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Theoretical and Practical Basis for Developing Criteria of Evaluating STEAM Educational Materials for Preschool Children in Vietnam

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT: In the context of global education shifting towards competency development models, STEAM education is increasingly important in preschool education. However, in Vietnam, the development and use of STEAM learning materials lack objective scientific criteria for evaluation, leading to inconsistencies among educational institutions. This study aims to develop and verify a set of criteria for evaluating STEAM educational materials for preschool children in Vietnam. A mixed-methods research design was employed, combining surveys, interviews, observations, and document analysis at 23 kindergartens in Quang Ninh, Ninh Binh, Hanoi, and Ho Chi Minh City. The criteria development process followed five systematic steps from theoretical foundation to finalization. The findings revealed a limited understanding of STEAM education among administrators and teachers, as well as an insufficient current supply of STEAM materials and key challenges, including a lack of funding, coordination gaps, and the absence of evaluation criteria. The study successfully established a theoretical and practical foundation for developing a standardized, scientific, and feasible criteria system for evaluating STEAM educational materials, supporting educational institutions and teachers in selecting and using materials more effectively to promote comprehensive development among preschool children.

Keywords: *early childhood education, educational materials, preschool, STEAM, Vietnam*

I. INTRODUCTION

In the context of the world's education shifting strongly to the competency development model, STEAM education (Science, Technology, Engineering, Arts, Mathematics) is increasingly asserting its important role in preschool education. Many international studies have shown that integrating STEAM in the early stages of life not only stimulates creative thinking, technical thinking, and problem-solving skills but also develops children's ability to cooperate, communicate, and explore the world through practical experiences (Başaran & Bay, 2023; Voicu & Matei, 2021; Spyropoulou, Wallace, Vassilakis, & Poulopoulos, 2020; Awang, Yakob, Hamzah, & Talling, 2020; DeJarnette, 2018). Along with this trend, preschools in Vietnam have begun to incorporate many STEAM activities and learning materials to meet the requirements of educational innovation; however, the level of synchronization and quality of these learning materials remains unstable.

In the world, STEAM learning materials for preschool children are developed in various ways with the support of educational organizations and companies specializing in learning materials; however, the method of assessing the quality, suitability, and effectiveness of these materials is still inconsistent among countries (Voicu, Ampartzaki, Dogan, & Kalogiannakis, 2022). In Vietnam, the development and use of STEAM learning materials is increasingly popular, but is primarily based on teachers' experience or documents provided by units, lacking a system of scientific criteria for objective evaluation. This leads to a significant difference between educational institutions in the selection and design of learning materials, affecting the quality of organizing STEAM activities for children.

A significant gap in current research is that in Vietnam, there is no standardized set of criteria for evaluating STEAM learning materials for preschool children that has a clear theoretical basis and has been verified for its suitability and feasibility in practice. The absence of a unified evaluation tool makes it difficult for managers, teachers, and learning material development organizations when they need to select or design learning materials that meet requirements.

Based on this reality, this study was conducted with the aim of developing a set of criteria for evaluating STEAM educational materials for preschool children, while also verifying the suitability and feasibility of these criteria in the context of preschool education in Vietnam. This article presents part of the research results, including the theoretical and practical basis for developing criteria for evaluating STEAM educational materials for preschool children in Vietnam.

II. RESEARCH RESULTS OF THEORETICAL BASIS

2.1 Basic concepts

Learning materials are understood to encompass all means, including documents, tools, equipment, images, sounds, software, and other resources used in the teaching and learning process to support teachers and learners in achieving educational goals effectively (Bureekhampun & Mungmee, 2020). This concept encompasses various types, including printed learning materials, visual learning materials, digital learning materials, interactive learning materials, and self-created learning materials derived from available resources. According to the modern educational perspective, learning materials are not only tools to transmit knowledge but also factors that promote the positivity, initiative, and creativity of learners through creating an experiential learning environment (Piaget, 1972; Vygotsky, 1978).

