AQUADEMIA
2026, 10(1), ep26001
ISSN 2542-4874 (Online)
https://www.aquademia-journal.com/

Research Article

OPEN ACCESS

Physics as science primary education in Greece: An analysis of curriculum structure and pedagogical priorities

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Citation: Kotsis, K. T. (2026). Physics as science primary education in Greece: An analysis of curriculum structure and pedagogical priorities. *Aquademia, 10*(1), ep26001. https://doi.org/10.29333/aquademia/17797

ARTICLE INFO

Received: 09 Nov. 2025
Accepted: 12 Jan. 2026

ABSTRACT

Primary school science education is essential for cultivating scientific literacy, curiosity, and thinking from a young age. In Greece, the structure of the primary curriculum embodies both global tendencies and enduring national customs, with physics emerging as the predominant disciplinary emphasis, especially in the upper primary grades. This study analyzes the historical evolution, structural attributes, and educational philosophies of science teaching in Greek primary schools by qualitative document analysis of curriculum frameworks, textbooks, and pertinent research literature. The results demonstrate that, despite initiatives to encourage interdisciplinarity and inquiry-based learning, physics remains in a dominant position regarding content allocation, conceptual complexity, and instructional focus. This dominance fosters causal reasoning and experiential learning in accordance with constructivist principles, yet it simultaneously restricts exposure to biology, chemistry, and earth sciences, thereby limiting students' opportunities to attain a more holistic understanding of science. Implementation obstacles, such as inadequate laboratory infrastructure, resource constraints, and inconsistent teacher training, further impede the actualization of inquiry-based teaching. The discourse emphasizes the conflict between conventional disciplinary frameworks and modern international systems promoting equitable, competency-based science education. Recommendations encompass broadening disciplinary scope, facilitating ongoing professional development for educators, augmenting school resources, and synchronizing assessment methodologies with inquiry-based strategies to cultivate scientifically literate and ecologically conscious citizens.

Keywords: science education, physics education, primary curriculum, inquiry-based learning, Greek education

INTRODUCTION

Primary school science education is seen as fundamental for fostering scientific literacy, developing early thinking abilities, and promoting ongoing interaction with the natural environment. Global studies underscore that the initial years of education significantly influence students' views, curiosity, and propensity to engage in scientific investigation (Harlen & Qualter, 2018; Osborne & Dillon, 2008). In this context, physics occupies a unique position as it offers conceptual frameworks for elucidating everyday phenomena, like motion, light, heat, and electricity, while also cultivating analytical reasoning from an early age (Driver et al., 1994; Viennot, 2001). Modern viewpoints on scientific literacy emphasize the necessity of anchoring early science education in significant experiences that allow learners to comprehend the physical world through observation, prediction, and explanation (OECD, 2019; Sjøberg, 2010).

The basic curriculum in Greece embodies both international science education trends and established national traditions. In the initial three years of primary education, science is incorporated into the interdisciplinary topic "environmental studies," which integrates natural sciences, geography, and the social aspects of the environment. Beginning in the fourth grade, a specialized topic named "physics" (Φυσικά) is introduced, serving as the principal medium for science education, although it encompasses material related to biology, chemistry, and earth sciences (Kotsis et al., 2025). This organizational framework has prompted numerous researchers to contend that science education in Greek primary schools predominantly functions as physics education, with an undue emphasis on physics concepts compared to other scientific fields (Kallery & Psillos, 2001; Ravanis et al., 2004).

The preeminence of physics is not only a curricular construct; it is linked to enduring cultural and institutional beliefs that regard physics as the most essential of the sciences, capable of offering systematic explanatory frameworks for natural occurrences. Contemporary international standards, such as the OECD learning compass 2030, UNESCO's education for sustainable development goals, and European Commission directives on inquiry-based learning, promote balanced and interdisciplinary science curricula that amalgamate life, physical, and earth sciences to cultivate comprehensive scientific literacy (European Commission, 2015; OECD, 2019; UNESCO, 2017). These changes highlight the conflicts within the Greek curriculum about tradition, disciplinary inequity, and the overarching educational objectives of the 21st century.

