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Implementing the New Inquiry-Based Science Curriculum in Greece: Challenges for Teachers, Assessment, and Digital Innovation

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Abstract

The introduction of the new inquiry-based scientific curriculum in Greek primary school signifies a pivotal transition to an epistemologically and pedagogically enhanced learning model. This study analyzes the issues associated with the implementation of the curriculum, emphasizing teacher professional development, assessment reform, and the incorporation of digital innovation. Rooted in constructivist and sociocultural paradigms, the curriculum aims to convert science education from passive knowledge delivery to active inquiry and reflection. Nonetheless, established traditions of teacher-centered instruction, restricted formative assessment procedures, and inconsistent technological preparedness hinder this transformation. The ability of teachers to promote inquiry and create significant learning experiences relies on ongoing professional development and institutional backing via Experimental Model Schools, which serve as catalysts for pedagogical innovation. Assessment methodologies should transition to formative, process-oriented evaluations that prioritize thinking and creativity rather than rote memorization. Digital tools offer opportunities for visualization, simulation, and collaboration, but necessitate pedagogical integration to realize their revolutionary potential. The study indicates that the effective implementation of the reform requires systemic coherence, integrating curriculum design, teacher education, assessment, and technological policy to foster a culture of inquiry in Greek scientific education.

Keywords: Inquiry-Based Learning, Teacher Professional Development, Science Curriculum, Assessment Reform, Digital Innovation

Introduction

The introduction of the new inquiry-based scientific curriculum in Greek primary school signifies a crucial development in the progression of national science teaching methods [1]. Following its formal announcement in the Official Government Gazette [2], the reform operationalizes the principles of inquiry-based learning (IBL) through structured pedagogical sequences and student-centered experimentation. A recent study emphasizes that the curriculum embeds inquiry processes within daily classroom routines, encouraging the transition from rote content learning to active construction of knowledge through observation, questioning, and reasoning [3]. Furthermore, recent research underscores the centrality of experimental practice in cultivating conceptual understanding and reinforcing students' engagement with the processes of scientific investigation [4]. Empirical evidence supports this view, as inquiry-based laboratory experiences have been shown to enhance both conceptual understanding and self-efficacy among pre-service teachers when addressing complex physical concepts such as heat and thermal energy [5]. Complementarily, the analysis by Kotsis *et al.* [1] demonstrates that the new curriculum forms part of a broader national strategy for renewing science education, integrating formative assessment, digital innovation, and interdisciplinary connections. Despite its strong theoretical foundations, the reform's success depends on the preparedness of teachers, the coherence of curricular materials, and the systemic capacity to sustain inquiry-oriented practices across diverse classroom contexts [6]. In recent studies, pre-service teachers have expressed both enthusiasm and uncertainty about the integration of digital and artificial intelligence tools into science education, recognizing their potential to enhance inquiry, assessment, and personalization of learning [7]. This dimension highlights the need for continuous professional development and reflective practice to ensure that the technological components of the new curriculum are effectively aligned with inquiry-based pedagogical goals. Recent research on Greek primary education teachers' professional profiles further reveals that, although educators demonstrate a generally positive attitude towards STEM education, there remain variations in their confidence, training background, and perception of interdisciplinary integration [8]. Such findings underscore the importance of systematic teacher preparation to cultivate the competencies required for the sustainable implementation of inquiry-based and technologically enriched curricula. This transformation is consistent with broader international shifts in science education, where the STEM paradigm has evolved toward STEAM and STREAM frameworks that emphasize creativity, design thinking, and holistic knowledge construction [9]. Such integration supports a more inclusive and humanistic vision of science education, aligning the Greek curriculum reform with contemporary European and global trajectories in pedagogy and innovation. Within this evolving framework, the integration of Artificial Intelligence (AI) into primary science education has emerged as a transformative force that redefines the roles of teachers, learners, and assessment practices [10]. AI-based tools enable adaptive feedback, individualized inquiry pathways, and enhanced opportunities for scientific modeling, thus extending the principles of inquiry-based learning into technologically enriched environments. Recent analyses further highlight the pedagogical potential of AI platforms such as ChatGPT to cultivate experimental and reflective thinking in physics education, fostering a deeper understanding of the scientific process itself [11]. This perspective situates AI not merely as an instructional aid but as a metacognitive partner capable of supporting hypothesis generation, data interpretation, and conceptual exploration within inquiry-based contexts. Similar insights have emerged internationally, where generative AI technologies are increasingly recognized for their dual potential to revolutionize scientific education and research while simultaneously raising ethical and epistemological concerns regarding authorship, data reliability, and cognitive dependence [12]. These considerations underscore the importance of establishing balanced frameworks that leverage AI's educational affordances while preserving the integrity of scientific inquiry and human creativity. Extending this discussion, Ateeq *et al.* [13] emphasize that the integration of AI in educational contexts demands a re-examination of academic integrity and evaluative practices, prompting a paradigm shift toward more holistic, process-oriented forms of assessment. Their analysis suggests that AI-driven environments can support authentic learning experiences and richer representations of student understanding, provided that ethical guidelines and transparent assessment criteria are firmly established.