In preschool education, learning materials play a crucial role in supporting children's exploration, interaction, and comprehensive development through integrated play-based learning activities. In addition, Circular 47/2020/TT-BGDDT stipulates that learning materials in preschool education facilities include physical means that store or reflect educational content, from publications to electronic learning materials and self-made learning materials designed by teachers to serve the activities of nurturing, caring for, and educating children (Ministry of Education and Training, 2020).

STEAM educational materials are understood as a collection of documents, means, tools, equipment, materials, and supporting products designed or selected to serve the organization of integrated activities in five areas: Science, Technology, Engineering, Art, and Mathematics (Yakman & Lee, 2012). STEAM materials not only convey knowledge but also play a role in arousing interest, stimulating thinking, and promoting children's ability to explore, create, and solve problems through interdisciplinary, practical experiences (Bers, 2020).

In preschool education, STEAM learning materials encompass a diverse range of forms, including open-ended materials (such as paper, straws, paper boxes, and wooden sticks), assembly models, simple experimental tools, interactive boards, art products, and digital learning materials (e.g., software, applications, or interactive videos). The outstanding features of STEAM learning materials are their openness, integration, high interactivity, and ability to stimulate critical thinking, thereby supporting children in learning through play and experience (Spyropoulou, Wallace, Vassilakis, & Poulopoulos, 2020).

For this study, the concept of STEAM learning materials was established as an approach to guide the data collection and analysis process, ensuring consistency in the approach and evaluation of learning materials used for preschool children.

2.2 Process of developing criteria for evaluating STEAM educational materials for preschool children

The process of developing criteria for evaluating STEAM educational materials for preschool children is grounded in contemporary pedagogical theories and empirical research in the field of early childhood education. The design of the process aims to ensure that the evaluation criteria are both scientific and suitable for educational practice, while supporting the comprehensive development of children.

First, the constructivist theory of Piaget (1972) and Vygotsky (1978) affirms that children are active subjects in the learning process. According to Piaget (1972), knowledge is formed through the mechanisms of assimilation and accommodation, helping children adapt to their environment. Vygotsky (1978) added that social support and language interaction play a decisive role in expanding the "Zone of Proximal Development" (ZPD). Therefore, STEAM learning materials must create conditions for children to explore, cooperate, and construct knowledge through experiential activities. This is an important theoretical foundation for forming criteria for evaluating STEAM learning materials (Piaget, 1972; Vygotsky, 1978).

Secondly, Kolb's (1984) Experiential Learning Theory emphasizes that effective learning occurs when children are engaged in a cycle of experience - reflection - generalization - experimentation. In the context of STEAM, learning materials must be practical, allowing children to experience trial and error and develop problem-solving skills. Therefore, assessment criteria should reflect the extent to which learning materials support practical experience and foster children's creative thinking (Kolb, 1984).

Thirdly, according to the STEAM educational approach, Yakman and Lee (2012) believes that STEAM is an interdisciplinary integrated model that aims to develop systems thinking and the ability to connect knowledge. Quigley and Herro (2016) also emphasize the role of project-based learning and experiential activities in developing children's problem-solving skills. Therefore, the criteria for evaluating STEAM learning materials must consider the level of interdisciplinary integration and the ability to encourage children to apply multidisciplinary knowledge to solve real-life situations (Yakman & Lee, 2012; Quigley & Herro, 2016).

Finally, the criteria development is also based on the competency frameworks of preschool education, including the Vietnam Preschool Education Curriculum (Ministry of Education and Training, 2021) and the Early Childhood Program Standards of the American National Association for the Education of Young Children (NAEYC, 2020). These frameworks all emphasize the comprehensive development of cognition, language, physical, emotional-social, and aesthetic aspects. At the same time, they also set requirements for the suitability, safety, and pedagogical value of learning materials. These requirements are an important foundation to ensure that the set of criteria for evaluating STEAM learning materials is appropriate to the age characteristics and supports comprehensive development for children (Ministry of Education and Training, 2021; NAEYC, 2020).

Based on the above theoretical foundations, the process of developing criteria for evaluating STEAM learning materials is oriented according to three main pillars: (1) Constructivist theory, (2) Experiential learning theory, and (3) STEAM integrated approach, combined with the framework of developmental competencies of preschool children. The process includes the following steps:

Step 1. Determine the theoretical and practical basis: The research team reviewed theories related to learning materials, STEAM, child development characteristics, and principles of learning material design. At the same time, survey practices are employed at preschools to identify the needs and challenges associated with using STEAM learning materials.

