ISSN:

DOI:

Journal of Child Development and Education
Volume 1, Issue 1, 2025, 55-66
Article Type: Review Article

Inquiry-Based Science Teaching in Primary School

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Abstract: This study aims to explore the role of inquiry-based science education in fostering scientific skills among primary school students. With a foundation in both national and international literature, the study first examines the definition and scope of inquiry-based teaching, and then focuses on its relevance within science education, including key factors that influence its effectiveness. Designed as a comprehensive literature review, this study draws on research from a wide range of national and international sources to present the current state of inquiry-based science education in primary schools. Findings indicate that inquiry-based science teaching enhances students' engagement, interest, and academic performance in science subjects. Findings also emphasize that this method also helps to correct common misconceptions, making it an effective approach for deepening students' understanding of scientific concepts. Additionally, the study underscores the importance of teacher competencies for the successful implementation of inquiry-based methods, highlighting that teachers must be well-equipped to guide students through inquiry processes effectively. The study suggests that, in the long term, inquiry-based science education has the potential to cultivate critical thinking and scientific inquiry skills that extend beyond primary education. Further research is recommended to examine the long-term impacts of inquiry-based science teaching on students' scientific literacy, curiosity, and problem-solving abilities.

Article History
Received: 15.11.2024
Accepted: 28.11.2024

Keywords
Inquary-based learning,
Primary school,
Science

Introduction

Education creates a strong network of interactions among parents, children, and society. A change in any one of these three elements triggers a domino effect, influencing the other two. Socio-political, economic, or social developments within society, in particular, lead to outcomes that directly impact education for children. For instance, historical transitions to Agricultural, Industrial, and Information Societies have resulted in profound transformations within educational practices, significantly shaping children's learning experiences. The developmental stages of societies have influenced both the content and methods of education provided to children, with each era prioritizing the cultivation of different skills. In agricultural societies, education involved learning basic survival skills primarily through trial and error (Arklan & Taşdemir, 2008). Following the Industrial Revolution, the concept of an Industrial Society emerged alongside social, economic, and political transformations. The new social structures that developed after the Industrial Revolution supported diversification in education, facilitating the emergence of new educational concepts. In the classical educational approach developed in industrial society, individuals exhibiting desired behaviors were rewarded, while those displaying unacceptable behaviors were punished in various ways (Saygılı, 2013). In this period, although new educational approaches were

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Cite as (APA7) : Ölçer, S. (2025). Inquiry-based science teaching in primary school. *Journal of Child Development and Education, 1* (1), 55-66.

developed and alternative methods were explored in place of classical approaches, they were unable to adequately respond to rapidly changing societal needs. With societal transformation, the Industrial Society gradually gave way to the Information Society, and from the second half of the 20^{th} century onwards, significant changes in children's education began to emerge. Today, in line with the needs of the Information Society, it has become increasingly important for children to acquire 21^{st} century skills, such as research, inquiry, and critical thinking. Following this perspective, the aim has been to move away from classical educational approaches and develop new teaching methods and approaches that are tailored to children’s individual differences. This approach seeks to provide each child with an education suited to their own learning pace, interests, and abilities. With each individual interpreting knowledge according to their own interests and needs, the concept of "individual differences" has come to the forefront. Considering the effects of these differences on the learning process, the concept of "learning styles" was developed (Çağıltay & Göktaş, 2013). New methods and approaches have been developed in education by taking into account children’s individual differences and learning styles. One of these innovative methods, inquiry-based learning, aims to make learning processes more effective by supporting children’s curiosity and desire to explore.

To maximize effectiveness in children's education, it is essential to thoroughly understand the new concepts, methods, and techniques developed within the educational system. In this context, comprehensive literature reviews and summarizing studies that consolidate research in this field are needed to gain a better understanding of current approaches in children's education. This study aims to provide a general overview of inquiry-based science education for children and to examine the existing literature in a holistic manner. The significance of this study lies in its contribution to understanding how inquiry-based science education supports children’s scientific thinking, problem-solving, and curiosity. In this regard, the following question is addressed: What is inquiry-based learning?

1. What are inquiry-based learning approaches?
2. What is the role of inquiry-based learning in science education?
3. What types of national and international research have been conducted on inquiry-based science teaching?

Inquiry-Based Learning

Since the early 1900s, the concept known in English as "inquiry" and translated into Turkish as "araştırma sorgulama" has been explored and interpreted, yet a definitive definition has not yet been established (Crawford, 2014). Wheeler (2000) argued that the reason for the lack of a definitive definition of this concept and its varied interpretations by researchers lies in the flexible nature of the term "inquiry," which allows individuals to interpret it differently according to their worldview. Anderson (2007), in turn, classified the term "inquiry" as one of those with indefinite meanings, i.e., lacking a single, fixed definition. Considering these variations, five different myths about the concept of inquiry-based learning have been identified (NRC, 1996, as cited in Crawford, 2014). These myths are as follows:

Myth 1: In the inquiry-based process, all science topics must be covered.
Myth 2: A true inquiry process occurs only when students generate their own questions.
Myth 3: Inquiry-based teaching can be easily implemented through hands-on or kit-based instructional materials.
Myth 4: Hands-on activities guarantee the occurrence of inquiry-based learning.
Myth 5: Inquiry-based learning cannot be taught without drawing attention to the topic.

