**Journal of Mathematics and Science Teacher**
2025, 5(3), em083
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

**Research Article** **OPEN ACCESS**

# The new Greek inquiry-based learning science curriculum for primary education

Konstantinos T. Kotsis [1]*, Ourania Gikopoulou [2], Matthaios Patrinopoulos [2], Efstratios Kapotis [2], George T. Kalkanis [2]

[1] Department of Primary Education, University of Ioannina, Ioannina, GREECE
[2] National and Kapodistrian University of Athens, Athens, GREECE
***Corresponding Author:** kkotsis@uoi.gr

**Citation:** Kotsis, K. T., Gikopoulou, O., Patrinopoulos, M., Kapotis, E., & Kalkanis, G. T. (2025). The new Greek inquiry-based learning science curriculum for primary education. *Journal of Mathematics and Science Teacher, 5*(3), em083. https://doi.org/10.29333/mathsciteacher/16846

**ARTICLE INFO**

Received: 16 Dec. 2024

Accepted: 12 Aug. 2025

**ABSTRACT**

This article details the design, implementation, and assessment of the newly established national inquiry-based learning (IBL) science curriculum for primary education in Greece, officially enacted in 2024. This curriculum addresses enduring pedagogical difficulties, notably the prevalence of rote memorization and teacher-centered instruction, signifying a substantial movement towards student-centered, experiential learning. The framework is based on known IBL theory and highlights the cultivation of scientific skills, including observation, inquiry, experimentation, and reasoning. An essential unique aspect is the curriculum's methodical integration of digital tools, interdisciplinary STEM collaboration, and inclusive instructional design that addresses varied learning requirements. The curriculum was collaboratively developed with active educators and underwent a two-year pilot deployment in experimental model primary schools nationwide. Information from teacher diaries, student performance metrics, and classroom observations indicates heightened engagement, enhanced critical thinking, and increased participation, particularly among students with learning challenges or disabilities. These data indicate that the curriculum successfully integrates theory with classroom practice. This curriculum aligns with current trends in science education and incorporates contextually relevant aspects, contributing to national educational reform and the global discourse on IBL in early science education. The study emphasizes the promise of enduring collaboration between teachers and researchers in curriculum innovation and presents a scalable methodology for integrating IBL into primary school systems.

**Keywords:** inquiry-based learning, primary education, science education, STEM education, Greek modern curriculum

## INTRODUCTION

Presenting the new inquiry-based learning (IBL) science curriculum for Greek elementary schools marks a dramatic change from conventional teaching methods, which sometimes emphasize rote memorization and passive learning. In 2024, this curriculum became legislation for the nation. This creative framework promotes critical thinking, creativity, and active participation among young students through exploration and experimentation. Teachers help to create an environment where students acquire scientific knowledge and develop the skills needed for inquiry, including observation, questioning, and hypothesizing, by matching the curriculum with modern teaching strategies. This change is especially pertinent in a fast-changing world where knowledge of science is required to grasp difficult worldwide issues. Moreover, the new curriculum is meant to inspire a lifetime love of science by means of practical exercises and real-world applications, so ensuring that students are informed and competent of using their knowledge in relevant settings.

Beyond simple content acquisition, elementary school science education helps develop critical thinking and natural curiosity about the surroundings. Involving students in IBL motivates them to investigate scientific ideas actively rather than merely passively learning. Studies confirm that such pedagogical strategies greatly improve students' design skills and problem-solving capacity, so encouraging their involvement with STEM fields (Uzel & Bilici, 2022). Moreover, a well-organized scientific curriculum in elementary education lays the groundwork for students' future academic achievements and scientific-related career paths. This is especially relevant worldwide since recent research shows the several approaches used in different nations–including Greece–for teaching science (Stefanidou et al., 2024). Therefore, giving efficient science education top priority in elementary schools will help to produce informed, competent, environmentally conscious citizens ready to meet modern challenges.

