© Rzeszów University Press
ISSN 2719-6550
e-ISSN 2719-7417
"Journal of Education, Technology and Computer Science"
No. 6(36)/2025
https://journals.ur.edu.pl/jetacomps

Received: 14.08.2025
Accepted for printing: 24.11.2025
Published: 31.12.2025

DOI: 10.15584/jetacomps.2025.6.2
Scientific

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Analysis of Inquiry-Based Activities in Pre-Primary Education

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Abstract

The study focuses on the analysis of inquiry-based activities in pre-primary education, with an emphasis on working with small materials. The theoretical part defines the objectives of the inquiry-based approach, the metacognitive development of the child, and the teacher's role in inquiry-based teaching. Children's inquiry activities and their cognitive development are analyzed by an observer. Specific inquiry-based activities were carried out using small materials in a selected kindergarten.

Keywords: technical education, inquiry-based approach, pre-primary education

Introduction

Building on the insights of both domestic and international scholars, as well as findings from scientific studies (Droščák, Fuchsová, Rochovská, 2024; Gunčaga, Severini, Totkovičová, 2024; Dostál, Kožuchová, 2016; Pavelka et al., 2019; Stebila et al., 2022; Stebila, Hatvanyi, 2022), it has been confirmed that any effort to foster interest in technical education should be grounded in the natural curiosity of children and their specific learning needs. Technical education should be contextualized within everyday situations and closely interconnected with other subject areas through an interdisciplinary approach. Children should learn primarily through observation, experimentation, and hands-on inquiry. Technical education provides an effective learning environment that enables teaching and learning processes to adapt to the current needs of society. Education systems must remain flexible and capable of responding to rapid advances in science and technology, which necessitates the continual search for innovative instructional methods and forms. For these reasons, it is essential to determine what kind of technical education today's younger generations should receive.

This study focuses primarily on addressing current challenges related to the implementation of an inquiry-based approach in technical education. The essence of the "scientific method" in education lies in teaching that is inquiry oriented. In pre-primary education, it is grounded in the principle of relatively independent exploration of reality by children through active engagement in learning activities. Among the main objectives of the inquiry-based approach in early childhood education are the development of foundational critical thinking and metacognitive skills.

Metacognition refers to the capacity to be aware of and reflect upon one's thinking – essentially, "thinking about thinking" (Zelina, 2019). In the context of inquiry-based learning, metacognitive development plays a pivotal role because it encourages children to become aware of their cognitive processes and learning strategies, and to regulate and refine them actively. An inquiry-based approach particularly supports the development of skills essential for planning and monitoring one's learning – skills that are closely tied to both metacognitive awareness and critical thinking (Hlásna, 2018).

All processes within inquiry-based learning are inherently linked to the development of creative thinking, as creativity is intertwined with inquiry. When children become aware of their thought processes, they are better able to generate new ideas and explore unconventional solutions. Additionally, inquiry-based learning promotes the growth of communication skills. Children learn to clearly articulate their ideas, justify their reasoning, and persuade others during collaborative group activities, since inquiry-based learning is typically conducted in a team setting. Similar to what we can observe when applying role-playing games. (Wouters, Van Nimwegen, Van Oostendorp, Van Der Spek, 2013). Metacognitive development within the inquiry-based approach aims to empower children for autonomous learning and effective adaptation to life's challenges now and their future (Pintrich, 2002).

The aim of this qualitative study is to explore how inquiry-based activities using small materials support the development of children's metacognitive, creative, and critical thinking skills in pre-primary education. Specifically, the research seeks to analyze how children plan, test, and reflect on their learning during hands-on inquiry tasks in a kindergarten setting.

Research Methodology and Tools

In our research, we employed a qualitative case study approach (Yin, 2018) with elements of action research (Kemmis, McTaggart, Nixon, 2014), focusing on the observation and analysis of inquiry-based activities carried out in a pre-primary classroom. The methodological design was based on naturalistic and participant observation (Creswell, Poth, 2018; MacNaughton, Rolfe, Siraj-Blatchford, 2010), combined with the use of documentation tools, e.g., child worksheets and observers' notes (Denzin, 1978). Children's verbal expressions and behaviors were analyzed to identify evidence of critical thinking, creativity, and metacognitive processes (Schraw, Dennison, 1994; Whitebread, Coltman, Jameson, Lander, 2009). The educator's reflective analysis also contributed to the methodological triangulation of findings (Zeichner, Liston, 2014).