Recent reforms in the Greek curriculum, notably the 2021 "new school" initiative, seek to enhance inquiry-based learning, digital literacy, and interdisciplinary skills; however, the predominant focus on physics persists (Institute of Educational Policy, 2021; Kotsis et al., 2023). Simultaneously, research indicates ongoing difficulties in classroom execution, such as inadequate laboratory facilities, resource limitations, and variable teacher training, which can hinder the effective adoption of inquiry-based pedagogy and perpetuate textbook-centric instruction (Dimopoulos & Koulaidis, 2003; Kotsis & Panagou, 2023). The structural concerns prompt essential inquiries regarding the congruence between curricular objectives and actual pedagogical practices, as well as the ability of the Greek primary science curriculum to foster comprehensive and significant scientific literacy.

This paper investigates the significance of physics in Greek primary scientific education by studying its historical evolution, curricular framework, and teaching methodologies. This introduction contextualizes the Greek instance within wider international frameworks, preparing for a methodical examination of the advantages, drawbacks, and consequences of a physics-centric curriculum for early scientific education.

THEORETICAL BACKGROUND

Modern methodologies in primary science teaching are based on constructivist theories that highlight the active participation of learners in developing scientific comprehension. Classic and contemporary constructivist models assert that children commence their education equipped with intuitive interpretations of natural events derived from daily experiences, cultural beliefs, and informal reasoning (Driver et al., 1994; Piaget, 1970). These alternative conceptions are well documented in physics areas such as motion, heat, light, and electricity, where students frequently depend on strong intuitive notions that diverge markedly from scientific explanations (Duit & Treagust, 2003; Viennot, 2001). The learning of science necessitates organized opportunities for students to express, evaluate, and progressively enhance their concepts through directed inquiry, debate, and practical interaction with phenomena. This conceptual change perspective has influenced science curricula globally and is especially pertinent in primary education, as initial exposure to scientific concepts establishes the groundwork for further thinking.

The significance of physics in basic curriculum is often rationalized by its close connection to children's daily experiences and its ability to foster causal and mechanical reasoning (Osborne & Dillon, 2008). Greek research has substantially advanced this legacy by investigating how young learners comprehend physical phenomena and how focused education can facilitate conceptual development. Research on children's concepts of light, heat, and electricity demonstrates that experiential activities, analogies, and meticulously structured instruction can facilitate significant learning in physics from the earliest stages of education (Kaliampos & Ravanis, 2019; Ravanis, 2017). These findings highlight the educational potential of physics as a gateway to scientific reasoning, while simultaneously demonstrating the pedagogical challenges associated with confronting intuitive errors.

Globally, science education policy has progressively highlighted the significance of inquiry-based science education (IBSE) as a fundamental methodological framework for fostering scientific literacy and capabilities pertinent to the 21st century. Inquiry methodologies foster student engagement in inquiry, investigation, evidence interpretation, and explanation construction, processes that reflect scientific methods and enhance profound conceptual comprehension (European Commission, 2015; Harlen & Qualter, 2018). Research indicates that IBSE enhances students' motivation and reasoning when bolstered by effective teacher direction and sufficient resources (Abell, 2007). These concepts have shaped recent Greek curricular reforms that promote inquiry, innovation, and the application of everyday circumstances. The extent to which these aspirations are actualized is limited by teacher training, school infrastructure, and curricular traditions that persist in prioritizing physics content.

A complementary corpus of study emphasizes the overarching objectives of scientific literacy, which today encompass not just conceptual understanding but also the capacity to employ scientific reasoning in socially pertinent situations. Frameworks like the OECD learning compass 2030 and UNESCO's education for sustainable development emphasize the necessity for interdisciplinary comprehension, critical analysis, and involvement with socio-scientific matters encompassing health, environment, and technology (OECD, 2019; UNESCO, 2017). This transition affects the conventional supremacy of physics in primary scientific curricula, indicating a necessity for more equitable exposure to life sciences, chemistry, and earth sciences. Comparative curriculum studies in Europe indicate that the majority of nations have embraced integrated and multidisciplinary models that allocate content more equitably across scientific areas, a trend that stands in stark contrast to Greece's physics-centric primary curriculum (Sjøberg, 2010; Tsiouri et al., 2024).