Step 2. Build a preliminary criteria framework: The proposed criteria framework is based on the overview and survey results, including criteria groups such as pedagogy, STEAM integration, age appropriateness, openness and creativity, safety, etc. Each criterion is clearly described in terms of objectives and assessment levels.

Step 3. Consult an expert: Experts in the fields of early childhood education, STEAM, and learning materials development were invited to provide feedback to ensure the logic, feasibility, and relevance of the criteria. The results were used to revise and finalize the criteria framework.

Step 4. Testing and reliability assessment: The criteria framework was field-tested in several preschools. The data collected helped to assess the clarity, applicability, and relevance of the criteria, and to determine the reliability and validity of the criteria system.

Step 5. Finalize and issue: Based on feedback and testing results, the research team finalized a set of criteria to ensure scientific validity, feasibility, and suitability for practice. The set of criteria can then be issued to guide the selection, development, and evaluation of STEAM learning materials in a unified manner.

The above process demonstrates a close combination of theory and practice, contributing to the creation of an effective assessment tool that supports the improvement of STEAM activities in preschool education.

2.3 Factors influencing the development of evaluation criteria for STEAM educational materials for Vietnamese preschool children

The development of criteria for evaluating STEAM educational materials for preschool children depends on several factors to ensure that the materials are suitable for age characteristics and meet the requirements of the educational program and practical implementation in schools.

Developmental characteristics of preschool children

Preschool children exhibit unique characteristics in their physical, cognitive, linguistic, emotional-social, and aesthetic development. According to Piaget and Vygotsky, children learn through play, direct experience, and social interaction. Therefore, the criteria for evaluating STEAM learning materials must ensure that the materials are age-appropriate, safe, easy to manipulate, stimulate interest, and support children in exploring, cooperating, and developing visual-figurative thinking. This is the fundamental factor that determines the availability and effectiveness of STEAM learning materials for young children.

Objectives and contents of the preschool education program

The Vietnamese Preschool Education Program focuses on comprehensive development in 5 areas: physical, cognitive, language, aesthetic, and social-emotional. STEAM education emphasizes creative thinking, problem solving, cooperation, and knowledge application. Therefore, the criteria system for evaluating learning materials must ensure the consistency between the content of learning materials and the program objectives, integrating STEAM elements while closely following the educational requirements of each age group.

The nature of STEAM education

STEAM is an integrated educational model closely linked to experience, exploration, and practical problem-solving. Unlike traditional teaching that focuses on theory, STEAM emphasizes the active role of children in exploring, questioning, experimenting, and creating. Therefore, the criteria for evaluating STEAM learning materials must clearly demonstrate the level of interdisciplinary integration, the ability to stimulate creative thinking, aesthetic emotions, and collaboration skills. Learning materials should create opportunities for children to apply multidisciplinary knowledge and connect their learning with real-life experiences.

Conditions at preschools

Facilities, teaching equipment, educational environment, and socio-economic conditions of each locality directly affect the ability to implement STEAM. Some schools have access to modern teaching materials, while schools

in disadvantaged areas mainly rely on recycled or homemade teaching materials. Legal documents, such as the Circular on Minimum Equipment and the Preschool Education Program, are also important bases for selecting or evaluating teaching materials. Therefore, assessment criteria need to be flexible, feasible, and suitable for various practical conditions, avoiding a mechanical approach or undue pressure on teachers.

Professional competence of teachers and managers

Teachers and administrators play a decisive role in understanding, using, and applying the criteria system. Teachers need to have basic STEAM knowledge, understand the characteristics of child development, and know how to design integrated activities. If the team lacks capacity or has limited access to STEAM, the evaluation of learning materials is likely to be a formality. Therefore, the criteria must be straightforward, easy to understand, and accompanied by clear instructions for use. At the same time, educational institutions need to organize capacity building for teachers and administrators to improve their ability to access and apply the criteria set in a unified and effective manner.