A preschool teacher in the Slovak town of Budimír implemented the inquiry-based activities. The specific activities were designed in alignment with the national curriculum for the educational area *Human and the World of Work*. The observations were conducted in November 2024. The inquiry-based sessions were typically carried out with a group of ten children aged 5 to 6 years.

Inquiry-Based Activities in Classroom Practice

In the proposed set of activities, the focus was placed on the preparation and implementation of paper-based tasks, which represent an effective means of developing children's practical skills. These activities aim to enhance fine motor skills and hand-eye coordination. In addition, working with paper fosters the development of creativity, imagination, and spatial awareness in young children. Through various paper manipulation tasks, children also learn about the properties of this material and its diverse applications in everyday life.

Activity 1: "Pinwheel"

This activity aimed to select a suitable small material and use it to create a functioning pinwheel, drawing on children's prior experience (they had previously made a paper pinwheel). The objective was to compare and evaluate which material would be more suitable for constructing a pinwheel. Children were encouraged to apply their creative thinking without being provided with a predetermined procedure. Subsequently, they tested their designs in the school yard to observe under which conditions the pinwheel would spin or remain still, and to explore the circumstances that influenced its motion.

Activity procedure

The teacher's individual questions, along with selected responses from the children, were systematically arranged in tabular form.

Table 1. Introduction to the activity

T*: “Look at the table, children. What do you see on it?”	Ch*1: “A bottle cork, wire.” Ch9: “A string and beads.” Ch3: “All kinds of stuff — beads, feathers…” Ch5: “There are two big sticks, too.”

* T – teacher; Ch – Child

From the observer’s notes:

The children’s responses reflect their current level of knowledge. The children attempt to name as many materials as possible. Child Ch3 demonstrates this by using the expression “all kinds of stuff,” indicating a desire to identify a wide range of items. Child Ch5 notices two thicker sticks on the table and perceives their potential use in the upcoming activity. The children observe the materials, touch and examine the objects on the table, and begin to reflect on what they might create from them.

Table 2. Open-ended (generative) question

T*: “What could we use these materials for?”	Ch*1: “Beads for a necklace.” Ch10: “The wire for something we wanna stick on… like to a stick.” Ch7: “Flowers for decoration.”
T: “And what could we use feathers for?"	Ch8: "For a carnival mask." Ch10: "For an Indian headdress." Ch7: "For dream catchers."

* T – teacher; Ch – Child

From the observer’s notes:

These responses indirectly indicate the children’s ability to formulate hypotheses and consider alternative possibilities. The children’s creative suggestions surprised even the teacher, particularly their ideas involving colorful feathers. The mention of a “dreamcatcher” was the most unexpected response; however, Child Ch7 later explained that they have a dreamcatcher made of colorful feathers at home, as her mother believes that peacock feathers help capture pleasant dreams. Six-year-old children exhibit a high level of creativity, often linked to their ability to integrate information from diverse sources.

Table 3. Inquiry-based reasoning question

T*: “Can we make a pinwheel like the one we made before with all these things?”	Ch*1: "No, because we made the pinwheel from paper." Ch7: "And we drew on it." Ch6: "Probably just some of it.”

* T – teacher; Ch – Child

From the observer's notes:

The children recalled a paper pinwheel they had previously decorated with colored pencils. They did not consider the materials on the table suitable for making a wind pinwheel. Child Ch5 remembered that there were two thicker sticks and a piece of wire. To help the children evaluate the suitability of the available materials for building a pinwheel, the teacher distributed worksheets. The children were asked to reflect on whether each material could be used to construct a functioning pinwheel. Their assumptions were recorded on the worksheet: if they believed a material was suitable, they marked a circle in the box with a smiling face; if they thought the material was unsuitable, they circled the box with a sad face.

