METHODOLOGY FOR DEVELOPING RESEARCH SKILLS IN PRESCHOOL CHILDREN BASED ON STEAM TECHNOLOGY

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Abstract. This article presents a methodology for developing research skills in preschool children through the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) approaches. Research skills, including curiosity, observation, questioning, prediction, experimentation, and reflection, are foundational to lifelong learning, yet they are often underdeveloped in early childhood education because of fragmented curricula and limited inquiry-based practice. The study draws on constructivist and sociocultural theories of learning and on international frameworks for integrated STEM education. The proposed methodology consists of four sequential stages: stimulating curiosity, guided exploration, collaborative investigation, and reflective presentation. Each stage is linked to specific STEAM activities and to observable indicators of research competence. A three-level assessment framework is also described for monitoring children's progress. The methodology is intended for preschool educators, methodologists, and teacher-training specialists, and it offers a structured pathway for transforming everyday play into systematic inquiry.

Keywords: *preschool education; STEAM; research skills; inquiry-based learning; early childhood; teaching methodology*

1. Introduction

In the twenty-first century, societies increasingly depend on people who can ask questions, gather evidence, test ideas, and revise their conclusions. International organizations have repeatedly identified these abilities as core competencies for lifelong learning and professional life (OECD, 2018). Research competence does

not begin in school or university. Its foundations are laid in early childhood, when children explore objects, ask persistent questions, and try to understand cause and effect. Developmental researchers have long noted that preschool children are strongly motivated to make sense of the world around them (Piaget, 1973).

Despite this potential, preschool education in many settings still emphasizes the memorization of prepared information and the reproduction of answers supplied by adults. Activities are frequently organized around separate subject areas, and children have limited opportunities to plan investigations, test their own predictions, or reflect on what they have discovered. As a result, the natural curiosity of young children may diminish before it is channeled into systematic inquiry. This problem is especially visible where there is no clear methodological framework that teachers can apply to develop research skills at the preschool level.

STEAM education, which integrates Science, Technology, Engineering, Arts, and Mathematics, offers a promising response. Rather than treating each discipline as an isolated subject, STEAM approaches present learners with meaningful problems that require knowledge and reasoning from several fields at once (Yakman, 2008). Because such problems are typically open-ended and hands-on, they provide a natural setting for developing inquiry skills. However, the translation of STEAM principles into a structured methodology for young children, with explicit attention to research competence, remains underdeveloped.

The present article addresses this gap. Its aim is to propose and substantiate a methodology for developing research skills in preschool children on the basis of STEAM technology. The article pursues three objectives: to clarify the theoretical foundations and structure of research skills in early childhood; to describe a four-stage methodological model with its guiding principles and activities; and to present an assessment framework for monitoring children's progress. Three research questions guided the work: (1) Which components constitute research skills in preschool children? (2) How can STEAM activities be organized to support each

component? (3) How can children's progress be observed and evaluated in a developmentally appropriate way?

2. Theoretical Background

2.1 STEAM as an integrative approach

The acronym STEM was introduced to emphasize the connections among science, technology, engineering, and mathematics (Sanders, 2009). The later addition of the arts, giving STEAM, was proposed to reflect the role of creativity, design thinking, and aesthetic judgment in innovation (Yakman, 2008). Bybee (2010) argued that integrated STEM learning should begin early, since the habits of observation and reasoning formed in childhood shape later engagement with science and mathematics. Kelley and Knowles (2016) described integrated STEM education as an approach that uses engineering design as a context for connecting disciplinary knowledge with real-world problem solving. For young children, the integrative character of STEAM is particularly important, because children do not naturally separate disciplines in their everyday experience of the world.

2.2 Inquiry and research skills in early childhood

Inquiry-based learning is closely associated with the scientific practices described in national frameworks, including asking questions, planning and carrying out investigations, analyzing evidence, and constructing explanations (National Research Council, 2012). Although these practices are usually described for school-age learners, their early forms are visible in young children's behavior. Harlan and Rivkin (2004) showed that preschool children engage in genuine scientific thinking when they are given time, materials, and adult support to explore phenomena.

