EDP model in early childhood education. The proposed model comprises five phases: *engagement, exploration, explanation, elaboration, and evaluation*. The EDP selected in the study as suitable for preschool children includes *asking, imagining, planning, creating, and improving*, and is integrated into the 5E framework by substituting the elaboration phase with an EDP-focused phase. This integration emphasizes product creation, leveraging prior knowledge in science and mathematics to enhance practical understanding. During the evaluation phase, educators can systematically assess learning outcomes by incorporating the exploration and explanation components of the 5E model alongside the sequential steps of the EDP, providing a comprehensive review of both processes. The 5E-EDP model in early childhood education is studied and proposed in Figure 1.

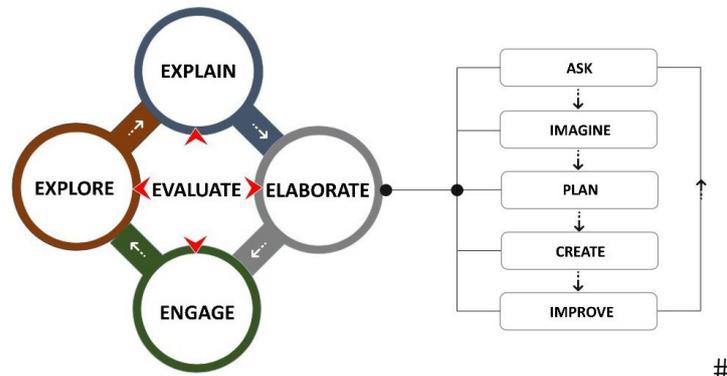


Figure 1. The 5E-EDP model in Early childhood education

### Context of Preschool Education Program in Vietnam

The 2009 Revised Preschool Education Program issued by the Ministry of Education and Training (MoET) was developed based on a child-centered approach, aiming for the comprehensive development of all domains in young children. These domains include cognitive development, physical development, social skills, emotional and social development, language development, and aesthetic development. The method of educating children of preschool age (3-6 years old) is based on experience and play (MoET, 2009). The national education program is a framework program that stipulates expected results, from which preschools develop plans and school education programs to meet the declared expected results. The preschool education program gives teachers and children more “autonomy and flexibility in teaching and learning” (Vu, 2021). Teachers are allowed to choose the topics and the contents of teaching based on children’s interests and the actual condition of each region. In addition, the preschool education program focuses on assessing the child's progress, facilitating the teacher’s adjustment to the educational plan, and setting up activities relevant to children’s abilities (MoET, 2009).

In Vietnam, preschool education has many advantages in using this model, such as flexibility in teaching content and time for children to work in 25-30 minute lessons or projects lasting several weeks. STEAM education is consistent with an integrated, experiential, hands-on perspective in the current Vietnam early childhood education

curriculum (MoET, 2009). Despite identifying STEAM education as effective in developing children's competencies, Vietnamese preschool teachers lack confidence and lack ways to interest children in participating in STEAM educational activities (Shaw et al., 2021). Although the 5E model is encouraged to be used in STEAM education in preschools, preschool children still have few opportunities to practice and experience. Teachers still play a central role in the instructional steps of the 5E model. Therefore, applying STEAM education does not entail developing problem-solving or creativity capacity (Shaw et al., 2021).

In the next part of the study, we experimentally evaluate the effectiveness of using the 5E-EDP model compared to using only the 5E model in STEAM educational projects in developing creativity for preschool children.

## **Methodology**

A quasi-experimental study collected pre- and post-experimental data from experimental and control groups. This is an appropriate method for verifying the effectiveness of the 5E-EDP model in developing creativity for preschool children aged 5-6 years. Because of practical and ethical barriers, the controlled group, the experimental group before and after the quasi-experimental study, was conducted instead of the random group (Miller et al., 2020). In quasi-experiment designs – in which the participants are not randomly assigned to the experiment conditions – the effect estimate cannot be attributed to the intervention with the same confidence as in randomized control trials. More specifically, a self-selection bias can occur. However, quasi-experiment designs with experimental and control groups that are pre- and post-tested can still provide information on the effectiveness of an intervention (Larzelere et al., 2004).