III. RESULTS AND DISCUSSION

3.1 Survey contents

General information about teachers: Professional qualifications, work experience, experience teaching preschool children, especially children in an integrated environment.

Perception of STEAM learning materials: Understanding the characteristics, roles, and uses of STEAM materials in developing children's thinking, creativity, problem-solving, and collaboration skills. Awareness of how to select, design, and evaluate materials appropriate to the developmental characteristics of preschool children.

Level of application of STEAM materials in the classroom: Frequency and method of using STEAM materials in educational activities. Adjust materials and activities according to children's needs, abilities, and developmental characteristics.

Difficulties and challenges: Difficulties in selecting, designing, and utilizing STEAM learning materials; limitations in facilities, equipment, time, and professional capacity; and difficulties in evaluating the effectiveness of learning materials on children's capacity development.

Support needs and suggestions: Training on STEAM learning materials; guidance documents, checklists, and scales to evaluate the effectiveness of learning material use.

3.2 Survey methods

The survey method was implemented in combination:

Questionnaire and in-depth interview: Collect quantitative and qualitative information on teachers' perceptions, adoption levels, and difficulties.

Direct observation: Record how teachers utilize materials and observe children's reactions and interactions during STEAM activities.

Document analysis: Review current curriculum, instructional materials, instructional manuals, and assessment criteria.

3.3 Survey toolkits

A questionnaire and scale to assess the level of application of STEAM materials by teachers.

Checklist and scale to assess the suitability, creativity, integration, and effectiveness of learning materials.

Observe children directly participating in STEAM activities using various learning materials.

3.4 Survey subjects

The survey subjects include 100 managers (Principals, Vice Principals) and 200 teachers directly teaching at 23 kindergartens in the provinces/cities of Quang Ninh, Ninh Binh, Hanoi, and Ho Chi Minh City.

3.5 Results and Discussion

Level of understanding of teachers, administrators, and teachers about STEAM education in preschool education

Table 1. Level of understanding of STEAM of managers and teachers

Level of understanding	Managers (%)	GV (%)
Very little understanding	11.3	16.9
Little understanding	58.8	67.7
Average understanding	18.6	9.2
High Understanding	11.3	5.6
Very high Understanding	15.6	7.8

The results show that the majority of managers and teachers understand very little or little about STEAM, while the rate of high and very high understanding is still low. Through in-depth interviews, it shows that many people still consider STEAM an educational method, but this is an incorrect concept. In the most accurate understanding, STEAM is an integrated educational approach designed to develop learners' maximum potential.

Opinions of administrators, teachers, and parents on the adequacy of the current STEAM educational materials in preschools

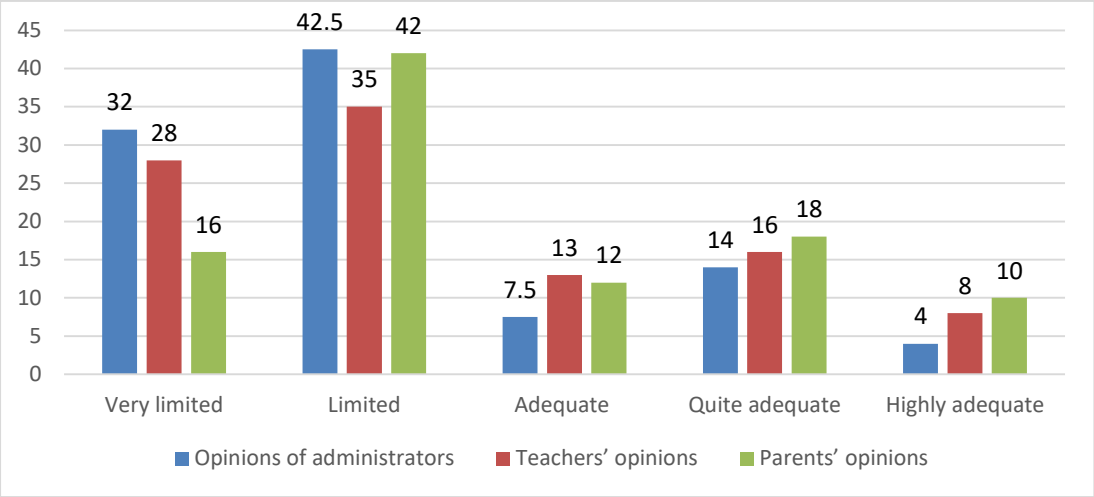

Figure 1. Assessment of the adequacy of the current STEAM educational materials in preschools