Comprising primary, secondary, and tertiary education levels and strongly focusing on standardizing and rigorous curriculum, the Greek educational system is distinguished by its disciplined framework. Six years of primary education seeks to produce fundamental literacy, numeracy, and critical thinking ability. However, the system has struggled to meet modern educational demands, especially in relation to encouraging IBL, which is ever more important in a fast-changing global environment. The movement toward including creative teaching strategies–such as those shown in contemporary competency-based courses–showcases the need for reform to improve student involvement and learning results. Recent studies underline the need to match educational practices with the demands of a technologically driven future, as stated in research supporting better teacher training and ethical issues in curriculum design (Kotsis, 2024a). Reevaluating the Greek educational system to embrace inquiry-based approaches could thus greatly improve the learning process for younger students.

Recent international research highlights significant diversity in how IBL is implemented across national contexts. For example, countries like Finland and Singapore integrate inquiry-based methods through competency-based curricula supported by robust teacher training and digital infrastructure (Chu et al., 2021; Spyrtou et al., 2018). In contrast, the Greek system has only recently initiated such reforms at a national level. The present study contributes to this discourse by analyzing a rare case of a state-mandated, IBL-based curriculum, offering insights from its two-year pilot in Greek experimental model schools and inviting comparative reflection on effective implementation strategies.

## THEORETICAL FRAMEWORK

Analyzing the theoretical framework of IBL inside the curriculum framework helps one understand its emphasis on active student participation and experiential learning. Pedaste et al. (2015) outline a thorough research cycle that spans orientation, conceptualization, investigation, conclusion, and discussion (Prince & Felder, 2006). This approach promotes critical thinking and problem-solving abilities, which exactly complement the objectives of the Greek curriculum–combining scientific ideas with practical uses. Moreover, the good application of IBL calls for coherent assessment strategies that stress understanding above memorizing. Practical experiments grounded in IBL help students develop hypotheses and examine results, thus improving scientific literacy (Kotsis et al., 2024). In the end, the IBL structure enhances students' learning opportunities and gets them ready for informed citizenship in a fast-changing scientific scene.

### Traditional Methods of Teaching Science in Greece

Greek conventional approaches to teaching science have been distinguished by their dependence on textbooks and the absence of a coherent plan for science education. Particularly in the elementary and lower secondary levels, Greek school science textbooks are central in the pedagogic debate and the main source of socializing pupils into the practices and conventions of the scientific community (Koulaidis & Dimopoulos, 2022). Though several programs aim to improve science education, Greece lacks a comprehensive plan, as shown by the below-average performance of Greek students on tests such as PISA (Karagiannidis et al., 2022). Integrating elements of the history of science into the curriculum has lately been a focus of efforts to enhance science education; this has shown promise in fostering critical thinking among elementary school students. For example, a project on electromagnetism showed how including historical viewpoints might improve students' involvement and critical analysis of scientific knowledge (Patrinopoulos & Iatrou, 2019). Although conventional approaches have been mostly textbook-based, there is increasing awareness of the need for creative ideas that support critical thinking and active participation in scientific education.

Often restricting students' interaction with the content, the conventional scientific teaching strategies in Greece have mostly stressed rote memorization and a teacher-centered approach. Historically, this pedagogy has depended on textbooks and direct instruction, in which case teachers transmit knowledge without encouraging critical thinking or student research. Such approaches (Gikopoulou, 2017; Kapotis & Kalkanis, 2016) can impede the acquisition of scientific reasoning and problem-solving abilities, thus impeding fundamental elements of modern science education. Technology in the curriculum has been suggested as a transforming element since it improves conventional approaches by supporting multimedia resources and interactive learning opportunities (Savvidou et al., 2024). Thus, including these technical instruments inside a more inquiry-based framework might close current gaps and enable a more intense investigation of scientific ideas. The change from traditional approaches to inquiry-based science education (IBSE) marks a fundamental change meant to equip children for a knowledge-driven society as Greece tries to improve its educational practices.

### Evolution of the Curriculum Over the Years

Especially in science education, the development of educational curricula has constantly reflected society's needs, new knowledge paradigms, and pedagogical developments. Primary school curricula have changed from rote memorization to IBL frameworks emphasizing critical thinking and practical experience. From conventional pedagogies to modern methods involving students in meaningful scientific inquiry, promoting knowledge retention and problem-solving abilities is necessary for future learning (Asilevi et al., 2024). These changes are especially clear in the recent adoption of the new inquiry-based Greek science curriculum, which fits world trends supporting cognitive involvement and experiential learning. The way the curriculum is set responds to the need for a more dynamic learning environment, encouraging academic success and personal development among younger students. Therefore, appreciating the pedagogical innovations that define today's educational scene depends on knowing this development.

