Organizing Science and Technology Activities to Develop Problem-Solving Competence for 5–6-Year-Old Children: A Quasi-Experimental Study in Ho Chi Minh City, Vietnam

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This study aimed to evaluate the effectiveness of a four-step procedure for organizing science and technology activities in developing problem-solving competence among preschool children aged 5–6 years in Ho Chi Minh City, Vietnam. Using a sequential explanatory mixed-methods research design, the study conducted an experimental intervention with 126 preschool children in Ho Chi Minh City. A regression analysis accounting for baseline scores and the Group × pre-test interaction indicated a significant advantage for the experimental group at the mean baseline level ($b = 5.16$, 95% CI [3.35, 6.97], $p < .001$, after accounting for school as a fixed effect). The significant Group × pre-test interaction indicated that the magnitude of the group difference varied according to children's initial problem-solving scores ($b = 0.69$, $p < .001$). The experimental group showed a markedly higher increase in mean scores compared with the control group. The findings confirm the importance of structuring science and technology activities toward experience, experimentation, and reflection in the context of early childhood education reform.

Keywords: early childhood education, science and technology, problem-solving competence, organizational procedure, 5–6-year-old children.

INTRODUCTION

The early years provide an important foundation for children's subsequent learning and development (OECD, 2026). Within early childhood education, problem-solving skills can be fostered through developmentally appropriate learning experiences that provide children

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with opportunities to approach and resolve unfamiliar challenges (Diamond, 2018). In Vietnam, the new early childhood education curriculum that is currently being developed and piloted also emphasizes the transition from knowledge transmission to the development of qualities and competencies, particularly science and technology competence and problem-solving competence (Ministry of Education and Training, 2026).

Science and technology activities are considered an ideal context for developing problem-solving competence in preschool children aged 5–6 years. Through these activities, children are encouraged to observe, ask questions, conduct experiments, and adjust solutions based on practical experiences (Davies & Howe, 2003; Fleer, 2015). However, the organization of these activities in preschools in Vietnam still faces many limitations. Many teachers continue to apply one-way knowledge transmission, limiting children's opportunities to fully experience the problem-solving process from problem identification to the evaluation of results (Hoang, 2012). The gap between theoretical perspectives on competence development and the practical organization of activities requires experimental studies to propose feasible procedures.

Recent international research has extended this evidence base by emphasizing design-oriented, inquiry-based, and iterative approaches to STEM learning in early childhood. Yalçın and Erden (2021), for example, reported that preschool STEM activities organized according to a design-thinking model supported children's creativity and problem-solving skills. More recent research on early engineering has highlighted the importance of failure analysis, repeated testing, and teacher facilitation when children encounter difficulties during the engineering design process (Erol, 2024). A systematic review of early-childhood STEM teaching and learning similarly shows increasing attention to integrated problem solving, teacher preparedness, digital and non-digital learning environments, and the quality of pedagogical implementation (Revák et al., 2024). These developments suggest that the effectiveness of early STEM experiences depends not merely on exposing children to science and technology content, but on how teachers structure inquiry, design, testing, revision, and reflection.

Although many international studies have examined the development of problem-solving competence through STEM education or the Engineering Design Process (EDP), the application of these models in the context of early childhood education in Vietnam remains limited. Domestic studies have mainly focused on theoretical descriptions, while there are still few experimental studies that verify the impact of a specific organizational procedure on children's problem-solving competence (Nguyen, 2019). Therefore, this study addresses this gap by developing and empirically examining a four-step procedure for organizing science and technology activities for 5–6-year-old children. The proposed procedure draws on the engineering problem-solving approach described by Stone-MacDonald et al. (2015), as well as principles of the 5E instructional model and experiential learning theory (Bybee et al., 2006; Kolb, 1984). Rather than reproducing these established approaches, the study organizes selected principles into a simplified, developmentally appropriate sequence for preschool science and technology activities. The contribution of the proposed procedure lies in explicitly connecting the instructional stages with targeted components of children's problem-solving competence and in incorporating iterative improvement, supported by teacher scaffolding, as an integral part of children's problem-solving process.

The study focuses on addressing three main research questions:

1. What is the current state of problem-solving competence among children aged 5–6 years in Ho Chi Minh City?
2. Does organizing science and technology activities according to the proposed four-step procedure significantly improve children's problem-solving competence?
3. How do preschool teachers perceive the feasibility and effectiveness of the proposed organizational procedure in practice?