The results showed that the majority of the survey groups rated the problem as "Limited" or "Very limited", with the highest percentages among managers and parents. The "Adequate" level was chosen very little, demonstrating that the need for improvement is still evident. The "Quite adequate" and "Highly adequate" levels only accounted for a low percentage in all three groups. Overall, there was a consensus that additions and improvements were needed, reflecting specific differences in perception among managers, teachers, and parents.

Difficulties of managers and teachers when using criteria to evaluate STEAM educational materials for preschool children

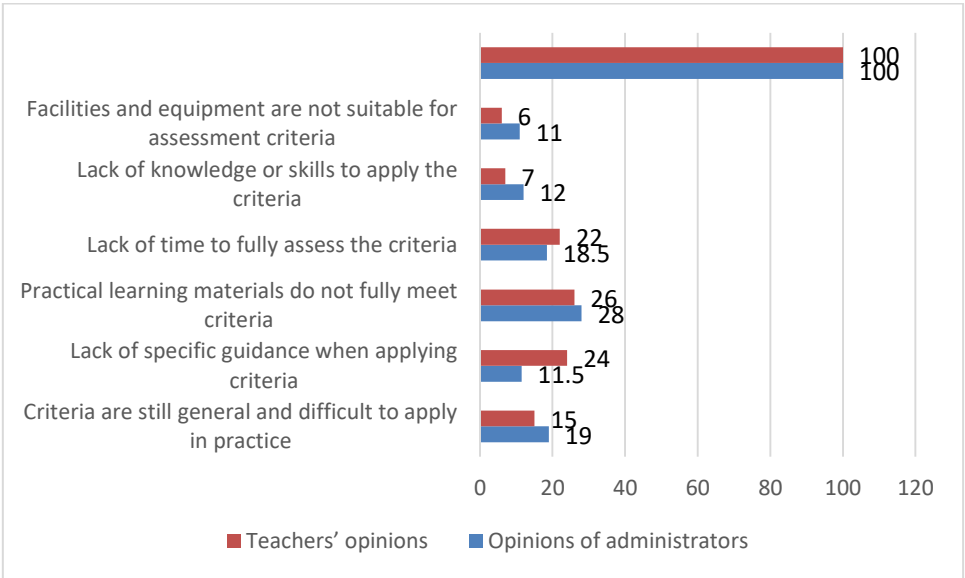

Figure 2. Difficulties in using criteria to evaluate STEAM educational materials for preschool children

The survey results indicate that managers and teachers share common difficulties, particularly the issues of "Learning materials do not meet the criteria" and "Criteria are too general." However, teachers face more obstacles, including "Lack of specific instructions" and "Lack of time for assessment." In contrast, managers pay more attention to limitations in knowledge, skills, and facilities. These differences indicate a need for a synchronous solution in terms of instructions, time, and implementation conditions to enhance the effectiveness of the criteria application.

Types of STEAM educational materials for preschool children currently being used by teachers