### Influence of International Educational Trends on Greek Science Education

Though the effects have been complicated and multifarious, international educational trends have clearly affected Greek science education. As Chiu and Duit's (2011) discussion of the globalization of science education highlights the need of a high degree of scientific literacy worldwide, which has resulted in more global cooperation and monitoring via tests like TIMSS and PISA, Greek students' below-average PISA results (Karagiannidis et al., 2022) show that Greece has struggled to match its scientific education with international norms despite these worldwide attempts. This underperformance emphasizes in Greece the need of curriculum reform, creative teaching strategies, and improved teacher professional development (Karagiannidis et al., 2022). Moreover, although Greek policy-making has benefited from foreign research, it usually functions as a comparative tool rather than a basis for strategic planning, partly because of inadequate home research infrastructure in comparative education (Tsoumanis et al., 2023). International progressive education movements, especially in the early 20th century when Greek teachers adopted pedagogic ideas from Germany, have historically shaped Greek pedagogy (Stefanidou & Mandrikas, 2023). But the present economic difficulties in Greece have diverted attention from reform of education, so complicating the integration of foreign educational trends into Greek scientific education (Tsoumanis et al., 2023). Overall, Greece struggles greatly in properly applying these influences to improve its scientific education system, even while international trends offer a framework for possible developments.

Particularly by using IBL techniques, emerging global educational trends drastically changed Greek scientific education. These trends underline critical thinking, group learning, and practical applications–all of which fit Greece's goal of modernizing its educational system. Reviewing worldwide practices shows that nations prioritizing IBL have reported better student involvement and a deeper conceptual knowledge of science (Chu et al., 2021). Such realizations help the Greek curriculum to incorporate related approaches and create a learning environment where students' curiosity drives their study of scientific ideas. Furthermore, as generative AI and digital tools proliferate in education (Alasadi & Baiz, 2023) their ability to personalize learning experiences and improve participation cannot be underlined. Thus, adjusting these global trends not only helps to raise the quality of scientific education in Greece but also fits more general objectives of enhancing graduate employability and competence development in a fast changing global scene.

The incorporation of IBL into national science curricula has emerged as a prevalent educational reform technique in various nations; nevertheless, its execution differs markedly in scope and design. Nations like Finland and Canada have established IBL through organized learning sequences, formative assessment frameworks, and robust teacher training initiatives that facilitate open-ended exploration and interdisciplinary integration (Chu et al., 2021). Likewise, Singapore integrates IBL inside a centralized STEM framework that prioritizes practical experimentation and advanced thinking from the onset of primary education. Conversely, the Greek educational system has just lately initiated a deliberate endeavor to integrate IBL at a national scale. This curriculum overhaul, formally implemented in 2024, is one of the first to integrate IBL ideas into a cohesive national science program for elementary education. The co-development by teacher-researchers and their pilot deployment in experimental model schools represents a unique instance within the European context. This study significantly contributes to international discourse by illustrating Greece's adaptation of global pedagogical trends to local educational environments and by suggesting a scalable framework for implementing IBL in traditionally content-heavy institutions.

## INTRODUCTION TO INQUIRY-BASED LEARNING

Through active participation and critical thinking, IBL is an educational method whereby students explore and investigate scientific ideas. Rooted in constructivist theories, IBL challenges students to create questions, design experiments, analyze data, and present results, thus promoting better knowledge retention and understanding (Pedaste et al., 2015). This pedagogical approach allows students to participate in a dynamic inquiry flow (Kotsis, 2024c) by means of a cyclical process comprising orientation, conceptualization, investigation, conclusion, and discussion). Using practical experiments and real-world applications that link scientific ideas to students' daily life, the curriculum seeks to improve these ideas (Kotsis et al., 2023a). Through this program, the focus on digital resources and group learning advances diversity. It meets various student needs, so ensuring that the ideas of IBL help to develop critical thinking and problem-solving abilities is vital for the 21st century.