To understand the inquiry-based approach, it is essential first to define the concept of inquiry clearly. Inquiry is not merely limited to reviewing sources on a particular topic. Conducting a literature review alone is insufficient to achieve one of the primary goals of inquiry, which is to solve a specific problem. To solve a problem, an individual must possess basic scientific thinking skills such as observation, classification, communication, measurement, inference, and prediction, as well as higher-order skills like controlling variables, formulating hypotheses, interpreting data, operational definition, and experimentation (Aydoğdu, 2014). In other words, inquiry is a process that involves identifying assumptions about a topic deemed worthy of investigation, evaluating alternative explanations related to these assumptions, and selecting the most suitable explanations based on evidence (NRC, 2000).

Inquiry-based learning, which is founded on the constructivist approach, aims to develop students' inquiry skills (Lim, 2001). In this learning approach, the roles of the teacher and student differ significantly from traditional methods. Rather than conveying the topic through direct instruction, teachers guide students to explore and make sense of the subject through well-structured problems (Love et al., 2015). In addition, the activities within the inquiry-based approach enable students to actively engage in the processes outlined in NRC's (2000) definition of inquiry, including identifying assumptions, generating solutions, conducting experiments, and evaluating results. Through this engagement, students also learn how science is conducted (Martin, 2009). The cycle followed in this process is called the inquiry cycle. The inquiry cycle consists of the steps of formulating a research question, planning the inquiry process, conducting research, drawing conclusions, evaluating, and sharing findings.

One of the aims of inquiry-based teaching is for students to keep their minds active throughout the process and to develop an inquisitive attitude (Artigue & Blomhøj, 2013). In inquiry-based learning, the importance of the inductive approach, in which students can make logical inferences about concepts, is emphasized by the teacher (Rocard et al., 2007, as cited in Maaß & Doorman, 2013). Additionally, the report "Inquiry and the National Science Education Standards" (NRC, 2000) published in the United States outlines several essential characteristics that should be present in a classroom with an inquiry-based learning environment. These characteristics are as follows:

- Students engage with scientifically oriented questions.
- Students prioritize evidence when responding to questions.
- Students formulate explanations based on evidence.
- Students connect explanations to scientific knowledge.
- Students communicate and justify their explanations.

To further clarify the concepts of inquiry and investigation, specific characteristics need to be established. Minstrell (2000) identified several essential features that should be present in inquiry-based education. These include developing habits of mind, motivating students, designing hands-on and minds-on activities, and encouraging students to generate questions. Lederman and et al. (2014) identified eight characteristics of the nature of inquiry and argued that these should be explicitly communicated to students in inquiry-based learning environments. Without this explicit communication, it has been observed that students often do not recognize these characteristics during the process. These characteristics are as follows:

1. All scientific inquiries begin with a specific question and do not always test a hypothesis.
2. Multiple scientific methods are used in scientific research.
3. The inquiry process is shaped by the research question.
4. Different researchers conducting the same inquiry may arrive at different results.
5. The method chosen in the inquiry process can affect the research outcome.
6. Research results must be consistent with the data collected.
7. Scientific data and scientific evidence are distinct concepts.
8. Explanations are developed through a combination of collected data and existing knowledge.

Approaches to Inquiry-Based Learning

Inquiry-based learning can be implemented in various ways within classroom settings. In the process of inquiry-based teaching, the teacher may provide extensive guidance through questions and activities to help students reach conclusions or, alternatively, offer minimal guidance, allowing students to carry out most of the process independently. Inquiry-based teaching is categorized into four types based on the degree of guidance provided by the teacher and the amount of information given to students about the topic (Bell et al., 2005; Martin-Hansen, 2002). Within the scope of the information in the literature (Bell et al., 2005; Martin-Hansen, 2002; Contant et al., 2018), Table 1 provides a summary of inquiry-based learning types.

Table 1. Approaches to Inquiry-Based Learning

Types of Inquiry	Research Question	Inquiry Process	Research Outcome
Open Inquiry	Determined by the student	Planned by the student	Generated by the student.
Guided Inquiry	Determined by the teacher	Planned by the student	Generated by the student
Constructivist Inquiry	Determined by the teacher	Planned by the teacher	Generated by the student
Confirmation Activities	Determined by the teacher or written material	Determined by the teacher or written material	Determined by the teacher or written material

A. *Open Inquiry*: Students, typically working in groups, plan all the steps of the inquiry process themselves. Since the research question and subsequent steps are determined by the students, this approach is also referred to as student-initiated inquiry (Vasquez, 2008). The student fully assumes the role of a scientist. Therefore, students are required to have advanced cognitive skills and a strong understanding of scientific research processes. Although the entire process is carried out by the student, the teacher should play an active role by intervening when necessary and guiding students in the right direction (Banchi & Bell, 2008).