Table 4. Guiding questions

T*: "How do we begin making a pinwheel?"	Ch*10: "We'll put the stick and the wire together."
T: "How do we put together them? "	Ch4: "We'll wrap the wire around the stick and leave one end sticking out."
T: "What will our next step be? "	Ch5: "Let's poke the cork onto the wire." Ch2: "Let's poke the feathers into the cork."

* T – teacher; Ch – Child

From the observer's notes:

Children at the age of six are already capable of developing a sequence of steps necessary to achieve a specific goal. In this case, they followed the suggestion provided by Child Ch10. The child focused on the basic components of the construction and understood that connecting these two elements was essential for creating the pinwheel. Child Ch4 began offering more specific instructions and recognized that the wire needed to be attached to the stick in a particular way to serve as the pinwheel's axis. Child Ch5 understood that the cork was another important structural element and demonstrated awareness of where it should be placed. Child Ch2 reflected on the functionality of the individual components and recognized that the feathers were necessary for the pinwheel to spin. With the help of the teacher's guiding questions, the children were able to break down a complex task into more straightforward steps and identify the required materials. They formed a mental image of the final product and were able to anticipate how the different parts would work together. The teacher allowed the children to test their ideas in practice. Some children inserted the feathers into the cork, but when they tried to make the pinwheel spin, it got stuck and did not rotate properly.

Table 5. Problem-solving question

T*: "What could we do to help the pinwheel spin better?"	Ch*4: "I think that if we put a bead in there, it will spin better." Ch2: "I think so too. I had a plastic pinwheel, and there was a bead in it." Ch1: "I agree."

* T – teacher; Ch – Child

From the observer's notes:

The children added one bead in front of and one behind the cork stopper. They drew on their prior experience with making a paper pinwheel as well as their familiarity with a plastic toy version. Finally, Child Ch7 suggested twisting the wire to prevent the beads from falling off. This revealed that Ch7 has great technical thinking, but is also generous, as the suggestion was shared with the other children as well.

Table 6. Descriptive question

T*: "What's left on the table?"	Ch*1: "Flowers." Ch8: "Oh, the letters are still there."

* T – teacher; Ch – Child

From the observer's notes:

The children discussed how they could attach flowers and leaves to the pinwheel. Child Ch8 suggested gluing them onto the cork. At this point, Child Ch4 recalled that when feathers had previously been glued to the cork, the pinwheel had great difficulty spinning. Based on that earlier experience, the children began to consider an alternative solution. They concluded that attaching the flowers and leaves using wire would likely be more effective. The teacher intentionally included an item that was not necessary for constructing the pinwheel. The children correctly identified that the string did not belong. In the final phase, they recorded the verified materials needed for the pinwheel construction on their worksheets and compared these findings with their initial assumptions. Children whose predictions matched the outcome expressed great joy and a sense of accomplishment. Conversely, those whose assumptions were not confirmed felt disappointed and frustrated. The teacher reassured them by explaining that even scientists do not always get their predictions right – and that such experiences provide valuable lessons for further inquiry.

Outdoor Inquiry Activity: "Why Does It Spin or Not Spin?"

The children were eager to test their completed pinwheels in the schoolyard. During outdoor time, the teacher continued to pose additional questions.

Table 7.

T*: "What did we have to do to get the propeller spinning?"	Ch*10: "We had to blow on it." Ch9: "We ran with it!" Ch2: "It twisted when the wind blew."

* T – teacher; Ch – Child

From the observer's notes:

Child Ch10 was the first to recall that they had to blow on the pinwheel, as there was no wind outside. However, not all children chose to blow–some ran around the yard with the pinwheel, and their movement caused it to spin. Child Ch9 later recalled this observation. Ideally, when the wind is blowing, there is no need to blow on the pinwheel or move quickly; the air current alone makes it spin. That is why it is called a wind pinwheel.

Table 8.

T*: "Why does the propeller spin when the wind blows?"	Ch*3: "...because the wind is blowing on it." Ch6: "The wind blows into the pinwheel." Ch10: "The air is moving." Ch7: "Sometimes the wind blows hard, and then the pinwheel spins fast."