Emerging as a fundamental pedagogical tool in the curriculum, IBL encourages active student involvement through exploration and critical thinking. In line with the curriculum goals, IBL stresses the value of inquiry, experimentation, and challenge to develop 21st century skills including cooperation and problem-solving. Studies showing IBL greatly improves student learning outcomes–especially in terms of developing analytical skills and scientific literacy–and some prefer it over more conventional approaches (Pedaste et al., 2015). Encourage students to generate hypotheses, carry out experiments, and consider their results, and the curriculum supports a disciplined inquiry cycle (Kotsis et al., 2024). Especially it combines practical tools to link scientific ideas with daily life, encouraging relevance and involvement among young students (Kalkanis, 2021). Thus, IBL emphasizes its important part in contemporary educational practices since it changes science education and helps students negotiate challenging worldwide problems. Particularly in projects including multidisciplinary themes, such as astronomy-related initiatives in minority schools in Greece (Molla, 2020), research shows that IBL can considerably increase student involvement and motivation in science education. Such initiatives show the possibilities of IBL to foster a better knowledge of content and inspire students to interact with their community, so encouraging a more responsive educational environment that fits different learning requirements.

### Historical Context of Inquiry-Based Science Education in Greece

Greek IBSE has changed drastically and been shaped by both historical and modern educational programs. Originally found in ancient experiments like the eratosthenes experiment, revived in contemporary classrooms to involve students in hands-on scientific inquiry, IBL has long history. Part of a worldwide European project, this experiment showed the value of IBSE by measuring the earth's circumference using students from Greece and other nations, so improving their knowledge of scientific ideas via useful application (Sotiriou & Bogner, 2015). Greece has lately taken part in initiatives like "chain reaction," sponsored by the European Commission, meant to include IBSE into secondary education. Teachers and students were among the several stakeholders involved in this project, which underlined the benefits of customizing IBSE to fit cultural and curricular requirements so improving the learning environment (Katsampoxaki-Hodgetts et al., 2015). Moreover, combining IBSE with the past of science and technology has been investigated to enhance science education by providing teachers with creative ways to involve their students using digital tools and historical background (Bruneau et al., 2012). Furthermore, it is recommended that the efficacy of IBSE be improved by including digital and collaborative learning elements, such as the acceptance of connectivity approaches, which fit the learning styles of the Net Generation (Trna & Trnová, 2012). Aiming to inspire a greater knowledge and appreciation of scientific inquiry among students, the historical background and modern adaptations of IBSE in Greece show a dynamic approach to science education overall.

The historical background of inquiry-based education in Greece shows a slow change due to national educational reforms and worldwide pedagogical trends. Historically, Greek education stressed rote memorization and standardized testing, stifling students' critical thinking and creativity. However, since the early 2000s, student-centered learning models–combining inquiry-based approaches and encouraging active exploration and experimentation–have clearly shifted (Stylos et al., 2022). This development corresponds with more general European projects supporting inclusive and transversal educational approaches stressing critical thinking, problem-solving, and practical applications (Stylos et al., 2023a). Combining technology and multidisciplinary themes like health and climate change has enhanced the curriculum even more and let students relate scientific ideas to daily life (Kotsis et al., 2024). Such historical changes reflect continuous attempts to produce scientifically informed people capable of properly handling difficult worldwide problems.

### Benefits of Inquiry-Based Science Learning for Young Students

For young students, IBSE provides many advantages, including developing critical thinking, creativity, and active participation in the learning process. This pedagogical method greatly improves students' educational experiences and results by motivating them to investigate, challenge, and build their knowledge (Sam, 2024). Basic to developing analytical and critical thinking skills, students learn "how to think" rather than "what to think" by means of problem-solving through exploration and high-level inquiry (Qablan et al., 2024; Sasanti et al., 2024). In the context of young children, IBL entails activities including observation, classification, and surveys that enable them to actively participate in scientific inquiry and deepen their knowledge of scientific ideas (Howitt & Roberts, 2023). Research showing sixth-grade students showed notable improvement in their analytical thinking skills following participation in IBL activities shows that the method of IBL has been shown to improve analytical thinking skills among elementary students. Moreover, since students find learning more interesting and pertinent to real-world settings, this method improves cognitive abilities and raises student motivation and satisfaction (Mikhail & Moresoli, 2024; Sam, 2024). IBSE is a great teaching tool for promoting lifelong learning and adaptation since it gives young students the necessary tools to negotiate challenging society issues (Mikhail & Moresoli, 2024).