B. *Guided Inquiry:* In this level of inquiry, unlike open inquiry, the teacher provides the inquiry question to the students. However, it is the students' responsibility to plan an approach suited to the research question and reach a conclusion. This allows students the opportunity to explore different methods in planning experiments and collecting data. The teacher assumes an active facilitative role for students who design their own inquiry process (Contant et al., 2018). In other words, the teacher is responsible for encouraging students and guiding them throughout the process (Banchi & Bell, 2008).

C. *Structured Inquiry:* Frequently used in science laboratories, this type of inquiry involves the teacher providing both the inquiry question and the steps that students should follow to reach a conclusion (Contant et al., 2018). Students solve the problem by using the given inquiry question and following the provided process.

D. *Confirmation Activities:* These activities are conducted for students to verify specific information provided in the textbook or by the teacher. Compared to other types of inquiry, the student is more passive. The research question, inquiry process, and expected outcomes are directly given to the students. Although this process is often conducted in a hands-on manner in laboratory settings, students are not cognitively active. Therefore, some argue that these activities should not be considered a type of inquiry-based learning (Contant et al., 2018).

Factors Associated with Inquiry-Based Learning Approach

In order for inquiry-based teaching to be realized effectively, it is very important to determine the factors related to this approach. Teachers' knowledge of the variables within the scope of which students will improve with this approach will provide awareness to the teacher. This will contribute to planning an effective teaching process.

Şimşek and Kabapınar (2009) aimed to examine the effect of inquiry-based learning on students' conceptual understanding, science process skills and attitudes towards science course. Inquiry-based activities were carried out with 20 fifth grade students aged 10-11 during the week. In the data obtained at the end of the application, it was determined that inquiry-based learning approach had a positive effect on students' conceptual understanding and scientific process skills. When the variable of attitudes towards science course was analyzed, results similar to Maxwell et al. (2015) were found.

Maxwell et al. (2015) aimed to investigate how the use of inquiry-based learning approach in 4th grade science course affected students' academic achievement, attitude and interest in the course. With the participation of 42 students, the science course was taught with inquiry-based learning in the experimental group while the control group was taught with a traditional method. According to the 6-week post-test results, although the academic achievement of the students in the experimental group was higher than the control group, this result was not statistically significant. In addition, although the positive attitudes of the students who received inquiry-based learning showed a statistically insignificant decrease, it was determined that they developed more positive attitudes compared to the students who received education with the traditional method.

In addition to the studies revealing the positive effects of using inquiry-based learning approach in science education on student achievement, studies have been conducted on how the use of this approach in specific subjects in science education will affect student achievement. Yılmaz and Öztürk (2021) aimed to examine the effect of scientific inquiry-based teaching activities on the academic achievement of primary school fourth grade students in the "Matter and Nature" unit in the Science course. For this purpose, a quasi-experimental design with pretest-posttest control group was used in the study conducted with 100 primary school 4th grade students in the 2019-2020 academic year. The lessons were taught with the students in the experimental group on the basis of inquiry-based teaching method and with the students in the control group by applying traditional methods. Although there was no significant difference between the academic achievement of the two groups in the pre-test results, the academic achievement of the group receiving inquiry-based education was higher than the other group in the post-test results.

Similar to Yılmaz and Öztürk's (2021) study, other studies that use inquiry-based learning in different subjects of science have also been conducted. Akaygün and Adadan (2021) aimed to examine the effect of inquiry-based science teaching on 4th grade students' perceptions of climate change and science learning environments. In the study conducted with 68 students using a quasi-experimental design, the students in the experimental group addressed the related topics with an inquiry-based approach. While only 25% of the students were aware of the main consequences, causes, and possible solutions of climate change before the application, this rate increased to 50-85% after the application.

In addition to these studies, there are also studies examining the impact of inquiry-based education in underdeveloped countries. Mamombe et al. (2019) examined the effect of inquiry-based learning on making sense of the structure of gaseous substances in a study with 4th grade students in South Africa. In this study, in which an experimental research design was used, inquiry-based learning approach was used in the experimental group, while lecture method was used in the control group. The findings of the study emphasize that inquiry-based learning approach is more effective in understanding the subject. In addition, it is stated that inquiry-based learning approach can be used to eliminate misconceptions about the structures of gaseous substances.

In a study examining the effect of inquiry-based science teaching on learning to learn competence in primary school, it was emphasized that inquiry-based learning approach improved students' learning to learn competence at a higher level compared to the traditional approach (Letina, 2020). Accordingly, it is concluded that students' learning to learn skills will improve as a result of teaching basic sciences with inquiry-based learning approach. Students' planning the inquiry process with inquiry-based learning, identifying the resources they will need for a specific problem, and actively participating in reasoning processes are shown to be among the main factors in the development of learning to learn skills.

In order to use inquiry-based learning in science lessons, teachers' attitudes towards this approach and the frequency of using it in their lessons are other issues worth investigating. Letina (2019) aimed to determine whether there is a relationship between classroom teachers' attitudes towards inquiry-based learning approach and their experiences with this approach and the frequency of using this approach in their lessons. For this purpose, 275 classroom teachers (1st -4th grade) were studied. When the data obtained were analyzed, it was concluded that teachers who had positive attitudes towards inquiry-based learning did not apply this approach frequently enough in their classes. In addition to this result, it was found that teachers who experienced inquiry-based learning approach during their formal education and had positive attitudes towards this approach increased the frequency of using this approach in their own classrooms.