The preschool selected for this study is a public institution in an urban area where innovative educational approaches, such as STEAM and the 5E model, are actively implemented. The selection criteria for the school were as follows: (i) a sufficient number of children aged 5-6 years to enable meaningful participation in the research; (ii) consistent

physical conditions across classrooms; (iii) compliance with the national standard preschool education curriculum; and (iv) a willingness to participate and provide support for the research. The preschool was recommended by district administrators and evaluated as being of average quality compared to other regional preschools. The experimental group included 32 children (17 boys and 15 girls). The control group included 31 children (17 boys and 14 girls). Four teachers (each group has 2) working with those two groups had college and university education and 10 to 20 years of experience. All teachers have been trained 2-3 times on organizing STEAM educational activities for preschool children organized by management levels. The consent form for participating in the study of four teachers and parents was sent and confirmed before conducting the survey.

Treatment in the control group and experimental group: Children in both experimental and control groups participated in implementing projects according to their class plans over ten weeks. Each project lasts two weeks; the names of the projects are: “Making cages for baby rabbits,” “Making automatic water-absorbing plant pots,” “Decorating shoes for mom,” “Making bridges,” and “Making small tents.” The control group followed the traditional implementation of the 5E model. Specifically, during the elaboration phase, the teacher conventionally conducted activities, guiding children to apply the knowledge they had acquired by identifying and exploring similar objects or providing instructions for creating products, with the teacher assuming a primary and directive role. The implementation steps of the 5E-EDP model, along with suggested activities and questions, are described in Table 1. Figure 2 provides a photographic illustration of the steps.

The experimental group carried out the project according to the 5E-EDP process in which the manipulation step was replaced by using materials to create the discovered object. The steps to make this product are based on the EDP process. Teachers organize two sessions per week for each of these projects. During the remaining time, teachers organize educational activities for children based on the program prescribed by the MoET.

During the EDP phase, teachers in the experimental group create an intellectually stimulating environment to foster children's imagination and well-being. They allocate sufficient time for children to think and imagine during design activities, refrain from imposing ideas through modeling, and incorporate open-ended questions throughout the

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Table 1. *The steps in the 5E-EDP model and the suggested activities and questions in the “Making small tents” project*

Steps	Description	Activities and guiding questions
Engage	<i>Content from different STEAM disciplines is aligned and connected. Children are involved in authentic problems.</i>	<i>Watch the fairy tale video “The Watermelon”. Where did the character in the story live? Would you like to help the boy build a tent to live in? Introduce the “Tent” project.</i>
Explore	<i>Children are actively engaged in posing questions and planning and designing experiments.</i>	<i>Children explore different types of tents through pictures. What parts does a tent have? What materials are used to make a tent? Why are tents often in the shape of a triangular prism?</i>
Explain	<i>Teachers will encourage children to clarify concepts in their own words, to obtain proof and confirmation from their explanations, and to perform discussion activities.</i>	<i>Children present their findings and describe different types of tents. Children share suitable materials for making tents. The teacher refines and clarifies the knowledge.</i>
Elaborate (Using EDP)	<i>Ask: Identify the problem to be solved and understand the requirements and constraints.</i>	<i>What do we need to do to create the tent?</i>
	<i>Imagine: Encourage children to be creative and develop ideas to solve the problem.</i>	<i>Children describe different ideas for creating the tent. Group discussions are held to compare and choose the best idea. Children are free to be creative without worrying about their ideas' feasibility.</i>
	<i>Plan: Develop a specific plan and draw a design blueprint</i>	<i>Discuss in groups how to draw the tent design. Assign tasks within the group.</i>
	<i>Creat: Children begin building the product according to the outlined plan</i>	<i>Children carry out the technical work to create an actual tent.</i>
Evaluate	<i>Improve: Children improve the product they created</i>	<i>If you were to do it again, what adjustments would you make to make the tent more beautiful and sturdy?</i>
	<i>The teacher provides feedback and evaluates students' knowledge and understanding of concepts or skills. Children engage in self-assessment and peer evaluation.</i>	<i>Children present their group's product. Evaluate the process of creating the tents for each group and acknowledging progress. How do you feel about your group's tent? What do you think about the other groups' tents?</i>