Collectively, these theoretical frameworks elucidate the primary concerns examined in this analysis: the cognitive and pedagogical justification for early physics education, the curriculum's congruence with modern interpretations of scientific literacy, and the repercussions of disciplinary imbalance on student learning. They establish the conceptual basis for assessing how the Greek primary curriculum facilitates or hinders the development of substantial and thorough scientific comprehension.

METHODOLOGY

This study utilized a qualitative document analysis method to investigate the importance and predominance of physics in the Greek primary science curriculum. Qualitative document analysis is widely used in educational research to examine policy frameworks, curricular structures, and instructional orientations through the systematic interpretation of textual and institutional data (Bowen, 2009; Rapley, 2018). This approach facilitated a comprehensive examination of the conceptualization, organization, and justification of science education during successive Greek curriculum revisions, and how these patterns align with current international norms.

The dataset comprised three principal groups of documents. The official curriculum and policy documents released by the Greek Ministry of Education and the Institute of Educational Policy, specifically the 2011 and 2021 curriculum frameworks for "environmental studies" and "physics," served as the primary source for comprehending content allocation, educational objectives, and suggested teaching methodologies. Secondly, primary school textbooks and teacher guides were examined to ascertain how curricular intentions are implemented within instructional resources. Third, peer-reviewed research literature from Greek and international sources was examined to contextualize curricular elements within broader trends in science education, encompassing studies on children's conceptions, inquiry-based learning, and disciplinary balance (e.g., Driver et al., 1994; Harlen & Qualter, 2018; Kotsis et al., 2025; Ravanis et al., 2004).

The analysis was conducted in three iterative phases. Initially, documents were classified inductively to discern repeating themes pertaining to academic focus, including the representation of physics, biology, chemistry, and earth sciences across various grade levels. During the second step, deductive coding was employed utilizing categories extracted from the theoretical framework, encompassing inquiry-based teaching, constructivist principles, scientific literacy frameworks, and curriculum integration models. This integration of inductive and deductive coding facilitated the creation of data-driven patterns while ensuring the alignment of findings with known theoretical frameworks.

In the third stage, results from Greek documents were juxtaposed with international standards, including the OECD learning compass 2030, UNESCO's education for sustainable development framework, and European Commission directives on science education. This comparative analysis facilitated the recognition of similarities and differences between Greek curricular frameworks and wider global trends that prioritize interdisciplinarity, inquiry, and competency-based education (European Commission, 2015; OECD, 2019; UNESCO, 2017). During the process, analytical notes were employed to consolidate emergent insights and enhance interpretations.

This methodological approach does not intend to assess student learning outcomes or classroom practices directly. It offers a systematic analytical framework for comprehending how curricular choices, disciplinary conventions, and pedagogical directives influence the character of science instruction in Greek primary schools. The technique provides a thorough and theoretically informed assessment of the significance of physics in the Greek curriculum by integrating policy texts, instructional materials, and research literature.

RESULTS

The examination of Greek primary science education uncovers a distinct historical trend in which physics progressively emerged as the predominant element of the curriculum. Following the reforms of the 1970s and 1980s, subsequent policy documents have sought to modernize scientific education by using inquiry-based methodologies and broadening material beyond mere descriptive environmental topics (Dimopoulos & Koulaidis, 2003). Notwithstanding these initiatives, physics retained a preeminent status, bolstered by curricular modifications in the early 2000s and the 2011 reorganization that established "physics" as the principal science topic in the higher primary grades. Recent reforms, notably the 2021 curriculum revision under the "new school" initiative, have further prioritized competencies, digital literacy, and interdisciplinary connections, while maintaining physics as the principal disciplinary anchor (Institute of Educational Policy, 2021; Kotsis et al., 2023).

The existing curriculum is structured into two separate parts. In grade 1-grade 3, scientific content is incorporated into "environmental studies," a topic that merges natural and social aspects, focusing on observation, classification, and commonplace phenomena. In grade 4-grade 6, science education is unified under the subject "physics," which includes disciplines often categorized within physics, biology, chemistry, and geology. Nonetheless, the allocation of content in textbooks and official directives demonstrates a distinct preponderance of physics-related topics, encompassing electricity, magnetism, force and motion, thermal phenomena, sound, and light (Kotsis et al., 2025). Subjects from biology, chemistry, and earth sciences are infrequently represented and lack significant conceptual depth, resulting in an imbalanced disciplinary distribution within the curriculum.