For the purposes of this study, research skills in preschool children are defined as an integrated set of six components: curiosity about phenomena; observation and description; questioning; prediction; simple experimentation; and communication and reflection. Each component can be developed at a level appropriate for children aged five to six years.

2.3 Theoretical foundations

The methodology rests on two complementary perspectives. From a constructivist standpoint, knowledge is actively built by the learner through interaction with the environment (Piaget, 1973). Children construct understanding by acting on objects, noticing outcomes, and adjusting their ideas. From a sociocultural standpoint, development is mediated by language and by collaboration with more knowledgeable partners (Vygotsky, 1978). The concept of the zone of proximal development implies that adults can scaffold children's inquiry through guiding questions and can gradually withdraw support as competence grows. Together, these perspectives justify a methodology in which children investigate actively and in cooperation with peers and teachers.

3. Methodology

3.1 Research design

The study followed a developmental-pedagogical design. The methodology was developed through analysis of relevant scientific literature and of existing preschool practice, and it was structured as a sequence of stages that can be implemented in regular preschool groups. Its applicability is assessed through systematic observation, documentation of children's work, and reflective analysis by teachers.

3.2 Participants and setting

The methodology is intended for children aged five to six years attending preschool institutions. Groups of 10 to 15 children are recommended, because this size allows each child to take part in discussion, handle materials, and receive individual feedback. Sessions last 25 to 30 minutes and are held two or three times per week, integrated into the daily program.

3.3 Guiding principles

Four principles underpin the methodology: (a) play as the leading activity of preschool age; (b) child agency, meaning that children's questions and ideas guide the direction of investigation; (c) integration of disciplines through a single authentic

problem; and (d) documentation, so that children's thinking becomes visible to themselves and to adults.

3.4 The four-stage model

The methodology consists of four sequential stages, summarized in Table 1. In practice the stages are cyclical: children may return to an earlier stage when a new question emerges from their work.

Table 1. Stages of the STEAM-based methodology

Stage	Aim	Typical STEAM activities	Research skills developed
1. Stimulating curiosity	Engage children with a surprising phenomenon or everyday problem	Mystery boxes; sound and light play; "What happens if?" displays	Curiosity, observation
2. Guided exploration	Let children handle materials and notice regularities under teacher guidance	Sorting objects by sinking and floating; building with blocks and magnetic tiles	Observation, description, questioning
3. Collaborative investigation	Children formulate predictions, test them in small teams, and record outcomes	Ramp races; bridge-building challenges; color-mixing experiments with drawn records	Prediction, experimentation
4. Reflective presentation	Children share findings, explain their reasoning, and revise ideas	Drawn or dictated "discovery books"; gallery walks; short puppet presentations	Communication, reflection

In Stage 1, the teacher presents a phenomenon that invites questions, such as a mystery box whose contents must be guessed by touch and sound. The aim is not to deliver an explanation but to generate interest and a shared sense of wonder. In Stage 2, children explore materials freely while the teacher asks open questions that direct attention to features, comparisons, and changes. In Stage 3, small teams turn their questions into predictions, test them with simple procedures, and record results with drawings or symbols. Changing only one condition at a time is encouraged where possible, which introduces the basic logic of controlled comparison in an age-appropriate form. In Stage 4, children present their results to the group, explain why

an outcome surprised them, and decide whether their original idea should change. This final stage closes the cycle and prepares the next investigation.

Across all stages, mathematics appears in counting, measuring with non-standard units, and comparing quantities; technology appears in simple tools such as magnifiers, timers, and digital cameras; engineering appears in design challenges; and the arts appear in drawing, music, and dramatization as forms of representation and expression.

3.5 Assessment framework

Table 2 presents three descriptive developmental levels for each research skill component. The levels are qualitative, reflecting the nature of assessment in early childhood, where children's competence is best judged through observed behavior over time rather than through tests.