Problem-Solving Competence of Children Aged 5–6 years

Problem-solving competence is defined as the ability of individuals to use cognitive processes to understand and resolve situations in which the solution is not immediately apparent (OECD, 2012). For children aged 5–6 years, problem-solving competence is not only the ability to find the correct answer but also a sequence of cognitive behaviors and actions including problem identification, proposing solutions, implementation, and evaluation of results (Aydoğan et al., 2009a). According to Aydoğan et al. (2009b), the Problem-Solving Skills Scale (PSSS) identifies ten components that constitute this competence, ranging from recognizing the problem to selecting the most unusual solution.

At ages 5–6 years, children are typically in the preoperational period, characterized by increasingly symbolic and intuitive forms of reasoning (Piaget, 1954). During this period, children increasingly use representation, comparison, and simple reasoning when engaging with problem situations (Nguyen et al., 2003). However, children's problem-solving competence does not develop naturally but is strongly influenced by the educational environment and the guidance of adults (Vygotsky, 1978). Therefore, developing an appropriate competence framework and measurement instruments is an important initial step in evaluating the effectiveness of educational interventions.

Science and Technology Activities in Early Childhood Education

Science and technology activities in early childhood education are not simply the transmission of knowledge about the natural world but a process in which children actively interact and use their senses and tools to explore objects and phenomena (Davies & Howe, 2003). In this study, technology is conceptualized primarily from an engineering-design and material-based perspective. It includes simple tools, recyclable and natural materials, structural components, mechanisms, connectors, and other human-made resources that children can manipulate, combine, or modify to achieve a practical purpose or solve a concrete problem. Digital devices, software applications, and screen-based technologies were not the primary focus of the intervention. This distinction is important because contemporary early-childhood STEM research includes both digital technologies and non-digital design-and-making experiences.

Studies indicate that science and technology activities are highly integrated, closely connected with real life situations, and encourage processes of trial, error, and adjustment (Fleer, 2010). These characteristics are consistent with the way children learn through experience. In Vietnam, the new early childhood education curriculum that is currently being piloted has officially incorporated technology into science exploration activities and renamed them science and technology activities, emphasizing the objective of developing thinking skills and problem-solving competence (Ministry of Education and Training, 2026). The content of these activities often revolves around familiar topics such as the human body, animals, plants, natural phenomena, and household technological devices.

Procedure for Organizing Activities to Develop Problem-Solving Competence

To develop problem-solving competence effectively, science and technology activities need to be organized according to a structured pedagogical procedure. The proposed four-step procedure was informed by the engineering problem-solving framework presented by Stone-MacDonald et al. (2015), which emphasizes the development of young children's problem-solving and critical-thinking skills through engineering and STEM experiences. The procedure also incorporates principles of inquiry-oriented learning and experiential learning (Bybee et al., 2006; Kolb, 1984). However, the present study does not reproduce these frameworks as originally formulated. Instead, selected principles were reorganized into four developmentally appropriate stages—Problem Identification, Implementation, Improvement, and Sharing—to provide teachers with a structured process for organizing science and technology activities for 5–6-year-old children.

The proposed procedure is not intended to replace established instructional frameworks such as the engineering design process (EDP), the 5E instructional model, or experiential learning. Rather, its contribution lies in translating selected principles from these approaches into an operational procedure specifically designed for science and technology activities with 5–6-year-old children.

The procedure differs from established approaches in three interconnected ways. First, it establishes an explicit alignment between each instructional stage and specific components of children's problem-solving competence. Whereas the EDP primarily describes an engineering design process and experiential learning describes a broader cycle of learning from experience, the present procedure is organized around observable problem-solving behaviors expected of preschool children. Second, the procedure treats improvement as a distinct and structured stage in which children examine the outcome of an initial attempt, identify difficulties, modify their approach, and test the revised solution. Third, these processes are integrated with developmentally appropriate teacher scaffolding, concrete materials, peer interaction, experimentation, and opportunities for children to communicate and reflect on their solutions.

Thus, the originality of the present study is primarily pedagogical and operational rather than theoretical. It develops and empirically examines a competency-oriented and context-sensitive operationalization of established principles for science and technology education with preschool children.