Inquiry-based learning theoretically converts the classroom into an environment of investigation, debate, and collaborative reasoning. Students are urged to explore phenomena, formulate inquiries, and develop answers grounded in empirical data [14]. The implementation of this pedagogical style in Greek schools faces entrenched traditions of teacher-centered education and high-stakes assessment. The Greek education system has historically been characterized by centralization and reliance on textbooks, which have limited teachers' authority to engage in open-ended research [15]. The adoption of the new curriculum necessitates a reconfiguration of the teacher's role, transitioning from the transmitter of authoritative knowledge to the facilitator of inquiry and reflective conversation [16].

Teacher preparation is a vital element in this transformation. Inquiry-based education requires both a conceptual comprehension of scientific subject and an epistemological awareness of the processes involved in the construction of scientific knowledge. Educators must be prepared to support students' reasoning, facilitate discussions, and assess intricate demonstrations of comprehension. Research indicates that such competencies cannot be cultivated solely through brief workshops; they necessitate ongoing professional development, collaborative learning settings, and mentoring frameworks that exemplify inquiry-based pedagogy [17]. In Greece, Experimental Model Schools are acknowledged as vital institutions for cultivating these abilities, providing environments where novel pedagogical methods can be evaluated, improved, and shared [16].

Another aspect of the reform is to the updating of evaluation methods. Conventional evaluation methods, focused on written examinations and factual memorization, are incompatible with the objectives of inquiry-based learning, which prioritizes thinking, creativity, and problem-solving skills. The revised curriculum mandates formative, process-focused assessment techniques that evaluate students' inquisitive and communication abilities. This transition involves both institutional backing and cultural transformation, as educators and administrators adapt to new standards for evidence of learning and educational responsibility [2].

The focus on digital innovation as a stimulus for inquiry is equally transformational. The incorporation of technology in science education offers instruments for experimentation, simulation, and data visualization that augment students' engagement with intricate concepts. Digital platforms can enhance collaboration, enabling students to develop experiments, share results, and collaboratively remark on their findings [18]. International experience illustrates that the pedagogical efficacy of technology is contingent upon its application: digital tools should function as facilitators of inquiry rather than replacements for it [19]. Effective deployment necessitates teacher training in both technical proficiency and the pedagogical design of digital inquiry spaces.

The introduction of the new inquiry-based scientific curriculum in Greece signifies both a problem and an opportunity. It opposes entrenched educational frameworks, evaluative standards, and educator identities, while presenting an opportunity to reconceptualize science education as a process of exploration, reasoning, and engagement. The success of the reform will ultimately hinge on the extent to which teachers are enabled to implement inquiry authentically, bolstered by cohesive evaluation systems and intelligent incorporation of digital innovation. This study examines the emerging challenges and perspectives associated with the implementation of inquiry-based science education in Greece, emphasizing the critical roles of teacher agency, reflective assessment, and technological mediation in educational transformation.