design process. Additionally, they embrace diverse ideas and perspectives from children while recognizing and valuing their individuality and efforts. .Figure 2 presents the steps of the 5E-EDP model as applied to the project “Making small tents.”

Steps	Session	Content
E1. Engage	1	
		Introducing the “Tent” project through “The Legend of the Watermelon.”
E2 -E3. Explore- Explain	2	
		Explore several types of tents.
	3	
		Why are tents often made in triangular shapes?
4		

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Discover materials that suit the criteria for making tents.			
E4. Elaborate- Using the EDP process	5		
	Asking - Imagining: Ask children about the tent's criteria, style, material, and construction method		
	6		
Planning: Draw a design, assign tasks, and prepare materials to make a tent			
	7		
Creating: Children make tents according to the proposed design and plan			

	8		
Testing: Check whether the tent meets the criteria or not.			
	9		
Improvement: Carry out tent improvements and testing			
E5. Evaluate	10		
Organise project reporting session			

Figure 2. Photographic illustration of the project “Making small tents”

**Instrument**

To evaluate the creativity of preschool children in both experimental and control groups, the study used the Test of Creative Thinking – Drawing Production (TCT-DP). Unlike traditional tests of creativity that focus on quantity or production, the TCT-DP also examines the qualitative characteristics of creative performances. The total score provides a general estimate of creative potential. The TCT-DP is a suitable tool for determining the impact of creativity development programs in school settings through testing or retesting (He, 2024). The TCT-DP includes the following assessment indicators: presented fragments (at most 6

points), continuation (at most 6 points), new elements (at most 6 points), connections by line (at most 6 points), connections by theme (at most 6 points), boundary-breaking - internal (0 or 6 points), boundary-breaking - external (0 or 6 points), perspective (0 or 6 points), humor and affectivity (at most 6 points), and unconventionality (four sub-criteria, each scored 0 or 6 points). Sometimes, a time factor (at most 6 points) is also considered. According to the TCT-DP theoretical framework, the maximum total score is 72 points (Urban, 2005). The TCT-DP scale was used to assess children in both the experimental and control groups at two time points: before and after implementing five projects (10 weeks). Each child's score at each assessment point was the average of the TCT-DP Form A and TCT-DP Form B test scores. This approach enhances the reliability of the children's creativity scores. The research team, along with four teachers from the two experimental and control classes, participated in scoring the children based on the TCT-DP scale. The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.

*Research Hypothesis H1: There is no statistically significant difference between the mean creativity scores of the experimental and control groups in the pre-test.*

*Research Hypothesis H2: There is no statistically significant difference between the mean creativity scores of the experimental group and the control group in the post-test.*

## **Results**

The TCT-DP test tool measured children's creativity in experimental and control groups, including before and after the experiment. Table 2 describes the basic descriptive statistical parameters: Average value, Standard Deviation, and Standard Error Mean. The results showed that the children's creativity scores in the experimental and control groups increased after the intervention.