* T – teacher; Ch – Child

From the observer's notes:

The children's responses show that even six-year-olds can think about natural phenomena and come up with simple explanations. They start to grasp cause-and-effect relationships. In Child Ch3's reaction, we see an emerging awareness of the link between wind and the movement of the pinwheel, even though the child cannot yet explain how the wind makes it turn. Child Ch6's answer is a bit more detailed, hinting at an emerging understanding that wind is basically moving air.

Table 9.

T*: "Have you seen such a large wind propeller anywhere?"	Ch*1: "Yeah, when we were in Austria, they were super tall and spinning around." Ch7: "I saw it in the fairy tale Perinbaba."

* T – teacher; Ch – Child

From the observer's notes:

Child Ch1 recalls a real-life experience involving a large wind turbine and links it to a specific location (Austria), which shows developing concepts of space and time. Child Ch7 talks about a fairy tale. It's important to understand that at this age, children may not fully distinguish between reality and fantasy. They are actively trying to understand the world around them and build mental models of how it works. The teacher explained to the children that wind energy can be used for various practical purposes.

Educational strategies

From the observer's notes:

The educational strategies, aligned with the learning objectives and the nature of the activity, included guided conversation through questioning techniques, the use of individual recording sheets, collaborative work on a product combined with critical evaluation, as well as observation and experimentation with a pinwheel (focused on the conditions under which the pinwheel spins).

Teacher's Reflection

The length of the learning activity matched a typical lesson; however, it needed more flexibility during its execution. Building the wind pinwheel took place both indoors and outdoors, as the children tested and observed its rotation in real conditions. They experimented and explored different ways to make the pinwheel spin. The activity was not only fun for the children but also offered meaningful learning opportunities through their critical thinking, hands-on involvement, and direct experience. In the future, it could be beneficial to visit the only preserved windmill in Slovakia, located in Holíč (Trnava District).

Reflective Evaluation by the Observer

Difficulty and Level of Activities: The selected activities were suitable for the children's age and prior experience. Although the children had previously made paper pinwheels, this activity challenged them to build a pinwheel using various small materials. At first, their assumptions were imprecise; however, as the activity went on, their hypotheses became more accurate and more closely matched reality. This gradual change shows the activity's effectiveness in encouraging inquiry-based thinking skills.

Motivation and Interest in the Activities: The children demonstrated strong engagement with the task of constructing a pinwheel from materials other than paper. The colorful feathers sparked great interest, as most of the children had never encountered them before. They expressed a desire to use all the materials provided and were disappointed when a piece of string remained unused. Some suggested wrapping it around the stick to include it in the design. When the pinwheel did not function as expected, the children experienced disappointment, yet they actively explored solutions to improve the design (e.g., adjusting how feathers were attached to the cork), which they eventually achieved. The children showed exceptional interest in experimenting with the conditions that affected the pinwheel's motion outdoors. These moments aroused their curiosity and encouraged further exploration.

Educational Strategies: The cognitive development of six-year-old children is active, characterized by emerging abilities in critical thinking, curiosity, and understanding cause-and-effect. The teacher effectively used a variety of teaching methods, including observation, guided discussion, and alignment with the learning goals. The children were prompted to observe closely, which boosted their critical thinking skills and experimentation. The activity and assessment also promoted teamwork, as children shared ideas and discussed their findings. Using individual recording sheets further improved their communication and analytical skills by helping them question their assumptions and reflect on what they observed.

Time Allocation

The inquiry-based activity was well suited to the available timeframe and was successfully finished within 40 minutes. This duration was selected based on the children's developmental stage and attention span (ages 5–6), ensuring consistent engagement and reducing fatigue – both of which helped the activity succeed.

Discussion

The inquiry-based approach has a significant impact on the metacognitive development of children, as it actively engages them in thinking about their cognitive processes. Throughout the activities, children are consistently encouraged to plan their steps, monitor their progress, and reflect on what they have learned. For example, when experimenting with the rotation of a pinwheel, they are guided to formulate predictions before the investigation and later compare those with actual outcomes. This process helps them become aware of how their thinking and learning evolve.