Table 2. Levels of research skill development in preschool children

Component	Level 1 (Emerging)	Level 2 (Developing)	Level 3 (Established)
Curiosity	Responds to phenomena when prompted	Initiates questions about phenomena independently	Sustains interest in a phenomenon across several sessions
Observation	Notices the most obvious features	Describes several features using simple vocabulary	Compares features and notes changes over time
Questioning	Asks few questions, mostly with adult help	Asks questions that can be tested through action	Formulates questions that suggest a plan of investigation
Prediction	Guesses without giving reasons	Predicts an outcome and gives a simple reason	Predicts, tests, and explains the difference between prediction and result
Experimentation	Manipulates materials without a clear plan	Repeats a simple action to test an idea	Changes one condition at a time and compares results with peers
Communication and reflection	Describes results with single words or gestures	Explains findings in short sentences	Revises an idea in response to evidence and peer input

Data for the assessment are gathered from several sources: structured observation sheets completed by teachers at the end of each session, photographs and drawings of children's work, audio recordings of children's discussions made with parental consent, and teachers' reflective journals. Triangulation across these sources is intended to reduce the subjectivity inherent in observational assessment and to show the development of each child over time.

3.6 Ethical considerations

Participation requires written consent from parents or guardians. Children's identities are protected in all reports through the use of pseudonyms and the omission of identifying details. Activities use only safe, age-appropriate materials, and children may withdraw from any activity at any time without consequence.

4. Results and Discussion

4.1 Expected implementation outcomes

When the four stages are implemented consistently, the methodology is expected to change the way children approach everyday phenomena. In the early weeks, teachers can expect children to begin asking "why" and "what if" questions spontaneously during routine activities. As the cycle is repeated, children are expected to become more deliberate in their experiments: they state a prediction before acting, repeat actions to check outcomes, and begin to compare their results with those of classmates. Progress should be recorded against the levels in Table 2, so that movement from Level 1 to Level 2 and from Level 2 to Level 3 can be identified for each component.

4.2 Interpretation in relation to the research questions

With respect to the first research question, the analysis supports treating research skills as a set of six interrelated components rather than a single ability. Curiosity and observation form the entry point of inquiry, while prediction, experimentation, and reflection develop as children gain experience of testing ideas. With respect to the second question, the four-stage model shows how a single authentic problem can be used to address several components at once, so that the

integration of STEAM disciplines is not an additional burden on the teacher's program but a way of organizing existing activities. With respect to the third question, the three-level framework offers a practical means of observing progress without imposing formal tests on young children.

4.3 Discussion

Compared with traditional preschool practice, the proposed methodology shifts the teacher's role from the transmitter of answers to the facilitator of inquiry. This shift is consistent with the notion of scaffolding derived from Vygotsky's sociocultural theory, in which adults support children's thinking within the zone of proximal development and gradually withdraw support as competence grows (Vygotsky, 1978). The use of everyday materials and familiar contexts is also consistent with the argument that learning is strengthened when formal and informal experiences are connected (Eshach, 2007).

The methodology also responds to the concern that early science experiences are often brief, unsystematic, or limited to demonstrations by the teacher (Harlan & Rivkin, 2004). By requiring children to predict, test, and present their findings, the model gives inquiry a clear structure while retaining the openness and playfulness that characterize early childhood.

Several limitations should be acknowledged. The methodology depends on teachers who understand both the STEAM approach and the developmental characteristics of preschool children, so teacher preparation is a necessary condition for its success. The assessment framework is qualitative and therefore depends on careful and consistent observation. Finally, the sessions require time, materials, and a supportive physical environment, which may be difficult to provide in every institution. These limitations point to directions for future research, including controlled comparative studies, longitudinal tracking of children's progress, and adaptation of the materials to the linguistic and cultural context of Uzbek-medium preschool institutions.

5. Conclusion

This article has presented a methodology for developing research skills in preschool children on the basis of STEAM technology. Research skills were defined as six interrelated components, namely curiosity, observation, questioning, prediction, experimentation, and communication with reflection. The methodology consists of four stages, stimulating curiosity, guided exploration, collaborative investigation, and reflective presentation, each linked to concrete STEAM activities and to specific developmental indicators. The three-level assessment framework enables teachers to monitor progress through observation of everyday behavior.

The main contribution of the methodology is that it provides preschool educators with a coherent sequence for turning play into inquiry, grounded in constructivist and sociocultural theory and aligned with international frameworks for integrated STEM learning. Its value will be confirmed through systematic implementation and evaluation, and it is offered as a foundation for further research and practical development in early childhood education.

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