Based on the output, Table 3 looks at the value of the Sig. Levene's Test for Equality of Variances is  $0.444 > 0.05$  then it can be interpreted that the The variance of the Group data experiment and the control is homogeny. Further hypothesis Tests were conducted using a

Table 2. Descriptive statistic

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre-test	Experimental	32	17.0000	3.74166	.66144
	Control	31	16.9032	3.01502	.54151
Post-test	Experimental	32	22.2188	3.32861	.58842
	Control	31	19.9355	3.21388	.57723

Table 3. Independent Samples Test (Pre-test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper	
Pre-test	Equal Variances assumed	.593	.444	.113	661	.911	.09677	.85777	-1.61844	1.81199
	Equal variances not assumed.			.113	559.064	.910	.09677	.85483	-1.61370	1.80725

T-test with the help of SPSS software. Sig. (2-tailed) = 0.911 > 0.05 (confidence interval equal to 95%). Therefore, there is no statistically significant difference in the creativity scores of the two control and experimental groups in the pretest (accept Hypothesis H1).

Using Levene's Test for Equality of Variances, Table 4 shows Sig's value. This amounts to 0.791 > 0.05. Therefore, it falls into the case of equal variances, as assumed; we conduct a t-test for equality of means, Sig. (2-tailed) = 0.007 < 0.05 (confidence interval equal to 95%). Then, the zero hypothesis is rejected, and the research hypothesis is received, meaning there is a significant difference in the creativity between groups learned by the 5E model and those discovered by the 5E-EDP model. Suppose the average children's creativity in the experimental group is 22.2188, higher than the average creativity scores of children in the control group of 19.9355. Based on the statistical results, Hypothesis H2 is rejected, indicating that preschool teachers utilizing the 5E-EDP model in organizing STEAM educational projects significantly enhance children's creativity compared to those using the traditional 5E model. Furthermore, regarding the scores reflecting the criteria of flexibility

and originality, the experimental group achieved higher post-test scores than the control group. Flexibility emphasizes the approach and organization of thought, demonstrating the participant's ability to connect ideas and themes in various ways, as indicated by the connections by line and theme. Originality is reflected in the new elements and unconventionality items related to developing novel and creative elements and connections that distinguish themselves from existing ones.

Table 4. *Independent Samples Test (Post-test)*

	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Post-test	Equal Variances assumed	.071	.791	22.768	661	.007	2.28327	.82474	.63409	3.93244
	Equal variances are not assumed.			.770	61.000	.007	2.28327	.82428	.63502	3.93151

## Discussion

Creativity is a crucial skill to cultivate in preschool education, serving as a fundamental capacity for children to navigate, adapt, and thrive in a dynamic and ever-evolving society. Numerous studies have demonstrated the effectiveness of the 5E instructional model in STEAM education for fostering creativity among preschool children (Anggraeni & Suratno, 2021; Timotheou & Ioannou, 2021; Eroğlu & Bektaş, 2022). However, in the Vietnamese context, the implementation of the 5E model often remains rigid, with teachers predominantly occupying a central role throughout the instructional process. This limits children's opportunities for hands-on engagement and experiential learning. To address this limitation, integrating the EDP into the 5E model-by replacing the elaboration phase with EDP-enhances opportunities for creative engagement. This integration enables children to actively

participate in ideation, product design, iterative refinement, and evaluation. Through a quasi-experimental research design, this study provides empirical evidence that the proposed 5E-EDP model for STEAM education at the preschool level is significantly more effective in fostering creativity than the conventional 5E model. Building on the EDP-5E model previously suggested by Lottero-Perdue et al. (2015) for preschool education, the 5E-EDP model offers a novel contribution to the field. It expands the application of STEAM education, specifically targeting the development of creativity in young learners. This model presents an additional resource for educational administrators and preschool educators, offering innovative strategies to implement STEAM education effectively in early childhood settings.