These advantages for young students greatly increase their involvement and help develop critical thinking abilities necessary for citizenship in the twenty-something century. Within the framework of the curriculum, IBL helps students to investigate and investigate scientific ideas by means of practical experimentation and real-world problem-solving, so fostering a closer knowledge retention and understanding. Studies show that by letting students be active participants in their learning paths and so foster ownership over their educational experiences, IBL helps to increase motivation and curiosity (Kotsis et al., 2023b). As students work in groups, IBL also promotes teamwork and communication while guiding them through obstacles together, so developing their cooperative skills. Preliminary assessments of the curriculum indicate that students engaged in inquiry-based approaches displayed improved attitudes toward science and greater proficiency in critical thinking, so preparing them for future academic pursuits in STEM fields (Stylos et al., 2023b).

Emphasizing the part students play as active participants in their learning process, IBL helps them to investigate, ask questions, and interact critically with materials. Emphasizing student-centered discovery instead of passive information absorption, IBL develops critical thinking and problem-solving abilities vital in modern education. Key components of IBL are the development of open-ended questions, the quest of research, and cooperative knowledge building–all of which advance a better knowledge retention and comprehension of information. Moreover, as observed in the evolution of the inquiry-based Greek science curriculum for elementary schools, the strategic integration of IBL fits with contemporary educational objectives, so fostering scientific inquiry abilities from a young age (Dwivedi et al., 2023). This alignment guarantees relevance and applicability in students' learning experiences since it helps them to be ready to negotiate future challenges in a fast changing knowledge environment.

### Comparison with Traditional Teaching Methods

Primary school science education undergoes a major change in delivery when conventional teaching strategies give way to inquiry-based approaches. Often resulting in passive learning environments where students are limited to rote memorization and lack engagement, traditional teaching strategies–characterized by a teacher-centered approach–often lead to By means of active participation, inquiry-based science fieldwork helps students to acquire critical skills including problem-solving, communication, and teamwork. Studies using inquiry-based approaches show that students exposed to them view their science learning skills more favorably than those in conventional environments, where negative impressions might impede drive and skill development. Furthermore, including technology into inquiry-based courses improves learning opportunities (Wen et al., 2023), in line with the modern needs of a knowledge-driven society as demonstrated by Greece's attempts to modernize education by creative human resource management and teaching strategies. This development emphasizes the need for educational institutions adopting more interactive pedagogies to produce a scientifically literate population.

## CURRICULUM DESIGN AND IMPLEMENTATION

Effective learning environments depend critically on well considered curriculum design and implementation in developing the inquiry-based Greek science curriculum for primary schools. Emphasizing student-centered, multidisciplinary methods combining fundamental scientific ideas with practical applications, this curriculum conforms with modern educational models. Using IBL, as described by Kotsis et al., the curriculum motivates students to participate actively in scientific inquiry, so developing critical thinking and problem-solving ability by means of practical experiments and group projects (Kotsis, 2024b). Furthermore, including digital tools improves the interactive nature of education and encourages participation and inclusivity in various classrooms (Kotsis et al., 2024). Pilot studies show that effective implementation depends on constant professional development for educators and strong assessment strategies that give descriptive feedback top priority over conventional testing approaches, so ensuring that teachers and students can adapt flexibly to changing educational needs (Stylos et al., 2023a).

The new Greek science curriculum's main elements center on an inquiry-based approach meant to encourage primary students' critical thinking and experiential learning. Emphasizing multidisciplinary connections, this curriculum combines biology, chemistry, and physics to provide a coherent knowledge of scientific ideas in real-world settings (Kotsis et al., 2023b). Encouragement of hands-on experiments, which let students actively interact with the content, create hypotheses, and evaluate data, so promoting scientific literacy and problem-solving abilities (Kotsis et al., 2023a). The curriculum also addresses inclusivity by using contemporary digital technologies to lower learning gaps and improve student involvement (Kotsis et al., 2023b). Including modern ideas like climate change fits the goals of producing informed, rational people with critical thinking skills needed to negotiate challenges of the 21st century (Gikopoulou, 2019). Therefore, the new curriculum stresses on the mastery of scientific knowledge and gets students ready for cooperative and creative future roles.