Teachers and Professional Development Challenges

The adoption of inquiry-based learning in the revised Greek science curriculum necessitates a fundamental shift in the teacher's role and professional identity. In conventional Greek classrooms, science education has historically been characterized by expository teaching and reliance on standardized textbooks, establishing the teacher as the primary authority and disseminator of scientific information [15]. Conversely, the inquiry-based approach repositions the educator as a creator of learning environments and a facilitator of student inquiry. This transition necessitates significant pedagogical and epistemological transformations, requiring educators to develop new professional competencies that encompass not only topic expertise but also skills in inquiry orchestration, dialogue facilitation, and reflective evaluation [14].

The shift to inquiry-based teaching is notably complex. Studies in Greek education indicate that educators frequently encounter uncertainty and anxiety while striving to implement novel approaches that contest traditional instructional and evaluation practices [16]. Numerous educators perceive limitations imposed by the curriculum's elevated demands for open inquiry and interdisciplinary integration, especially when they are inadequately prepared in experimental design or the management of inquiry-based classroom activities. The challenges are worsened by the scarcity of practical training opportunities and mentoring frameworks that could assist educators in translating theory into effective classroom application.

Professional development is therefore a vital factor in the successful execution of curriculum implementation. The Official Government Gazette [2] clearly states that the reform's goals can only be realized with ongoing, contextually relevant training for instructors. Transient seminars or singular workshops are inadequate to cultivate the profound pedagogical transformation necessary for inquiry-based learning. Rather, enduring, collaborative modalities of professional development, including professional learning communities, lesson study, and reflective practice groups, are crucial for enabling educators to internalize the epistemic principles of inquiry and incorporate them into their daily teaching [17].

The Experimental Model Schools in Greece are pivotal to this process. They function as dynamic laboratories for pedagogical innovation, enabling educators to observe, plan, and assess inquiry-based lessons in genuine classroom environments. Kotsis and Tsiouri [16] assert that these schools function as nodes within a larger network of pedagogical innovation, connecting universities, teacher education institutions, and classroom practitioners in a mutually reinforcing cycle of reflection and experimentation. Such partnerships inspire teachers to perceive themselves not only as executors of mandated curricula but as co-creators of educational knowledge.

Epistemological understanding among educators is especially crucial in the Greek environment. Inquiry-based learning requires educators to view science not as a static collection of facts, but as a dynamic process that includes reasoning, hypothesis testing, and collaborative validation. This viewpoint requires educators to engage in inquiry like learners, formulating questions, devising experiments, and participating in evidence-based arguments [20]. When educators adopt this approach, they enhance their ability to cultivate genuine inquiry experiences for their students, reconciling theoretical curriculum objectives with practical classroom realities.

The primary issue of adopting the new inquiry-based scientific curriculum is not solely in modifying teaching methods but in fostering a lasting culture of inquiry among educators. Professional development must extend beyond the enhancement of technical skills to address teachers' beliefs, attitudes, and identities. By placing inquiry at the core of both student and teacher learning, the reform encourages a reinvention of professionalism in science education, rooted in reflection, collaboration, and epistemic curiosity.

Assessment and Evaluation Challenges

The implementation of inquiry-based learning in the Greek primary science curriculum requires a significant transformation in both pedagogical methods and the assessment of student learning. The Official Government Gazette [2] characterizes evaluation as a fundamental element of the educational process, aimed at enhancing students' conceptual comprehension, reasoning abilities, and metacognitive growth. This approach starkly contrasts with conventional procedures in Greek schools, where assessment has always been synonymous with written examinations and summative evaluations that emphasize factual recollection rather than the inquiry process. The continued use of these traditional evaluation methods constitutes a major barrier to achieving the epistemological and pedagogical objectives of the new curriculum.