Table 1 illustrates the thematic units incorporated in the 5th grade and 6th grade science curriculum alongside their respective academic areas, thereby highlighting this discrepancy. Despite being officially designated as elements of an integrated science curriculum, the classification indicates that physics-related content predominantly prevails in the upper primary grades, while chemistry, biology, and environmental science are represented by fewer and more specialized modules. This distribution offers definitive proof of the disciplinary focus indicated in the research and underscores the crucial importance of physics as the foundational framework for scientific instruction in Grades 5 and 6.

The pivotal importance of physics is further demonstrated by the relative emphasis and organization of its material. In grade 5 and grade 6, physics concepts are systematically developed from observable phenomena to more abstract models, but topics from other scientific disciplines are generally limited to discrete modules. The preeminence of physics is evident in the phenomena considered crucial for

Table 1. Thematic units for grade 5-grade 6 in greek primary school science and their disciplinary classification

Thematic unit	Disciplinary domain(s)
Science and education–Methodology	–
Energy and matter	Physics
Heat and temperature & thermodynamics	Physics
Molecules	Chemistry
Cells, life, & biological systems	Biology
Ecosystems–Climate change	Environmental science & biology
Fields and waves–Sound and light	Physics
Forces–Motion	Physics
Electromagnetism	Physics
Acids, bases, & salts	Chemistry
Modern physics–Technology	Physics

foundational science education, which emphasize commonplace physical processes and experimental scenarios such as circuits, motion, shadows, and thermal dynamics (Ravanis, 2017; Ravanis et al., 2004; Stylos & Kotsis, 2021). These characteristics suggest that physics is the primary avenue for pupils to engage with and investigate scientific concepts during primary education.

Official policy materials underscore pedagogical direction that prioritizes inquiry-based learning, practical experience, and the application of parallels and everyday contexts to facilitate conceptual development. Educators are urged to facilitate student learning through inquiry, prediction, observation, and interpretation, thereby connecting the curriculum with global trends in constructivist pedagogy and IBSE (European Commission, 2015; Harlen & Qualter, 2018). The integration of information and communications technology (ICT) is emphasized, with suggestions for digital simulations, multimedia tools, and virtual laboratories intended to enhance scarce physical resources. Nevertheless, these proposals often stay aspirational because of structural and resource-related limitations.

The research also recognizes other strengths within the existing curriculum. The focus on fundamental physical principles aids students in linking academic science to relatable situations and fosters the initial cultivation of causal reasoning. The transition from descriptive investigation in early grades to structured conceptual learning in upper primary corresponds with developmental research on children's scientific cognition (Driver et al., 1994). The curriculum's clear endorsement of inquiry, experimentation, and real-world examples demonstrates conformity with modern international standards for primary science teaching.

Concurrently, many deficiencies and implementation shortcomings were recognized. The preeminence of physics restricts engagement with biology, chemistry, and earth sciences, leading to a curriculum that fails to embody the interdisciplinary essence of contemporary scientific literacy frameworks (OECD, 2019; UNESCO, 2017). Resource constraints are prevalent: numerous primary schools are deficient in specialized science materials or laboratory facilities, compelling educators to depend predominantly on textbooks and demonstrations instead of facilitating student-led inquiry activities (Kotsis, 2025; Kotsis & Panagou, 2023). Teacher preparation poses obstacles, as the majority of primary educators are generalists with little confidence in teaching science, especially physics, despite curricular mandates for inquiry-based instruction (Kallery, 2004). Assessment practices predominantly emphasize written tasks and recall, with insufficient incorporation of performance-based or formative assessment strategies recommended in international literature, further complicated by the assessment requirements of the new inquiry-based curriculum (Kotsis, 2025). These elements collectively create a continuous disparity between the curriculum's articulated objectives and everyday instructional methods.