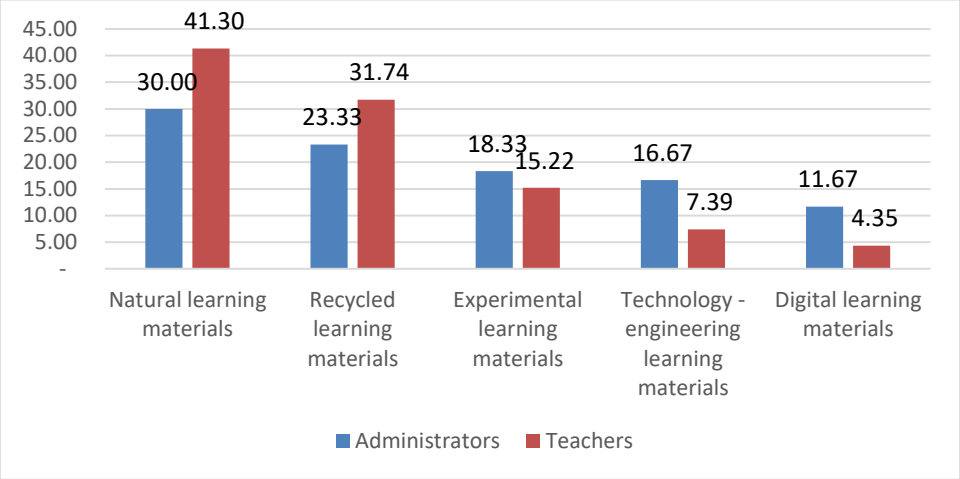

Figure 3. Types of STEAM educational materials for preschool children currently used

The survey results show that natural learning materials are used most because they are readily available and easy to find, followed by recycled learning materials due to their economic and environmental education significance. Experimental learning materials and technology, such as engineering learning materials, are used less due to limitations in equipment and declining popularity. Digital learning materials have the lowest rate, reflecting the limited application of technology in preschool classes. This shows the need to increase investment and training to diversify STEAM learning materials.

Frequency of using STEAM educational materials in educational activities

When we asked teachers about the frequency of using STEAM educational materials in their educational activities, they responded as follows:

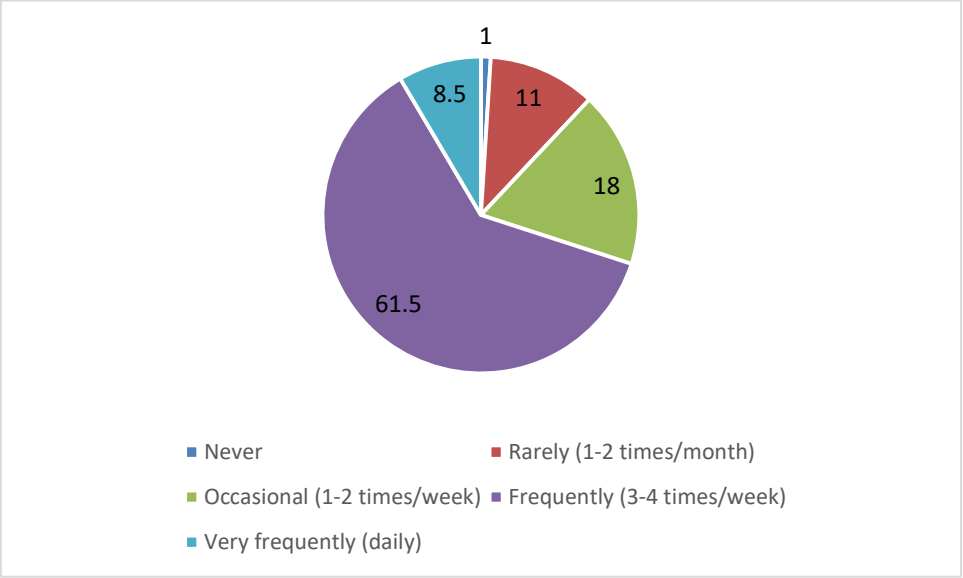

Figure 4. Frequency of using STEAM educational materials in educational activities

The chart shows that the group that participates regularly (3-4 times/week) has the highest rate (61.5%), while the occasional rate is 18% and rarely is 11%. The daily participation rate remains low (8.5%), and there are almost no cases of non-participation (1%). Overall, the activity is maintained regularly but not at the daily level.