METHOD

Research Design

This study uses a mixed methods approach, combining quantitative and qualitative research according to an explanatory sequential design. The focus of the study is a quasi experimental design with an independent control group, using a pre-test and post-test control group design to evaluate the impact of the procedure for organizing science and technology activities on the problem-solving competence of children aged 5–6 years. The research procedure was implemented through three main phases: (1) investigating the current situation and developing the procedure for organizing activities; (2) conducting a pedagogical experiment with an experimental group and a control group; and (3) analyzing quantitative and qualitative data to explain the experimental results.

Experimental Procedure / Intervention

As defined in the theoretical section, technology in this study refers to non-digital, material-based tools and resources from an engineering-design perspective (see Science and Technology Activities in Early Childhood Education). The procedure for organizing activities was designed according to four steps, integrating the components of problem-solving competence into each stage. Table 1 presents the operational structure of the proposed procedure, showing how teacher scaffolding, children's actions, and targeted components of problem-solving competence are explicitly aligned at each stage.

Table 1

Summary of the Procedure for Organizing Science and Technology Activities to Develop Problem-Solving Competence

Steps of the procedure	**Teachers' Activities**	**Children's Activities**	**Components of problem-solving competence**
Step 1 Organizing children to identify the problem	The teacher organizes a conversation activity about the goal of problem-solving	Participating in a conversation about the goal of problem-solving	Problem recognition
	The teacher organizes activities for children to explore ways to solve similar problems	Explore ways to solve similar problems	Problem identification
	The teacher organizes brainstorming	Predict, sketch, ask questions, and propose	Asking questions

	activities for children to predict, sketch, ask questions, and draw possible ways to solve the problem	possible solutions	about the problem Predicting the causes of the problem Determining the completeness of information needed for problem-solving
Step 2 Organizing children to implement the solution	The teacher organizes activities for children to implement and try different ways of solving the problem	Implement and try different ways of solving the problem	Identifying the components of the problem Using objects differently from known objects
	The teacher encourages children to solve the problem individually or cooperate with peers	Solve the problem individually or cooperate with peers	Finding the most appropriate solution
	The teacher supports children in examining the problem-solving method and deciding whether it solves the problem to improve it	Examine the problem-solving method and decide whether it solves the problem to improve it	Selecting the most appropriate solution
Step 3 Organizing children to improve the solution	The teacher guides children to record and analyze what has occurred	Record and analyze what has occurred	Identifying the components of the problem Predicting the results of a sequence of actions
	The teacher supports children in improving the problem-solving method	Improve the problem-solving method	Determining the completeness of information needed for problem-solving Selecting the most unusual

			solution among several possible solutions
Step 4 Organizing children to share	The teacher organizes activities for children to draw and talk about the problem-solving methods	Draw and talk about problem-solving methods	Evaluation and reflection
	The teacher organizes activities for children to reflect and compare the initial ideas with the results	Reflect and compare the initial ideas with the results Evaluation and reflection	

Research Participants and Sample

The study was conducted in preschools located in Ho Chi Minh City, Vietnam. Survey sample for the current situation: This sample included 367 preschool teachers and 370 children aged 5–6 years, selected using a stratified random sampling method to ensure representativeness.

Pedagogical experimental sample: A total of 126 children aged 5–6 years participated and were equally divided into two groups. Experimental group: 63 children who participated in science and technology activities organized according to the four-step procedure proposed in this study (Problem identification, Implementation, Improvement, Sharing). Control group: 63 children who participated in activities organized according to the currently implemented conventional procedure.

The study used a quasi-experimental pre-test–post-test control-group design. Participants were not individually randomized. The experimental and control groups were formed with attention to comparability in age, gender composition, and baseline problem-solving competence. Pre-test scores were examined before the intervention to assess initial group comparability. Pre-test results indicated no statistically significant difference between the groups ($p > 0.05$).

Research Instruments

Data were collected through instruments that had been tested for reliability and validity.

The Problem-Solving Skills Scale (PSSS), originally developed by Aydoğan et al. (2009b), was used to assess children's problem-solving competence. The original instrument comprises 50 items organized into 10 components of problem-solving skills. For use in the Vietnamese context, the instrument was linguistically and culturally adapted before data collection. The adaptation process focused on preserving the conceptual meaning of the original constructs while ensuring that the wording and task contexts were understandable and developmentally appropriate for Vietnamese preschool children.