DISCUSSION

The results demonstrate that the Greek primary science curriculum is influenced by a persistent disciplinary tradition, wherein physics serves as the principal foundation for pupils' engagement with scientific concepts. This focus, interpreted through constructivist learning theory and research on children's conceptions, underscores the belief that physics provides conceptually rich opportunities for fostering causal reasoning and linking school science to students' everyday experiences (Driver et al., 1994; Osborne & Dillon, 2008). The significance of physical phenomena, including motion, heat, light, and electricity, corresponds with research indicating that young learners' intuitive concepts can be effectively transformed through thoughtfully crafted experiential experiences (Kaliampos & Ravanis, 2019). From this viewpoint, the physics-centric framework can be perceived as adhering to a cognitive and pedagogical logic that regards physical science as essential to early scientific literacy.

Nevertheless, within the framework of modern international standards, the disciplinary disparity apparent in the Greek curriculum prompts apprehensions over the comprehensiveness and inclusivity of students' scientific experiences and their general scientific literacy (Tsoumanis et al., 2024). Global policy documents underscore the significance of multidisciplinary and competency-oriented science education that amalgamates life sciences, chemistry, earth sciences, and socio-scientific challenges (OECD, 2019; UNESCO, 2017). The Greek curriculum's pronounced emphasis on physics restricts comprehensive exploration of biological and environmental subjects that are becoming increasingly vital to global educational concerns, such as sustainability, climate change, and public health (Bybee, 2013). Comparative research on European curricula indicates that Greece deviates from the integrated models prevalent in much of the European Union, where a balanced approach to disciplines is deemed crucial for fostering comprehensive scientific literacy (Tsiouri et al., 2024). These disparities indicate that although the Greek approach maintains its historical consistency, it may limit the scientific viewpoints accessible to learners during a crucial developmental phase.

A second observation arising from the findings pertains to the enduring disparity between instructional objectives and their practical execution. Although government publications robustly advocate for inquiry-based learning, experimentation, ICT integration, and constructivist pedagogy, the correspondence between these aspirations and classroom realities is constrained. Insufficient laboratory facilities, dependence on centralized textbooks, and unpredictability in instructor confidence contribute to a limited teaching environment where inquiry tends to be theoretical rather than exploratory (Dimopoulos & Koulaidis, 2003; Kotsis & Panagou, 2023). This discrepancy reflects global research indicating that IBSE necessitates ongoing teacher development, institutional backing, and material resources to transition from demonstration-based instruction to genuine student inquiry (Abell, 2007; Harlen & Qualter, 2018). In the Greek environment, where primary educators are generalists with less formal training in science, these issues considerably affect the viability of realizing the curriculum's inquiry-based objectives.

Moreover, the preeminence of physics influences both the curriculum and students' conceptualizations of science. Studies demonstrate that students' enduring interest in science is affected by the variety of occurrences and contexts they encounter (Sjøberg, 2010). A curriculum predominantly focused on physics may unintentionally diminish the significance of life sciences, environmental concerns, and chemical processes that are crucial to current societal issues. This issue is exacerbated by the focus on sustainability and interdisciplinary problem-solving in global science education frameworks, indicating that future reforms in Greece may require a reassessment of the prominence of various scientific fields.

Ultimately, evaluation methodologies continue to be a source of contention. Notwithstanding the curricular discourse advocating for inquiry and experimentation, assessment in primary science persists in prioritizing written recollection of content over performance-based or formative processes consistent with worldwide competency-based evaluation models (Black & Wiliam, 2009). This misalignment perpetuates teacher-centered methodologies and constrains students' possibilities to exhibit scientific thinking, teamwork, and inquisitive abilities, which are essential elements of contemporary scientific literacy.

The findings together underscore the merits and weaknesses of Greece's physics-centric methodology in primary scientific teaching. The focus on physics fosters conceptual coherence and corresponds with studies on early scientific thinking; however, it also poses issues concerning disciplinary balance, inquiry execution, teacher preparedness, and assessment frameworks. Aligning the curriculum with current worldwide standards necessitates expanding the scientific disciplines included in primary school and strengthening the systemic supports essential for effective inquiry-based learning. Such advancements would enable Greece to preserve the intellectual advantages of its physics heritage while promoting a more holistic and socially pertinent framework of scientific literacy for the 21st century.