Teacher education is also very important for the correct implementation of inquiry-based learning approach. For this reason, prospective classroom teachers should have knowledge about inquiry-based learning and gain inquiry skills. Akben and Köseoğlu (2015) aimed to examine the professional development program developed for prospective classroom teachers to comprehend inquiry-based learning approach and lesson activities based on the 5E model in terms of various variables such as the candidate's ability to develop laboratory activities and beliefs about inquiry-based learning approach. In this 25-week long study conducted with 35 pre-service primary school teachers within the scope of Science and Technology Laboratory Practices I and II courses, quantitative data were collected with the "Inquiry-Based Laboratory Activities Evaluation Questionnaire" and qualitative data were collected with semi-structured interview forms. At the end of the research, it was determined that thanks to this professional development program, pre-service primary school teachers became aware of the impact and importance of inquiry approach in science teaching.

In order for the inquiry-based learning approach to be used effectively in classrooms, teachers need to master this process and have high inquiry skills. Bedir and Duman (2017) conducted a study with 627 pre-service teachers enrolled in Turkish, Science, Preschool, Classroom, Social Sciences and Elementary Mathematics Teacher Education programs in the 2015-2016 academic year in order to determine the inquiry skill levels of pre-service teachers. As a result of the data collected with the "Inquiry Skills Scale", it was seen that the highest level of inquiry skills belonged to the Classroom Teacher candidates.

Teaching Models and Approaches that Support Inquiry-Based Learning

There are supportive models and approaches available for implementing inquiry-based teaching. The 5E lesson plan model, STEM (Science, Technology, Engineering, and Mathematics), and argumentation-based learning are a few examples. When inquiry-based learning activities are integrated into these approaches, students' inquiry skills are further developed.

Inquiry-Based Learning Focused on the Learning Cycle and 5E Model

Although the inquiry-based learning approach is gaining importance worldwide, some educators still find it challenging to design inquiry-based lesson plans (Duran & Duran, 2004). Using a template for planning the inquiry-based teaching process can help address this issue. Therefore, the learning cycle approach can be employed to guide teachers in inquiry-based lessons (Abraham, 1997). The learning cycle model divides instruction into various stages. The learning cycle, developed by Karplus and Thier (1967) in the 1960s, consists of three stages: exploration, concept introduction, and concept application. In the exploration stage, students are introduced to and experience the concept for the first time. During concept introduction, students become familiar with the concept through interactions with peers, books, or the teacher. Concept application represents the stage where students apply what they have learned. Although there are variations of the learning cycle, such as 3E, 5E, and 7E, inquiry-based learning most commonly utilizes the 5E cycle.

The 5E instructional model consists of five stages: engage, exploration, explanation, elaboration, and evaluation. The engage phase involves checking students' prior knowledge and includes activities aimed at increasing their motivation. This is followed by the exploration phase, where students construct their understanding of the concept through hands-on experiences (Contant et al., 2018). In the explanation phase, students present their findings from the exploration stage, and the concept is explained through these presentations. While students take an active role in the engage and exploration phases, the teacher becomes more active during the explanation phase. After necessary clarifications of the concept, activities are introduced to help students integrate their understanding into different contexts. In the final evaluation phase, an assessment is conducted to determine if the learned concept has been understood and whether any misconceptions identified during the engage phase have been addressed. During the inquiry-based learning process, the teacher guides students through the questions they ask. Therefore, in the 5E learning model, it is essential to ask questions that align with the characteristics of each stage (Contant et al., 2018). Table 2 summarizes the general characteristics of the 5E learning model and indicates the types of questions that should be asked at each stage.

Table 2. Characteristics of the 5E learning model and suggested questions

	Teacher Activities	Student Activities	Suggested Questions
Engagement	• Identify misconceptions. • Increase student motivation. Determine what is needed for the exploration phase.	• Establish connections between past and new learning experiences. • Become motivated.	• What do you think would happen if...? • Have you ever seen or done...? • What do you want to know about...? • While observing this scientific phenomenon, why is this happening, and which variables are important?
Exploration	• Facilitate students' hands-on experience with the concept.	• Encounter new experiences. • Compare personal ideas with those of peers and the teacher.	• How are you answering our research question? • What is happening? How is the process going? • What data are you collecting? • What happens when ... changes?
Explaination	• Conceptualize students' discoveries. • Use and encourage scientific terminology during explanations.	• Present existing ideas. • Develop explanations based on prior experiences. • Use scientific terminology when providing explanations.	• What do you think you need to learn more about? • Do you agree with the explanation of ...? Why? • Considering what has happened, how have your thoughts on this topic changed?
0Elaboration	• Enable students to apply their ideas or extend them to different contexts.	• Apply acquired knowledge and skills in new areas. • Connect past experiences with new information.	• Would you expect the same results if you used different materials or organisms? • How would you use this method for ...? • What else could help with our explanation?