For psychometric examination in the present study, the 10 PSSS component scores were analyzed using data from the 370 children in the current-situation sample. Each component score ranged from 0 to 5, yielding a total possible score ranging from 0 to 50. Internal consistency across the 10 component scores was examined using Cronbach's alpha, and exploratory factor analysis was conducted at the component-score level to provide preliminary evidence concerning construct structure.

Survey questionnaire: A questionnaire administered to teachers to assess the current situation of organizing science and technology activities. The instrument used a *five - point Likert scale*.

Semi-structured interview protocol: Semi-structured interviews were conducted with 12 preschool teachers to obtain qualitative contextual information concerning the organizational procedure and practical implementation difficulties.

Experimental lesson plans: These included 12 science and technology activities designed according to the four-step procedure and implemented over a period of 12 weeks.

Evaluation rubric: Used to assess the activity products of children and teachers during the experimental process.

Data Collection Procedure

The data collection process was conducted according to the following steps. Firstly, pre-test - the initial level of children's problem-solving competence in both the experimental group and the control group was assessed using the Problem Solving Skills Scale. Secondly, experimental intervention – Before implementation, teachers responsible for the experimental condition received prior preparation on the four-step organizational procedure and the intended teacher roles at each stage. Across the 12-week intervention, the experimental group participated in one science and technology activity per week organized according to the same four-step framework. The control group continued regular science and technology activities according to the schools' existing plans and the national curriculum framework, without implementation of the four-step intervention procedure. Thirdly, post-test - children's problem-solving competence in both groups was assessed again using the same instrument applied in the pre-test. Children's problem-solving competence at pre-test and post-test were assessed using the same PSSS scoring framework. The assessments involved teachers who were familiar with the participating children. Consequently, although the same instrument and scoring structure were used across measurement occasions, complete assessor independence and blinding to classroom participation could not be ensured. Finally, teacher interviews were conducted, and children's activity products were collected during the experimental process to provide contextual qualitative information.

Data Analysis

Quantitative data were processed using SPSS Version 26.0. The statistical methods used included the following:

Descriptive statistics: Mean values and standard deviations were used to describe the level of problem-solving competence. Inferential statistics:

Independent Samples T test was used to compare differences between the two groups. *Paired Samples T test*, or the Wilcoxon signed rank test if the data were not normally distributed, was used to compare changes before and after the experiment within each group. Children were nested within two participating schools. Because only two higher-level school units were available, a school-level random-effects multilevel model could not be estimated reliably. School was therefore included as a fixed effect in the regression model to account for systematic between-school differences. The substantive pattern of the intervention results remained after adjustment for school. Nevertheless, the small number of schools limits the ability to estimate classroom- and school-level variance and is acknowledged as a limitation. Qualitative data were analyzed thematically to identify recurring themes related to teachers' perceptions, implementation practices, challenges, and professional needs.

Research Ethics

The study strictly followed ethical principles in educational research. Permission to conduct the study was obtained from the participating school administrators, and written informed consent was obtained from children's parents or legal guardians before participation. All personal information concerning children and teachers was coded and anonymized in the reporting of the findings. The intervention activities were designed to protect children's physical and psychological safety and to avoid disruption to the regular curriculum. Children in the control condition were to be provided access to the four-step procedure after completion of the study if the intervention was found to be beneficial.

RESULTS

This section presents the quantitative and qualitative research results on the effectiveness of organizing science and technology activities according to the four-step procedure in developing problem-solving competence among children aged 5–6 years.

Sample Characteristics

The study was conducted with 126 children aged 5–6 years from two preschools located in Ho Chi Minh City. The children were equally divided into two groups as presented in Table 2.

Table 2

Distribution of the Research Sample by Group and School

Group	Preschool	Number of children	Coding	Pre-test	Post-test
Experimental group	Preschool 1	32	EG 1	Yes	Yes
	Preschool 2	31	EG 2	Yes	Yes
Total number of children in the experimental group		**63**			

Control group	Preschool 1	32	CG 1	Yes	Yes
	Preschool 2	31	CG 2	Yes	Yes
Total number of children in the control group		**63**			
Total sample size of the study		**126**			

Note. N = 126.