Advantages for managers and teachers when using STEAM educational materials for preschool children

Table 2. Advantages of using STEAM educational materials for preschool children

Items	Managers (n=100)	Managers (%)	Teachers (n=200)	Teachers (%)
The school administration is attentive and provides close guidance	85	85.0	140	70.0
The school has sufficient funding to support implementation	60	60.0	95	47.5
The facilities are adequate (classrooms, equipment, learning materials)	72	72.0	120	60.0

Teachers have knowledge and skills in STEAM	55	55.0	110	55.0
There is specific guidance from higher authorities	68	68.0	115	57.5
Parents agree and support	50	50.0	105	52.5
Class sizes are appropriate for organizing effective STEAM activities	46	46.0	90	45.0
There is close cooperation between the school and parents	63	63.0	130	65.0
There are clear criteria for evaluating implementation effectiveness	40	40.0	80	40.0
Others	10	10.0	25	12.5

The survey results show that managers and teachers highly appreciate the leadership role of the Board of Directors (85% and 70%), as well as the facilities meeting the requirements (72% and 60%). Teachers' professional capacity is positively recognized (55%), along with support from superiors (68% and 57.5%), but funding and class size are limited. Coordination with parents is rated as good (63-65%), but the criteria for evaluating implementation effectiveness are unclear (40%). In general, the main advantages have been identified, and it is necessary to continue improving the limited factors.

Difficulties encountered when using STEAM educational materials for preschool children

Table 3. Assessment of managers and teachers on difficulties in using STEAM educational materials for preschool children

No	Content	Not difficult		Normal		Difficult		Average score		Ranking
		Manager (%)	Teacher (%)	Manager (%)	Teacher (%)	Manager (%)	Teacher (%)	Manager	Teacher	
1	Lack of funding	11	27.5	19	25.5	25	29.5	17	23.5	1
2	Lack of facilities	4	8	7	8.5	7	7	11	8.5	6
3	Teachers are not fully trained.	4.5	9	6	9.5	9	8.5	9	12.5	5
4	Lack of specific guidance from superiors	6	12.5	13	10.5	13	11.5	15	12.5	3
5	Parents do not understand STEAM well	4	7.5	7	8	9	8.5	7	7.5	7
6	Lack of STEAM classrooms	2.5	2.5	5	3.5	5	2.5	5	2.5	9
7	crowded classroom	3	6	13	7.5	4	6.5	6	6	8
8	There is no coordination between the school and parents.	8.5	16.5	17	16.5	15	15.5	17	16.5	2
9	Lack of evaluation criteria	6.5	10.5	13	10.5	13	10.5	13	10.5	4

The survey revealed that the most significant difficulty was a lack of funding (20.25 points), followed by a lack of coordination with parents (16.75 points). Lack of guidance from superiors (13.75 points) and evaluation criteria (11.75 points) made it difficult for teachers to implement. In addition, teachers were not fully trained (10.75 points), and a lack of facilities (9.75 points) was also an important barrier. The problems of parents not understanding STEAM, crowded classes, and a lack of classrooms, although having lower scores, still existed.

In general, a collaborative approach involving management, teachers, and parents is necessary to effectively implement STEAM learning materials.

IV. RECOMMENDATION

The development of criteria for evaluating STEAM educational materials for preschool children aims to ensure scientific accuracy, objectivity, and suitability with the goal of comprehensive development for children. The criteria are based on theories of preschool education, the STEAM approach, and practical implementation in preschool educational institutions. The criteria focus on basic requirements, including safety, durability, aesthetics, openness, creativity, interdisciplinary integration, and the level of suitability with children's psychological characteristics. At the same time, the criteria also focus on the effectiveness of organizing activities, the ability to stimulate interest, and the development of thinking and problem-solving skills in children.

The criteria development process is carried out through several steps, including document research, practical surveys, and consultation with experts, teachers, and managers. On this basis, the set of criteria is not only directional but also has high application value, enabling teachers to select, use, and improve learning materials in a scientific and creative manner. This is also the basis for educational managers to evaluate the level of meeting the requirements of STEAM education in learning materials, thereby developing plans to foster, support, and adjust as needed, contributing to the improvement of preschool education quality.

V. CONCLUSION

The research results not only supplement the theoretical basis for the field of preschool STEAM education but also have significant practical implications, supporting educational institutions, teachers, and learning material developers in selecting, designing, and using STEAM learning materials in a more scientific, effective, and consistent manner. From there, the research team has the basis to develop a system of criteria for evaluating STEAM learning materials that is appropriate, scientific, and feasible, while also supporting the organization of practical STEAM educational activities that promote the comprehensive development of capacity and interest in learning among preschool children.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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