Referance: Contant et al., 2018, p. 120

Inquiry-Based Learning Focused on STEM

In the United States, the rate of students choosing fields in science, technology, engineering, and mathematics (STEM) at universities is gradually decreasing (NRC, 2012). This trend hinders the development of individuals who can utilize and process knowledge. The effective use of scientific knowledge is an essential skill for scientific literacy (NGSS Lead States, 2013). One of the primary goals of STEM education is to enhance students' knowledge and skills in Science, Technology, Engineering, and Mathematics through collaborative group work (Baz, 2019).

STEM education not only contributes to individuals' acquisition of knowledge specific to the four core fields but also enhances cognitive skills such as inquiry, evidence-based reasoning, and logical thinking. Additionally, STEM education fosters the inquiry-based learning process by promoting skills such as questioning and problem identification, planning and conducting research, analyzing and interpreting data, constructing scientific explanations, developing evidence-based arguments, and evaluating collected data (NGSS Lead States, 2013). Therefore, STEM education is seen as an approach that supports the inquiry-based learning process.

Sanders (2009) defines this education as an approach that involves the integration of two or more STEM disciplines or the combined study of a STEM field with topics from other disciplines. Similarly, Kelley and Knowles (2016) define STEM education as a process in which two or more STEM disciplines are taught in an integrated manner. Based on these definitions, it is understood that while all four core areas—science, technology, engineering, and mathematics—are not mandatory in STEM education, the presence of at least two of these fields is considered sufficient. The seven steps to be followed in implementing this education are shown in Figure 1.

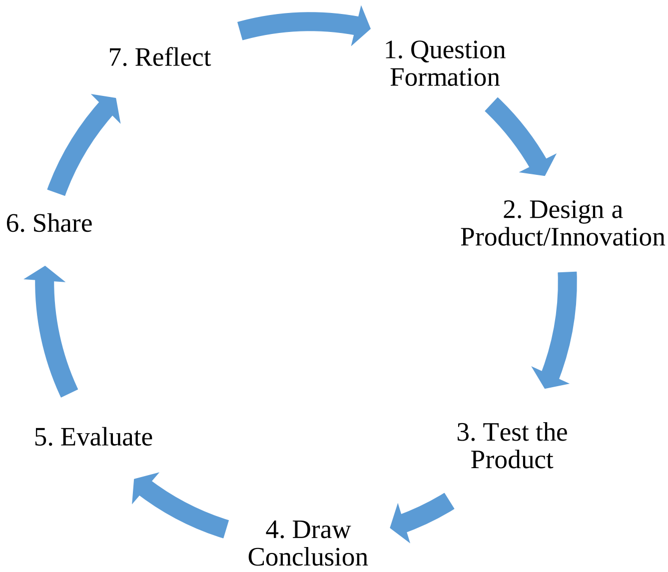

Figure 1. Steps to follow in STEM education

The ways in which STEM education supports inquiry-based teaching become clear when examining the inquiry cycle and the STEM education cycle presented in Figure 1. Both cycles, which share many common stages, begin with question formation. Who formulates the question and how it is created depend on the type of inquiry-based learning approach being adopted. This variation is also discussed in Table 1. The common steps between the FeTeMM education cycle and the inquiry cycle are as follows: (a) question formation, (b) designing/planning a solution related to the research question, (c) test the product, (d) drawing conclusions, (e) evaluation, and (f) sharing.

In STEM education, as in inquiry-based learning, the teacher assumes the role of a guide. Throughout the process, the teacher provides direction and ensures active student participation. The primary goal of the teacher in this guiding role is to foster students who question, investigate, create, and innovate in STEM fields (Baz, 2019).

Argumentation-Focused Inquiry-Based Learning

An argument is a dialogue that uses evidence to highlight the contrast between two opposing situations and aims to reach a logical conclusion (Kaya & Kılıç, 2008). Argumentation, on the other hand, is the process of supporting claims with specific justifications (Toulmin, 1958). The process of forming arguments, where claims are supported by evidence, is called argumentation. In education, argumentation-based learning—typically used by scientists—employs three main approaches: Toulmin's Argumentation Model, Argumentation with Socioscientific Issues, and Argumentation-Based Science Learning.

A. *Toulmin's Argumentation Model:* In Toulmin's model, where argumentation is defined as a reasoning process, arguments consist of three core components—claim, data, and warrant—and three auxiliary components: backing, qualifier, and rebuttal (Toulmin, 1958). In this model, students are provided with the core or auxiliary components and engage in discussions about them, or they are asked to identify these components within a given scenario.
B. *Argumentation on Socioscientific Issues:* Individuals use argumentation to address issues in

socioscientific areas such as politics, ethics, education, and health (Sadler & Zeidler, 2004), which has led to the use of argumentation in socioscientific topics. In this model, students are presented with a conflicting scenario and are asked to engage in a process of discussion and investigation around this issue.

C. Argumentation-Based Science Teaching: Initially defined in Turkey as experiential learning, argumentation-based learning (Günel et al., 2010) is an inquiry-based process in which knowledge is constructed through explanations supported by questions, claims, and evidence (Kariper et al., 2014). The inquiry-based argumentation framework keeps students actively engaged throughout the process, encouraging them to research structured, conflicting topics and support their explanations with evidence. In this model, students are viewed as scientists, and they are expected to develop their own arguments. Students conduct the necessary research independently as part of the argument-building process.