Inquiry-based learning (IBL) requires assessment methods that effectively capture the dynamic, iterative nature of student learning. Inquiry-oriented assessment prioritizes evaluating students' abilities to formulate questions, conduct experiments, gather and interpret data, and articulate their thinking, rather than assessing only the accuracy of their responses [14]. This comprehensive approach necessitates instruments and standards that are attuned to the processes of inquiry and contemplation. In fact, Greek educators frequently lack the expertise and resources to design and implement performance-based evaluations that align with these objectives. The problem is hence both technical and cultural: educators must perceive evaluation as an extension of learning rather than a distinct, evaluative act.

This shift also affects educational policy. The Greek curriculum reform positions assessment within a wider transition towards formative evaluation and student-centered pedagogy, highlighting continual feedback and self-assessment as tools for facilitating inquiry [6]. Research indicates that the execution of formative assessment is impeded by structural limitations, including substantial class sizes, time constraints, and insufficient institutional backing for personalized learning approaches [20]. Educators frequently experience a conflict between the progressive principles of the curriculum and the pragmatic requirements of accountability systems that favor measurable results.

Moreover, evaluation in inquiry-based settings must embody the interdisciplinary and collaborative nature of scientific work. Students are required to synthesize information from physics, biology, and environmental science, applying it to real-world issues that necessitate interdisciplinary reasoning. Conventional assessments are inadequate for measuring these competencies, which necessitate portfolio evaluations, reflective journals, and peer assessments. These alternative methods assess cognitive accomplishment while also offering insights into students' engagement, inventiveness, and ability for scientific argumentation [17]. Nonetheless, their implementation is constrained in Greek schools, where educators encounter both practical and conceptual obstacles in transitioning from entrenched testing practices.

A further aspect of the assessment challenge concerns educators' professional development. Kotsis and Tsiouri [16] assert that educators must possess the epistemological understanding required to design evaluation systems that accurately reflect the essence of scientific investigation. This entails creating rubrics to assess the quality of reasoning and the consistency of explanations, and interpreting student missteps as learning opportunities rather than shortcomings. The Experimental Model Schools reemerge as crucial environments for fostering these approaches, offering models of integrated teaching, learning, and evaluation cycles that reflect the essence of inquiry-based education.

The assessment issue is intricately linked to the philosophical underpinnings of the new curriculum. It prompts educators to reevaluate the definition of knowledge and the criteria for demonstrating comprehension in science education. Kyle [19] contends that the future of science education relies on transcending mere information reproduction to foster scientific reasoning and empowerment. In this context, assessment transcends mere performance measurement, evolving into an ethical and pedagogical obligation to cultivate learners capable of critical thinking and responsible action in a scientifically intricate world.

Digital Innovation and Inquiry-Based Practice

The incorporation of digital tools into the revised Greek primary scientific curriculum presents both a challenge and an opportunity for transforming inquiry-based learning. The Official Government Gazette [2] asserts that digital innovation is a basic enabler of the curriculum's educational philosophy, rather than a supplementary element. Technology is conceived as a facilitative instrument that broadens the scope of investigation, enabling students to visualize abstract concepts, gather and analyze data, and collaboratively engage in scientific reasoning. This digital realm of investigation corresponds with modern constructivist viewpoints that perceive learning as an active process of meaning-making, augmented by interactive and multimodal settings [14].

The educational promise of digital technologies in science instruction resides in their ability to model intricate systems and render invisible processes observable. Students can investigate themes such as energy transfer, motion, and ecological balance through virtual laboratories, simulations, and augmented reality environments, surpassing the constraints of conventional classroom resources [6]. These instruments provide risk-free experimentation, unrestricted repetition, and visualization that transcends physical limitations, all of which are vital for cultivating scientific reasoning at the fundamental level. However, its effective deployment necessitates a deliberate educational framework; technology should function as a tool for inquiry rather than an end in itself.

In Greece, the implementation of digital tools in science education has been inconsistent, frequently hindered by infrastructural inequalities, inadequate teacher training, and a deficiency of pedagogical frameworks that incorporate technology into inquiry-based methodologies. Educators often express uncertainty over the alignment of digital resources with the stages of the inquiry cycle: inquiring, researching, analyzing, and reflecting [15]. The difficulty is not inherently technological but epistemological: educators must utilize digital media as extensions of students' cognitive and inquisitive processes. In the absence of this congruence, digital tools may be relegated to mere ornamental embellishments instead of serving as agents of conceptual transformation.