Reliability and Exploratory Construct Evidence for the PSSS

Table 3

Reliability and Exploratory Construct Evidence for the PSSS Component Scores

Analysis	**Statistic**	**Result**
Sample size	N	370
Number of component scores	K	10
Internal consistency	Cronbach's α	.706
Sampling adequacy	KMO	.807
Bartlett's test	χ^2 (45)	419.41
Significance	p	< .001
First eigenvalue	λ1	2.789
Variance explained	%	27.9
Factor-loading range	—	.327–.575

Note. N = 370. EFA was conducted on the 10 aggregated PSSS component scores rather than the 50 individual items.

The 10 PSSS component scores demonstrated acceptable, although modest, internal consistency (Cronbach's α = .706). The Kaiser–Meyer–Olkin measure was .807, and Bartlett's test of sphericity was statistically significant, χ^2 (45) = 419.41, $p < .001$, indicating that the component-score correlation matrix was suitable for exploratory factor analysis. EFA indicated a dominant general factor, with a first eigenvalue of 2.789, accounting for approximately 27.9% of the total variance. Factor loadings ranged from .327 to .575. These findings provide preliminary evidence of a common underlying problem-solving dimension at the component-score level. Because item-level responses were not available for this analysis, the results should not be interpreted as full validation of the original 50-item factor structure.

Results of the Pedagogical Experiment

Descriptive statistics of children's problem-solving skills before and after the experiment

Children's problem-solving skills were measured in both groups before and after the experiment. The descriptive statistical results are presented in Table 4.

Table 4
Descriptive Statistics of Problem-Solving Skills Scores Before and After the Experiment for the Two Groups

Group	Time	*N*	Mean	Std. Deviation	Std. Error Mean	Difference (Post-test – Pre-test)
Control group	Pre-test	63	18.33	5.54	0.697	**+0.64**
	Post-test	63	18.97	5.81	0.73	
Experimental group	Pre-test	63	17.25	5.47	0.689	**+5.83**
	Post-test	63	23.08	8.75	1.10	

Note. N = 126.

The results show that the experimental group had a markedly higher increase in scores (+5.83 points) compared with the control group (+0.64 points). The standard deviation of the experimental group after the experiment (8.75) was higher, reflecting a greater variation in scores among individuals.

Analysis of Post-Test Problem-Solving Scores

The post-test analysis initially examined a conventional ANCOVA adjusting for pre-test scores. Because the homogeneity-of-regression-slopes assumption was subsequently found to be violated, the intervention outcome was reanalyzed using a regression model that retained the Group × pre-test interaction.

Before interpreting the conventional ANCOVA, the homogeneity-of-regression-slopes assumption was examined by testing the Group × pre-test interaction. The interaction was statistically significant, $F(1, 122) = 14.87$, $p < .001$, partial $\eta^2 = .109$, indicating that the association between baseline and post-test scores differed between the experimental and control groups. Consequently, the homogeneity-of-regression-slopes assumption required for conventional ANCOVA was not satisfied.

The outcome was therefore reanalyzed using a linear regression model that retained the Group × pre-test interaction, with the pre-test score centered at the sample mean and with school entered as a fixed effect to account for the two-school clustered structure of the sample. As shown in Table 5, at the mean baseline level, the experimental group had an estimated post-test score 5.16 points higher than the control group, $b = 5.16$, 95% CI [3.35, 6.97], $p < .001$. The Group × pre-test interaction remained significant, $b = 0.69$, 95% CI [0.35, 1.02], $p < .001$, indicating that the magnitude of the group difference increased as baseline scores increased. School also had a statistically significant fixed effect, $b = -1.89$, 95% CI [−3.71, −0.06], $p = .043$, indicating a modest difference in post-test scores between the two schools after controlling for group and baseline scores; the intervention effect remained materially unchanged after this adjustment. The model explained 57.3% of the variance in post-test scores ($R^2 = .573$, adjusted $R^2 = .558$), $F(4, 121) = 40.527$, $p < .001$.