In the context of the current preschool education program in Vietnam, teachers can flexibly choose topics and projects and determine teaching content goals and time for activities (from 25-30 minutes lesson to a project lasting several weeks). The exploration step in the 5E process is mainly used for scientific discovery, such as using a microscope to explore natural phenomena and understand the properties of materials and physical and chemical properties. Children have few opportunities to practice and experience (Anh & Hieu, 2023). The 5E-EDP model, in addition to the primary advantages of the 5E model, has an EDP technical design process that can help children increase the opportunity and time to practice experience for preschool children. This process helps children have more time to design and create products rather than just observing and exploring objects. Through experimental research, it has been shown that using the EDP process helps increase the creativity of 5-6-year-old preschool children. However, for this model to be effective, it is necessary to improve the awareness and skills of preschool teachers by changing the traditional teaching method and the habit of "helping," "modeling," and, at the same time, mobilizing resources in organizing this activity. Preschool children must also be regularly exposed to and continuously trained to form a "habit" of applying skills such as teamwork, sharing, collaboration, and exploration, i.e., in STEAM educational activities. To effectively implement the 5E-EDP model in STEAM education for fostering creativity in preschool children, teachers need to be patient and allow ample time for children to ask questions, imagine, design, and create during the EDP stage. The teacher's role is to establish a supportive environment, ensure children feel

comfortable participating, use open-ended questions, and acknowledge individual efforts. These findings align with the perspectives of Almeida et al. (2008) and Dere (2019).

Policies for training and fostering preschool teachers also need changes. Current preschool teacher training courses only stop at theoretical instruction, and preschool teachers have very different understandings of STEAM education and inconsistent understandings of STEAM projects for preschool children, including the 5E model (Tuan, 2023). It is necessary to increase the practicality of teachers in professional training courses. Preschool teachers feel more confident if equipped with theory, direct observation, and practice in the preschool classroom. The MoET of Vietnam also needs to issue more detailed policies on incorporating STEAM education into preschool education programs. Policymakers should consider issuing official documents that promote STEAM education initiatives in preschool settings and provide support for developing comprehensive STEAM education guidelines to foster the professional growth of early childhood educators. Specifically, these guidelines should emphasize established teaching models in STEAM education, such as the 5E model, inquiry-based learning, problem-solving approaches, and the EDP, as well as other expanded teaching frameworks like 5E-EDP, to facilitate the effective integration of STEAM education into preschool curricula.

The MoET must also establish policies and mobilize resources to further invest in preschool education. The MoET has issued a minimum list of supplies, toys, and equipment for preschool educational institutions (MoET, 2010). However, these categories need to be updated to keep pace with the overall advancement of technology. Some outdated devices, including DVDs and televisions, should be replaced with more advanced equipment such as monitors, interactive whiteboards, and Wi-Fi, along with scientific discovery tools for STEAM education and engineering design activities, such as microscopes, measuring instruments, and consumable materials like paper, adhesives, and tape. Implementing such regulations will provide a foundation for local authorities to adequately equip preschool education facilities.

## Conclusion

This study proposes a model that combines the 5E model with the EDP in STEAM education for preschool levels. The proposed model integrates a preschool-appropriate version of the EDP into the *elaborate* step of the 5E model. Based on a quasi-experimental study, the research results indicate that this model is more effective in developing children's creativity than using only the 5E model. Allowing preschool children to explore and explain before engaging in the engineering process facilitates implementation, as their experiences, knowledge, and skills are not yet fully developed.

The study further highlights the potential benefits of integrating multiple active teaching approaches, processes, or models within STEAM education. Educators can create a more dynamic and engaging learning environment by combining strategies such as problem-solving, inquiry-based learning, 5E, EDP, and play-based learning. This integrative approach allows children to explore concepts from multiple perspectives, fostering critical thinking, creativity, collaboration, and communication skills. The limitation of this study is the small experimental sample, which cannot be generalized to children living in different regions with different learning conditions and skills. Therefore, the generalisability of the research results still needs to be improved, and further research is needed to address this issue. A suggestion for future research is to employ a mixed-methods approach, combining both qualitative and quantitative methods to enhance the reliability and validity of the results. Specifically, data collected from quasi-experimental studies could be integrated with in-depth interviews with preschool teachers regarding children's creativity development. Another potential direction is to conduct research in preschools located in areas with varying infrastructure and cultural contexts to improve the findings' applicability and generalizability.

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