Inquiry activities directly foster the development of critical thinking, as children are required to analyze, evaluate, and synthesize information gathered through experimentation. For instance, when comparing the motion of the pinwheel under different conditions, they must critically assess the factors influencing its rotation – such as fast movement, twisting, or the effect of wind force. These discoveries are connected to broader theoretical frameworks. Through this process, children not only receive information but also learn to question, verify, and explore logical relationships between ideas.

Working with small and varied materials in inquiry-based activities also stimulates children's creativity. They learn to manipulate materials with different properties and experiment with their use, which enhances their ability to think beyond conventional frameworks, search for alternative solutions, and generate innovative ideas. In such activities, children identify problems (e.g., why the pinwheel fails to spin under certain conditions) and explore ways to resolve them.

Moreover, the inquiry-based approach fosters interdisciplinary learning. Over time, children develop a deeper understanding of the connections between various fields, such as science, technology, mathematics, and the arts. These links significantly enhance their overall development through interdisciplinary integration.

Conclusions

Children's responses to teachers' questions offered a fascinating insight into their thinking processes and demonstrated that even at the pre-primary level, they are capable of complex and analytical reasoning. Their ability to break down a task into individual steps, plan sequences of actions, and verbalize their thinking represents a foundational element for further cognitive development (Whitebread et al., 2009).

Implementing inquiry-based learning (IBL) in early childhood education presents both challenges and significant opportunities. Research suggests that the successful implementation of IBL requires the systematic development of teacher competencies already during pre-service teacher education (MacNaughton et al., 2010). This includes not only theoretical knowledge but also practical experience in applying inquiry-based methods in real educational settings (Harlen, 2013).

The effective use of inquiry-based activities depends on creating supportive learning conditions, including smaller group sizes and access to adequate materials and time (Larkin, 2012). Curricula for early childhood education should fully embrace the inquiry-based approach as a central element, rather than treating it as optional enrichment. When properly implemented, IBL allows children to explore and understand the world more deeply and holistically (OECD, 2017).

Inquiry-based learning has a profound impact on the development of metacognition, as it encourages children to reflect on their thinking processes, plan their actions, monitor their learning, and evaluate outcomes (Schraw, Dennison, 1994). For instance, when experimenting with the construction and motion of a pinwheel, children were guided to formulate predictions, test them, and reflect on the outcomes, thus strengthening their self-regulation and planning strategies (Veenman, Van Hout-Wolters, Afflerbach, 2006).

IBL also directly supports the development of critical thinking. As children compare results under different conditions and search for causal explanations, they learn to question assumptions, evaluate evidence, and identify patterns. These activities train them to draw conclusions based on logical reasoning and evidence, which are key aspects of critical thinking (Facione, 2011).

Moreover, working with varied materials in inquiry-based tasks stimulates creativity. Children experiment with different textures, properties, and tools, and learn to generate original ideas and innovative solutions beyond conventional expectations (Craft, 2005). They learn to identify problems and explore multiple solutions – skills essential for success in future learning and life.

Importantly, IBL promotes autonomy and responsibility for learning. Children keep records of their hypotheses and results, develop organizational skills, and engage in collaborative decision-making – all of which support their academic and personal growth (Kuhn, 2000). Even fine motor development, often the focus of early technical education, can be nurtured through inquiry-based work with small materials, promoting hand–eye coordination necessary for writing and other school tasks (Cameron et al., 2012).

Finally, inquiry-based learning encourages interdisciplinary thinking by connecting science, technology, engineering, arts, and mathematics (STEAM). Through integrated activities, children begin to recognize meaningful links between subjects and learn to apply knowledge across various domains, fostering a more comprehensive understanding of the world.

This contribution was prepared within the framework of the VEGA project No. 1/0264/26 A Multidimensional Model of Teachers' Well-being in the 21st Century and the VEGA project No. 1/0336/23 Research on the Equivalents of Didactics Theories in Teaching Practice and as a Consequence of the Extraordinary (Pandemic) Situation.

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