Table 5
Regression Model Predicting Post-Test Problem-Solving Scores, Adjusting for School

Predictor	b	95% CI	p
Intercept	19.57	[18.01, 21.13]	< .001
Pre-test (centered)	0.61	[0.37, 0.84]	< .001
Group (experimental vs. control)	5.16	[3.35, 6.97]	< .001
Group × pre-test score	0.69	[0.35, 1.02]	< .001
School (Preschool 2 vs. Preschool 1)	−1.89	[−3.71, −0.06]	.043

Note. *N = 126. Pre-test scores were centered on the sample mean (M = 17.79). School was dummy-coded (0 = Preschool 1, 1 = Preschool 2) and included as a fixed effect. The model explained 57.3% of the variance in post-test scores ($R^2 = .573$, adjusted $R^2 = .558$), $F(4, 121) = 40.527$, $p < .001$.*

Comparison of the ten Components of Problem-Solving Skills

The scores of the 10 components of problem-solving skills were compared between the two groups after the experiment. The results are presented in Table 6.

Table 6
Comparison of the 10 Components of Problem-Solving Skills Between the Experimental Group and the Control Group After the Experiment

PSSS component	Control group (Post-test)	Experimental group (Post-test)	Difference
	M-(SD)	M-(SD)	
PSSS1: Recognizing the Problem	3.65 (1.26)	3.89 (1.43)	+0.24
PSSS2: Identifying the Problem	2.56 (1.09)	2.92 (1.38)	+0.36
PSSS3: Asking Questions About the Problem	2.16 (0.85)	2.48 (1.27)	+0.32
PSSS4: Estimating the Cause of the Problem	2.02 (0.77)	2.44 (1.09)	+0.42
PSSS5: Deciding on the Adequacy of Information for Solving the Problem	1.86 (0.76)	2.33 (1.12)	+0.47
PSSS6: Identifying the Components of the Problem	1.87 (0.81)	2.40 (1.06)	+0.53
PSSS7: Using Objects Differently Than Known	1.83 (0.87)	2.33 (1.11)	+0.50
PSSS8: Guessing/ Predicting the Outcome of a Set of Actions	1.68 (0.82)	2.14 (1.09)	+0.46

PSSS9: Finding the most Appropriate Solution	1.11 (0.68)	1.68 (1.09)	+0.57
PSSS10: Choosing/Selecting the Most Unusual Solution Among Many Possible Solutions	0.24 (0.64)	0.46 (0.76)	+0.22
Total score	18.97 (5.81)	23.08 (8.75)	+4.11

Note. N=126. Each PSSS component has a possible score range of 0–5, and the total PSSS score ranges from 0 to 50. Higher scores indicate stronger demonstrated problem-solving competence.

The experimental group obtained higher post-test means than the control group across all 10 PSSS components. The largest descriptive between-group difference was observed for PSSS9 (1.68 vs. 1.11; difference = 0.57). Nevertheless, the absolute scores for the two solution-selection components remained relatively low within their possible range of 0–5, particularly for PSSS10 (M = 0.46 in the experimental group). Thus, the higher post-test means should not be interpreted as indicating mastery of these higher-order skills.

Qualitative Research Results

Teacher interview data were analyzed thematically. Five themes were identified concerning teachers' perceptions, current practices, implementation conditions, influencing factors, and professional needs. The synthesized findings are presented in Table 7.

Table 7

Themes and Analytic Findings From Teacher Interviews

Themes	Analytic Finding
1. Perceptions of problem-solving skills	Teachers generally recognized the role of science and technology activities in developing children's thinking and stimulating curiosity. However, teachers differed in their understanding of problem-solving skills: some tended to associate problem solving with successful task completion, whereas others emphasized the processes of thinking, experimenting, and adjusting solutions.
2. Practice of organizing activities	Science and technology activities were relatively common but were mainly organized as classroom-based learning activities using familiar content. Children's problem-solving experiences tended to emphasize the initial stage of a task, while analysis, exploration of multiple solutions, experimentation, and adjustment were less systematically organized.
3. Methods and Conditions	Teachers tended to prioritize visual and experiential methods conducted within the classroom, partly because of classroom-management and child-safety considerations. The use of open-ended resources, including recycled and natural materials and digital technology tools, remained limited and varied according to the conditions of individual schools.

4. Influencing factors	Teachers identified large class sizes, limited activity time, classroom-management demands, and child-safety requirements as major difficulties in organizing problem-solving activities. They also reported a lack of specific procedural guidance, which often required them to rely on their own professional experience.
5. Suggestions and Needs	Teachers expressed a need for a clearly structured and practical procedure for organizing science and technology activities. They also indicated a need for practice-oriented professional development, particularly in designing problem situations and organizing activities in small groups.