A crucial prerequisite for this digital transformation is the professional development of educators. Kotsis and Tsiouri [16] contend that the Experimental Model Schools provide a viable framework for connecting technical innovation with instructional applications. In these environments, educators can collaboratively create and evaluate digital inquiry activities, enhancing both technical skills and pedagogical understanding. Such venues exemplify the fundamental characteristics of inquiry that the curriculum aims to cultivate in students: exploration, reflection, and collaborative knowledge building. The development of teachers' digital literacy, viewed not only as technical skill but also as pedagogical proficiency, is essential for maintaining innovation in scientific education.

Outside the classroom, digital innovation also alters the social and cultural aspects of learning. Digital platforms and educational communities can link students from various schools and areas, facilitating the exchange of ideas and collaborative problem-solving about environmental and technical challenges of mutual interest [18]. These interactions reflect the collaborative essence of modern research and assist students in perceiving inquiry as a collective pursuit rooted on communication and ethical accountability. Furthermore, the integration of digital inquiry corresponds with wider European initiatives that connect science education to the advancement of sustainable and participatory digital citizenship [19].

However, actualizing the complete potential of digital innovation within the Greek setting necessitates systemic support, encompassing infrastructural investment, curriculum consistency, and policy alignment. According to Strat *et al.* [17], inquiry-based science education thrives when digital resources are integrated into a cohesive framework of teacher education, research, and institutional collaboration. The Greek reform offers a chance to reinvent both the content and methodology of student learning through multimodal, collaborative, and inquiry-based interactions with technology. If effectively executed, digital innovation may convert the Greek scientific classroom into a vibrant environment of exploration, creativity, and epistemic empowerment.

Discussion

The introduction of the new inquiry-based scientific curriculum in Greece highlights both the transformative potential and the structural limitations of educational reform. The reform aims to establish a novel educational culture based on curiosity, logic, and experimentation. However, its implementation relies on the dynamic interaction among educators, institutional frameworks, and the broader socio-educational context. The Greek story illustrates that curriculum reform transcends merely incorporating new content or instructional guidelines; it is a multifaceted process involving cultural negotiation, professional development, and epistemological reorientation [15].

Educators are at the core of this transition. Research continually demonstrates that they serve not only as executors of curricular policy but also as interpreters and facilitators of educational transformation [16]. Their convictions regarding science, education, and evaluation significantly affect the viability of inquiry-based learning in the classroom. The efficacy of the reform will consequently depend on the implementation of enduring professional development frameworks that foster reflective practice, epistemic awareness, and pedagogical confidence. Experimental Model Schools provide a crucial function in this process, acting as catalysts for innovation where theory intersects with practice. These schools exemplify the practical implementation of inquiry through collaborative research, curriculum design, and peer observation [20].

Assessment continues to be a vital and contentious domain. Despite the curriculum advocating for formative and process-oriented evaluation, the institutional focus on standardized testing persists in influencing teachers' methodologies and students' anticipations [2]. The simultaneous presence of progressive and traditional assessment paradigms generates a tension that frequently limits experimentation and introspective risk-taking. Transitioning to authentic assessment necessitates a cultural transformation that acknowledges learning as a continuous process rather than a quantifiable conclusion. Educators require assistance in creating alternative instruments, rubrics, portfolios, and self-assessment frameworks that embody the epistemic intricacies of inquiry and promote metacognitive involvement [14].

Digital innovation presents both novel opportunities and emerging imbalances. The curriculum anticipates that technology can enhance the scope and profundity of inquiry via simulations, digital experiments, and collaborative online platforms [6]. Nevertheless, digital inclusion in Greek schools is inconsistent, characterized by discrepancies in infrastructure, teacher readiness, and resource accessibility. This digital divide may unintentionally perpetuate educational disparities, constraining the democratizing potential of inquiry-based education. Digital competence should be redefined as a type of professional literacy, emphasizing the capacity to meaningfully incorporate technical tools into inquiry processes rather than utilizing them as mere adjuncts. When utilized successfully, digital technologies can serve as epistemic mediators that link observation, reasoning, and communication in innovative ways [18].