The Role of Inquiry-Based Learning in Science Education

Science has come into being through the search for natural events and facts in nature, and one of the aims of science is to enable individuals to understand their environment correctly (Temizyürek, 2003). Although this general purpose of science has always been the same, developing science and technology has determined that traditional science education does not serve this purpose and the needs of society (Yalaki, 2019). This led to the emergence of reform initiatives such as Science, Society and Technology (SST) and then Science, Technology, Society and Environment (STSE) in the United States in the 1960s, 70s and 80s (Yager, 1996). STSE teaching that starts with the introduction of a common problem of interest to society, i.e. a socioscientific problem, continues with students investigating the technological, scientific, social and environmental dimensions of the problem in order to solve the problem (Solomon & Aikenhead, 1994 cited in Yalaki, 2019). The fact that students conduct scientific research during the solution of the problem and come to a conclusion at the end of the research is an indication that the inquiry-based approach is used in this process.

These fundamental changes have led to changes in the specific goals, skills, and teaching approaches of science. Science literacy has become one of the main objectives in the current science curriculum of most countries (NRC, 2012; OECD, 2015). Today, the importance of science literacy is emphasized in PISA reports and exams, which are conducted internationally to measure the success of countries in science fields (MEB, 2019). Although there are many different definitions of science literacy, the National Research Council (NRC) defines this concept as an individual's ability to ask questions about daily life experiences with a sense of curiosity and to seek answers to these questions. Since inquiry-based instruction refers to how students use science (Martin et al., 2009), it is possible to say that it has an important place for science literacy.

Emphasizing the importance of science literacy has helped to increase the importance of Inquiry Based Science Education. Organizations such as the American Association for the Advancement of Science (AAAS), the National Science Foundation (NSF), and the National Research Council (NRC) have been working to emphasize the importance of Inquiry Based Science Education. The NRC's framework for K12 science education has led to the rapid expansion of Inquiry Based Science Education worldwide. Prior to this framework, inquiry education was included as a separate learning goal, but with the innovation, Inquiry Based Science Education was associated with all subjects.

Conclusion and Discussion

In this review study, it was concluded that inquiry-based teaching at the primary school level is an important tool in improving children's conceptual understanding (Şimşek & Kabapınar, 2009; Mamombe et al., 2019), academic achievement (Maxwell et al., 2015; Yılmaz & Öztürk, 2021) and attitudes towards science (Maxwell et al., 2015) as well as eliminating misconceptions (Mamombe et al., 2019). Inquiry-based teaching develops children's scientific process (Şimşek & Kabapınar, 2009), metacognition (Letina, 2020), and inquiry (Akaygün & Adadan, 2021) skills. This approach, which enables students to actively participate in the learning process, contributes to a deeper understanding of knowledge, especially by encouraging learning through experimentation and observation. However, in order for this method to be implemented effectively in classrooms, teachers need to have sufficient knowledge and skills, and they need to have an infrastructure that can guide students. In this context, studies on the attitudes and knowledge of prospective teachers towards inquiry-based learning method are also carried out in order to support teachers with professional development programs and to implement inquiry-based learning effectively (Bedir & Duman, 2017; Akben & Köseoğlu, 2015; Letina, 2019). It is important for teachers to develop positive attitudes towards this method and to strengthen their pedagogical skills related to this approach.

When the national and international literature is compared, it is seen that the studies on the effects of inquiry-based teaching approach show some similarities and differences. In the national literature, Şimşek and Kabapınar's (2009) study revealed that this method improved the conceptual understanding levels of primary school students, while Yılmaz and Öztürk (2021) emphasized the positive effects of this method on academic achievement. Akaygün and Adadan (2021) revealed the importance of inquiry-based teaching in terms of raising awareness on environmental issues. Akben and Köseoğlu's (2015) study with pre-service teachers states that this method improves teachers' pedagogical skills and contributes to pre-service teachers' classroom practices. In the international literature, Maxwell et al. (2015) investigated the effects of this method on students' academic achievement and observed that the method created positive effects especially in science achievement, but this effect was limited in creating long-term attitude changes. Mamombe et al. (2019) in South Africa reported that inquiry-based teaching was effective in understanding abstract concepts. Letina (2020) emphasized that this method improves students' learning to learn skills. In both national and international literature, it has been concluded that inquiry-based teaching method increases students' academic achievement, improves their conceptual understanding levels, and is especially effective in the field of science.

This review study sheds light on future studies by addressing the effects of inquiry-based teaching on primary school students and teachers in a holistic manner. Eliminating the deficiencies regarding the implementation of inquiry-based teaching in the classroom, supporting teachers with professional development programs, and expanding student-centered learning environments will increase the effectiveness of this method. In future studies, it is recommended to conduct long-term research supported by multiple data collection techniques in order for teachers to apply this method effectively. In addition, applied content can be added to undergraduate programs for pre-service teachers to develop inquiry-based teaching skills. Presenting activities that support this method to students, investigating its effects at different grade levels, and examining this method more comprehensively in creating environmental awareness are among the suggestions for future research. In this way, educational environments can be created where inquiry-based teaching can be applied more effectively and efficiently.