These qualitative findings complement the quantitative results by providing contextual information about teachers' perceptions, current practices, implementation challenges, and perceived need for a clearly structured procedure for organizing science and technology activities.

DISCUSSION

This study aimed to evaluate the effectiveness of a four-step process for organizing science and technology activities in developing problem-solving skills among children aged 5–6 years. The discussion of the results below clarifies the mechanism of the process's impact, compares the findings with previous studies conducted domestically and internationally, and identifies practical implications.

Effectiveness of the Process for Organizing Science and Technology Activities

The revised analysis indicated that the effect of the four-step procedure could not be adequately represented by a conventional ANCOVA because the homogeneity-of-regression-slopes assumption was violated. In the regression model retaining the Group × pre-test interaction, children in the experimental group had an estimated post-test score 5.16 points higher than those in the control group at the mean baseline level (95% CI [3.35, 6.97], $p < .001$). The significant Group × pre-test interaction ($b = 0.69$, 95% CI [0.35, 1.02], $p < .001$) further indicated that the magnitude of the group difference varied according to children's initial problem-solving scores. These findings support an intervention-group advantage while also showing that the magnitude of this advantage was not uniform across baseline levels.

Descriptively, the experimental group showed a larger pre-test-to-post-test increase (+5.83 points) than the control group (+0.64 points), a pattern consistent with the advantage identified in the regression analysis. Unlike conventional organization methods used in the control group, which often stop at children observing and following instructions, the proposed process requires children to participate in the entire cycle, from identifying problems, experimenting with solutions, and adjusting errors to reflect on the results. This finding is consistent with Aydoğan et al. (2009a), who reported that children's problem-solving skills can be supported through structured learning environments that provide opportunities for children to think and act on problems.

To illustrate the nature of this interaction, at one standard deviation below the mean baseline (approximately 12.3), the estimated group difference was approximately 1.4 points, whereas at one standard deviation above the mean (approximately 23.3), the estimated difference was approximately 9.0 points. This pattern indicates that children with higher initial problem-solving scores benefited more from the intervention.

Mechanism of Impact from the Perspective of Experiential Learning

Although the four-step process was designed specifically for preschool children, in terms of theoretical foundation it still follows the principles of Kolb's experiential learning model (1984).

• Problem Identification and Implementation: These correspond to Kolb's stage of Concrete Experience. Children directly manipulate materials, observe phenomena, and encounter problem situations.

• Improvement: This corresponds to Active Experimentation. Children do not perform the activity only once but are encouraged to try again and adjust their solutions based on previous results. This is a key difference from common practice, where children rarely could redo an activity after making mistakes.

• Sharing: This corresponds to Reflective Observation. Children reflect on the process they have undertaken and compare their experiences with those of their peers and teachers.

Analysis of Problem-Solving Skill Components

The component-level post-test results showed that the experimental group had higher mean scores than the control group across all 10 PSSS components. The descriptive between-group differences ranged from 0.22 points for PSSS10 to 0.57 points for PSSS9. Relatively larger differences were also observed for PSSS6 (0.53) and PSSS7 (0.50). Despite the experimental-group advantage, the absolute scores for the solution-selection components remained comparatively low, especially PSSS10, for which the experimental-group mean was 0.46 on a 0–5 scale. These descriptive findings suggest that the group difference was evident across multiple components, while higher-order solution-selection skills remained challenging for many children.

Practical Implications

Based on the research results, several recommendations are proposed:

1. Teachers: Teachers need to shift from the role of "knowledge transmitters" to that of "facilitators", with particular attention to the stages of Improvement and Sharing, which are often overlooked in practice.
2. Administrators: School administrators need to support the provision of open learning materials such as recycled and natural materials so that children have opportunities to experiment with different solutions without fear of making mistakes.
3. Teacher training: Training programs should focus on developing skills for designing problem situations and using guiding questions to stimulate children's thinking rather than providing ready-made answers.