In addition to its practical aspects, the reform prompts significant philosophical and ethical inquiries on the essence of science education in the 21st century. Inquiry-based learning disrupts conventional hierarchies of knowledge and authority by establishing students as co-creators of understanding. This transition involves a more democratic and participatory approach to education, along with the global trend connecting scientific education to sustainability and social change [19]. The Greek reform is not merely a national endeavor but also a component of a worldwide discourse on cultivating scientifically literate individuals capable of critical thinking, ethical action, and effective responses to intricate global issues.

The Greek example underscores the importance of coherence in educational reform. Strat *et al.* [17] assert that effective inquiry-based systems rely on the coherence of curriculum, teacher training, assessment, and policy. The fragmentation of these parts can undermine the intended efficacy of reform. The revised curriculum necessitates a collaborative strategy involving universities, teacher training institutes, legislators, and local communities. Systemic collaboration is essential for transforming inquiry-based learning from mere policy rhetoric into a lasting pedagogical culture that can influence future generations of learners and thinkers.

Conclusion

The introduction of the new inquiry-based scientific curriculum in Greece is a significant effort to transform the objectives, methodologies, and ethos of primary science teaching. By positioning inquiry as the fundamental pedagogical and epistemological premise, the reform aims to convert students' learning experiences from passive knowledge acquisition to active knowledge building. This transition embodies a comprehensive educational philosophy that integrates scientific comprehension with critical analysis, ethical consciousness, and civic participation [19]. However, the analysis illustrates that actualizing this goal necessitates surmounting various interconnected problems, including pedagogical, institutional, and technological obstacles.

Educators are key to this development. Their capacity to design, facilitate, and evaluate inquiry-based learning dictates the authentic realization of the reform's principles. The efficacy of the new curriculum relies on ongoing professional development initiatives that foster epistemological awareness and inquiry-based teaching methodologies [16]. Initiatives like the Experimental Model Schools are essential in this effort, offering collaborative settings where educators participate in reflective experimentation and exchange novel methodologies [20]. Nonetheless, these initiatives must be systematically broadened to encompass all educational institutions, underpinned by cohesive national policy and sustained investment in teacher training.

The reform of assessment continues to be a significant issue. The ongoing reliance on summative, content-focused assessments undermines the goals of inquiry-based teaching. Genuine evaluation methods, including formative assessment, portfolios, and performance tasks, should be essential to the instructional process, providing proof of students' reasoning and creativity rather than simple factual recall [14]. Aligning assessment with inquiry necessitates a culture revolution that redefines achievement and the valuation of learning within the school system [2].

The incorporation of digital innovation presents new opportunities for the execution of inquiry. Digital tools can enhance students' inquisitive abilities, link them to authentic scientific material, and promote collaboration within learning communities [18]. However, in the absence of sufficient training, infrastructure, and educational strategy, technology may exacerbate rather than alleviate disparities [15]. The objective is to guarantee that digital technologies serve as genuine facilitators of inquiry, enhancing conceptual comprehension and innovative problem-solving. Technological literacy must advance into digital inquiry literacy, a skill that integrates critical thinking, experimentation, and collaboration in the digital environment.

Ultimately, the Greek reform exemplifies that curricular innovation is a continuous process of reflection and adaptation. The success of this initiative will rely on coherence throughout all tiers of the education system, including curriculum design, teacher training, assessment frameworks, and policy alignment [17]. When well executed, the new inquiry-based science curriculum has the potential to revolutionize Greek primary education into a vibrant environment of scientific and humanistic learning, equipping pupils to confront uncertainty with curiosity and rationality. It reaffirms the persistent conviction that inquiry-based education empowers individuals to comprehend the world and actively engage in determining its future.

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