Future studies on inquiry-based science teaching in children's education are recommended with various aims. First, examining the effects of this teaching method on different age groups may contribute to the development of strategies appropriate for each age level. In addition, studies can be conducted to eliminate children's misconceptions in science subjects through inquiry-based teaching; the effectiveness of applied strategies can be evaluated to ensure that children better understand abstract and challenging concepts. Research aimed at developing long-term interest and attitudes towards science is also an important area; in this context, it would be useful to examine how inquiry-based instruction shapes children's interest and positive attitudes towards science.

Declarations

Authors' Declarations

Authors' contributions: All stages of the manuscript were carried out by a single author.

Competing interests: No potential conflict of interest was declared by the author.

Funding: No grants were received from any public, private or non-profit organizations for this research.

Ethics approval and consent to participate: : It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited from are stated in the bibliography.

Publisher's Declarations

The editorial process of this article was completed under the editorship of Dr. Ayşe Güler Küçükturan through a double-blind peer review with external reviewers.

Journal of Child Development and Education remains neutral with regard to jurisdictional claims in published maps and institutional affiliation.

References

Abell, S. K., & Volkmann, M. J. (2006). *Seamless assessment in science*. Heinemann.

Abraham, M. R. (1997). *The learning cycle approach to science instruction* (Research matters - To the science teacher, No. 9701). The National Association for Research in Science Teaching.

Akaygün, S., & Adadan, E. (2021). Fostering senior primary school students' understanding of climate change in an inquiry-based learning environment. *Education 3-13*, *49* (3), 330-343. https://doi.org/10.1080/03004279.2020.1854961

Akben, N., & Köseoğlu, F. (2015). Inquiry-based learning and 5E model in laboratory practices: A professional development program for prospective classroom teachers. *Ankara University Journal of Faculty of Educational Sciences (JFES)*, *48* (1), 161-198. https://doi.org/10.1501/Egifak_0000001357

Anderson, R. D. (2007). Inquiry as an organizing theme for science curricula. S. K., Abell ve N. G., Lederman (Ed.) *Handbook of research on science education* (pp. 807-830). Lawrence Erlbaum Associates.

Arklan, Ü & Taşdemir, E. (2008). Bilgi toplumu ve iletişim: Bilginin yayılması sürecinde kitle iletişim araçlari ve internet. *Selçuk Üniversitesi İletişim Fakültesi Akademik Dergisi*, *5* (3), 67-80.

Artigue, M., & Blomhoej, M. (2013). Conceptualising inquiry based education in mathematics. *ZDM—The International Journal on Mathematics Education*, *45* (6), 797-810. https://doi.org/10.1007/s11858-013-0506-6

Aydoğdu, B. (2014). Bilimsel Süreç Becerileri. *Fen bilimleri öğretimi* (s. 87-113) içinde. Anı Yayıncılık.

Banchi, H. & Bell, R. (2008). The many levels of inquiry. *Science and Children*, *46* (2), 26–29.

Baz, F. Ç. (2019). STEM eğitim döngüsüne Bloom taksonomisi çerçevesinde bakış. *Academia Eğitim Araştırmaları Dergisi*, *4* (2), 142-150.

Bedir, T., & Duman, B. (2017). Öğretmen adaylarının sorgulama becerilerinin incelenmesi. *Turkish Studies*, *12* (18). 105-120.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: Assessing the inquiry level of classroom activities. *The Science Teacher*, *72* (7), 30–33.

Çağıltay, K., & Göktaş, Y. (Eds.). (2013). *Foundations of instructional technologies: Theories, research, trends* (1st ed.). Pegem Akademi.

Contant, T. L., Tweed, A. L., Bass, J. E. & Carin, A. A. (2018). *Teaching science through inquiry-based instruction (*13th ed.). Pearson.

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (pp. 515–541). Routledge.

Duran, L. B., & Duran, E. (2004). The 5E instructional model: A learning cycle approach for inquiry-based science teaching. *Science Education Review*, *3* (2), 49-58.

Günel M., Kabataş-Memiş E. & Büyükkasap, E. (2010). Effects of the science writing heuristic approach on primary school students' science achievement and attitude toward science course. *Education and Science*, *35* (155), 49-62

Kariper, İ. A., Akarsu, B., Slisko, J., Corona, A., & Radovanovic, J. (2014 Fen ve teknoloji öğretmenlerinin argümantasyon tabanlı bilim öğrenme becerileri. *Erciyes Üniversitesi Fen Bilimleri Enstitüsü Fen Bilimleri Dergisi*, *30* (3), 174-179.

Karplus, R., & Thier, H. D. (1967). *A new look at elementary school scien* Rand McNally.

Kaya, O. N. & Kılıç, Z. (2008 Etkin bir fen öğretimi için tartişmaci söylev. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi (KEFAD)*, *9* (3), 89-100.