Limitations and Directions for Future Research

The study has several limitations that should be considered when interpreting the findings. First, although the current-situation phase involved a broader sample, the quasi-experimental intervention included only 126 children from two preschools in Ho Chi Minh City. Therefore, the experimental findings should not be considered nationally representative of Vietnamese preschool children or early childhood settings. Second, the 12-week intervention period may have been insufficient to determine whether the observed effects were sustained over time, particularly for higher-order problem-solving components such as PSSS9 and PSSS10. Third, potential assessment bias should be acknowledged. PSSS assessments involved teachers who were familiar with the participating children, and complete assessor independence and blinding to group participation could not be ensured. Teacher familiarity with the children and expectations regarding their performance may therefore have influenced some ratings. Fourth, although the same four-step procedural framework and intervention materials were used throughout the experimental condition, a formal quantitative measure of implementation fidelity was not available for all intervention sessions. Thus, variation in implementation across teachers or classrooms cannot be completely ruled out. Fifth, the psychometric examination of the Vietnamese PSSS was conducted using the 10 aggregated component scores rather than the 50 individual item responses. Although the component-level analysis provided preliminary evidence of a common underlying problem-solving dimension, further item-level validation is needed to establish the measurement properties of the Vietnamese adaptation more comprehensively. The qualitative component was also limited by the absence of complete verbatim interview transcripts linked to individual participant identifiers. Consequently, the thematic findings could not be supported by participant-level direct quotations. Future studies should retain fully transcribed and anonymized interview records to enable the use of representative verbatim quotations and provide richer qualitative description. Finally, the intervention involved only two preschools, which limited the ability to model school- and classroom-level clustering reliably.

Future research should replicate the intervention with larger and more geographically diverse samples across different regions of Vietnam and include a greater number of schools and classrooms to permit multilevel analysis. Longer intervention and follow-up periods are also needed to examine the sustainability of gains, particularly in higher-order problem-solving skills. Future studies should employ assessors who are independent of intervention delivery and blinded to group allocation and should triangulate PSSS ratings with video-coded observations, performance-based problem-solving tasks, and analyses of children's activity products. Systematic fidelity monitoring, including structured classroom observations and inter-rater checks, should also be incorporated to evaluate implementation consistency across teachers and classrooms. Finally, further psychometric research using item-level PSSS data and independent samples is needed to strengthen evidence for the validity and reliability of the Vietnamese adaptation.

CONCLUSION

This study provides evidence that the four-step procedure for organizing science and technology activities (Problem Identification–Implementation–Improvement–Sharing) was associated with improved problem-solving competence among children aged 5–6 years in the participating preschools in Ho Chi Minh City, Vietnam. Because the homogeneity-of-regression-slopes assumption for conventional ANCOVA was not satisfied, the outcome was analyzed using a regression model retaining the Group × pre-test interaction. At the mean baseline level, the experimental group had an estimated post-test advantage of 5.16 points (95% CI [3.35, 6.97], $p < .001$), while the significant interaction indicated that the magnitude of this advantage varied according to children's initial problem-solving scores. Descriptively, the experimental group showed a greater pre-test-to-post-test increase (+5.83 points) than the control group (+0.64 points). Component-level post-test comparisons also showed higher mean scores for the experimental group across all 10 PSSS components, although the higher-order components PSSS9 and PSSS10 remained low in absolute terms.

The teacher interview findings provided contextual information that complemented the quantitative results, particularly regarding teachers' perceptions, implementation challenges, and perceived need for a clearly structured and practically applicable organizational procedure. The four-step procedure is consistent with experiential-learning principles by providing opportunities for children to engage in a problem-solving sequence involving problem identification, implementation, improvement, and reflection on outcomes.

These findings should be interpreted considering the study limitations described above, particularly the two-school quasi-experimental design, potential assessor bias, absence of systematic fidelity measurement across all sessions, and limitations of the available psychometric and qualitative records. Replication with larger and more geographically diverse samples, independent blinded assessment, systematic fidelity monitoring, and stronger item-level psychometric validation is warranted.

From a practical perspective, the study proposes three main recommendations: (1) Teachers need to shift from the role of "knowledge transmitters" to that of "facilitators", with particular attention to the stages of Improvement and Sharing; (2) Administrators should support the provision of open learning materials and diverse resources so that children have opportunities to experiment with multiple solutions; (3) Teacher professional development should focus on skills for designing problem situations and using guiding questions. These conclusions contribute to providing a scientific basis for innovating methods of organizing science and technology activities in early childhood education, aiming to develop problem-solving skills, a core competency of the 21st century, for children from the earliest stage of life.

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