CONCLUSIONS AND RECOMMENDATIONS

The analysis reveals that science instruction in Greek primary schools is significantly influenced by the historical and institutional significance of physics, which continues to dictate the curriculum's form and content. This disciplinary perspective embodies enduring cultural beliefs regarding the fundamental importance of physics and corresponds with cognitive studies indicating that physical phenomena provide valuable opportunities for cultivating early reasoning abilities and linking academic science to daily experiences (Driver et al., 1994; Osborne & Dillon, 2008). The curriculum emphasizes experiential learning, inquiry activities, and the incremental introduction of abstract concepts, aligning with constructivist theories and global guidelines for competence-based science education (European Commission, 2015; Harlen & Qualter, 2018). These characteristics represent significant strengths that enhance the development of conceptual knowledge and scientific reasoning in early education.

The findings simultaneously disclose considerable shortcomings inherent in the curriculum's physics-centric framework. The diminished emphasis on biology, chemistry, and earth sciences limits students' access to comprehensive scientific knowledge, particularly in crucial domains necessary for tackling modern societal issues like sustainability, health, and environmental change (Bybee, 2013; UNESCO, 2017). The curriculum's focus on physics may thus limit students' scientific viewpoints during a critical period when extensive exposure might cultivate curiosity and sustain interest in various scientific fields. These concerns are substantiated by comparative evaluations indicating that the majority of European education systems emphasize integrated or balanced science curriculum that more accurately represent contemporary notions of scientific literacy (Tsiouri et al., 2024).

Alongside disciplinary inequity, systemic implementation difficulties endure. Inadequate laboratory equipment, material shortages, and inconsistencies in teacher training hinder the curriculum's inquiry-based objectives, frequently resulting in dependence on textbook-centric and instructor-led methodologies (Dimopoulos & Koulaidis, 2003; Kotsis & Panagou, 2023). These limitations underscore the necessity for ongoing professional development and improved resources to assist educators in implementing inquiry-based teaching. Assessment techniques necessitate reevaluation, as the persistent focus on recall-based tasks is incongruent with international frameworks that promote formative, performance-oriented, and competency-based evaluation methodologies (Black & Wiliam, 2009; OECD, 2019).

These findings yield various recommendations for enhancing primary science education in Greece. Initially, curriculum reform initiatives ought to focus on expanding disciplinary scope by prioritizing life sciences, chemistry, and earth sciences, thus aligning the curriculum with multidisciplinary frameworks of scientific literacy. These endeavors should leverage previous initiatives aimed at modernizing Greek scientific curricula and can be bolstered by the involvement of experimental model schools in testing innovative pedagogical approaches (Kotsis & Tsiouri, 2024). Secondly, ongoing and structured professional development is crucial for providing primary teachers, especially generalists, with enhanced content knowledge and pedagogical expertise necessary for delivering inquiry-based and conceptually robust scientific instruction. Third, investments in educational infrastructure and material resources are essential to facilitate genuine inquiry and practical experimentation, therefore diminishing dependence on demonstration-based techniques. Assessment reform must stress formative processes that evaluate students' inquiry abilities, reasoning, and collaborative problem-solving, thereby connecting evaluative methods with the curriculum's objectives and international standards.

Although the physics-centric heritage of Greek primary science education has significant advantages, especially in fostering early conceptual reasoning, it requires enhancement through a more comprehensive and balanced scientific framework. Rectifying the disciplinary, pedagogical, and systemic constraints highlighted in this analysis will facilitate the creation of a more holistic and forward-looking model of scientific literacy, more closely aligned with global standards and the scientific requirements of modern society.

Funding: No external funding is received for this article.

Ethical statement: The author stated that the study is based exclusively on qualitative document analysis of publicly available curriculum frameworks, policy documents, textbooks, and published research literature. It did not involve human participants, personal data, or interventions in educational settings. Consequently, ethical approval from an institutional review board was not required. The author further stated that the research was conducted in accordance with established ethical standards for educational research, ensuring transparency, academic integrity, and accurate representation of sources.

AI statement: The author stated that Grammarly was used solely for language editing and proofreading; no AI tools were used for content generation or data analysis.

Declaration of interest: The author declares that there are no competing interests.

Availability of data and materials: All data generated or analyzed during this study are available for sharing when appropriate request is directed to author.

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