Kelley, T.R. & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3* (11), 1-11. https://doi.org/10.1186/s40594-016-0046-z

Lederman, J. S., Lederman, N. G., Bartos, S. A., Bartels, S. L., Meyer, A. A., & Schwartz, R. S. (2014). Meaningful assessment of learners' understandings about scientific inquiry—The views about scientific inquiry (VASI) questionnaire. *Journal of research in science teaching*, *51*(1), 65-83. https://doi.org/10.1002/tea.21125

Letina, A. (2019). Factors influencing the frequency of use of inquiry-based approach to teaching primary science. *Croatian Journal od Education*, *20*, 153-166. https://doi.org/10.15516/cje.v21i0.3447

Letina, A. (2020). Development of students' learning to learn competence in primary science. *Education Sciences*, *10* (11), 325. https://doi.org/10.3390/educsci10110325

Lim, B. R. (2001). *Guidelines for designing inquiry-based learning on the web: Online professional development of educators* (Unpublished doctoral dissertation). Indiana University.

Love, B., Hodge, A., Corritore, C., & Ernst, D. C. (2015). Inquiry-based learning and the flipped classroom model. *Primus*, *25* (8), 745-762. https://doi.org/10.1080/10511970.2015.1046005

Maaß, K., & Doorman, M. (2013). A model for a widespread implementation of inquiry-based learning. *ZDM*, *45* (6), 887-899. https://doi.org/10.1007/s11858-013-0505-7

Mamombe, C., Mathabathe, K. C., & Gaigher, E. (2019). The influence of an inquiry-based approach on grade four learners' understanding of the particulate nature of matter in the gaseous phase: a case study. *EURASIA Journal of Mathematics, Science and Technology Education*, *16* (1), 1-11. https://doi.org/10.29333/ejmste/110391

Martin, A., Sexton, C. & Franklin, T. (2009) *Teaching science for all children an inquiry approach.* (5. Baskı). Pearson.

Martin, D. J. (2009). *Elementary science methods: A constructivist approach.* Delmar Publisher.

Martin-Hansen, L. (2002). Defining inquiry: Exploring the many types of inquiry in the science classroom. *Science Teacher*, *69* (2), 34-37.

Maxwell, D. O., Lambeth, D. T., & Cox, J. T. (2015, June). Effects of using inquiry-based learning on science achievement for fifth-grade students. In *Asia-Pacific Forum on Science Learning and Teaching*, *16* (1), 1-31.

Minstrell, J. (2000). Implications for teaching and learning inquiry: A summary. *Inquiring into Inquiry Learning and Teaching in science* (s. 471–496) içinde. American Association for the Advancement of Science.

National Research Council [NRC]. (2000). *Inquiry and the national science education standards*. National Academy Press.

National Research Council. (2012). *A framework for K─12 science education: Practices, crosscutting concepts, and core ideas.* The National Academies Press.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. The National Academies Press.

Organisation for Economic Co-operation and Development [OECD]. (2015). *PISA 2015: Draft science framework*. https://www.oecd.org/pisa/pisaproducts/Draft%20PISA%202015%20S cience%20Framework%20.pdf

Özden, Y. (2020). *New values in education* (13th ed.). Pegem Akademi Publishing.

Sadler, T. D., & Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, *88* (1), 4-27. https://doi.org/10.1002/sce.10101

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher*, *68* (4), 20-26.

Saygılı, S. (2013). Sanayi toplumundan bilgi toplumuna geçiş sürecinde eğitimde dönüştürücü bir entelektüel olarak öğretmenler. *Uşak Üniversitesi Sosyal Bilimler Dergisi*, *6*, 270-281.

Şimşek, P., & Kabapınar, F. (2010). The effects of inquiry-based learning on elementary students' conceptual understanding of matter, scientific process skills and science attitudes. *Procedia Social and Behavioral Science*, *2*, 1190-1194. https://doi.org/10.1016/j.sbspro.2010.03.170

T.C. Milli Eğitim Bakanlığı [MEB]. (2019). *PISA 2018 Türkiye Ön Raporu.*

Temizyürek, K. (2003). *Science teaching and practices* (1st ed.). Nobel Publishing.

Toulmin, S. (1958). *The uses of argument.* Cambridge: Cambridge University Press.

Vasquez, J. A. (2008). *Tools and traits for highly effective science teaching, K–8. Portsmouth*, NH: Heinemann.

Wheeler, G. F. (2000). The three faces of inquiry. In J. Minstrell & E. H. van Zee (Eds.), *Inquiry into inquiry learning and teaching in science* (pp. 14–19). American Association for the Advancement of Science.

Yager, R. E. (1996). History of science/technology/society as reform in the United States. In R. E. Yager (Ed.), *Science/technology/society as reform in science education* (pp. 3–15). SUNY Press..

Yalaki, Y. (2019) Bilimin doğası ve sosyobilimsel konular. *Fen öğretimi* (s. 27-51) içinde. Nobel.

Yılmaz, E., & Öztürk, E. (2021). Bilimsel Sorgulamaya Dayalı Öğretim Uygulamalarının İlkokul Dördüncü Sınıf Öğrencilerinin Fen Bilimleri Dersindeki Akademik Başarıları Üzerindeki Etkisi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, *22* (2), 1127-1163.