The effective application of the new inquiry-based Greek science curriculum in elementary schools depends on strategic planning concentrated on creating an interesting learning environment. Incorporating experiential learning and inquiry-based approaches that inspire students to create questions, run experiments, and apply their results to real-world settings will help to improve critical thinking and problem-solving abilities by means of which key strategies will be enhanced (Stylos et al., 2023a). Teachers' professional growth is vital since it provides the knowledge and abilities needed to enable IBL with efficiency. This corresponds with research showing the relationship between teachers' efficacy beliefs and their capacity to involve their students in scientific inquiry (Tsoumanis et al., 2024). Moreover, including digital tools and resources will help to foster inclusivity by allowing many learning environments and backgrounds (Kotsis et al., 2023b). Schools can build a strong educational framework that fits the objectives of the curriculum and equip students for the complexity of the scientific scene of the 21st century by implementing these approaches.

Since they are the main agents guiding student inquiry and critical thinking, teachers are important in enabling IBL inside the curriculum. Teachers who adopt a student-centered approach help to create an environment in which curiosity drives learning, so allowing students to create questions and pursue investigations linking scientific ideas to real-life settings (Kotsis et al., 2023a). To encourage active student participation and collaboration, effective teachers use digital tools and hands-on experimentation among other approaches (Kotsis et al., 2023b). In addition, teachers have to negotiate obstacles, including standardized tests, and get continuous professional development to improve their inquiry-based pedagogical techniques (Kotsis, 2024c). By encouraging students to take responsibility for their education, facilitators help them to build meaning from their discoveries and develop critical 21st century skills. This all-encompassing approach fits the goals of the curriculum and finally helps to produce informed and qualified future citizens.

Emphasizing IBL, this course invites students to probe, ask questions, and come to conclusions based on their results. Successful application of the curriculum depends much on efficient teacher training and resource allocation. Subject matter knowledge and pedagogical tools that support IBL and experimentation in classroom environments must equip teachers. Research indicate that customized professional development–that which fits particular teacher needs instead of a one-size-fits-all approach–is far more beneficial (Bondie et al., 2019). Moreover, support systems, including cooperative networks and mentoring programs, help teachers to be more confident and capable of presenting creative courses. Giving teachers and students access to modern teaching tools–digital tools and simulation technologies–enhances their educational opportunities. Institutions thus have to give continuous training and resource availability top priority in order to enable a smooth transition to inquiry-driven approaches, so fostering a more interesting and efficient science education for Greek young students (Stefanidou et al., 2024).

Developing the inquiry-based science curriculum depends much on effective curriculum design and structure since they directly affect the pedagogical approach and student involvement. This creative program stresses a constructivist approach, in which students actively engage in their education by means of inquiry and exploration, so developing critical thinking abilities. The curriculum is designed to incorporate cross-disciplinary themes so that teachers might establish significant links between scientific ideas and practical uses. Including qualitative research techniques also improves curriculum development, enabling it to be flexible enough for different learning environments and learner requirements (Spyrtou et al., 2018). Moreover, the design gives flexibility top priority since it is necessary to meet teachers' various difficulties using IBL. In the end, the deliberate attention on design and architecture guarantees that the curriculum satisfies educational criteria and generates a dynamic learning environment (Dwivedi et al., 2023).

## ASSESSMENT AND EVALUATION METHODS

Since they provide vital feedback on student learning and instructional effectiveness, effective assessment and evaluation strategies are absolutely necessary for the new inquiry-based Greek science curriculum to be implemented in primary schools. Emphasizing formative assessments that let teachers constantly monitor student development and knowledge, the curriculum gives descriptive assessment tools top priority over conventional standardized testing (Kotsis et al., 2024). Such assessments help to create an active learning environment in line with the inquiry-based approach that motivates students to participate in practical experiments and group problem-solving (Kotsis et al., 2023a). Furthermore, creative digital tools can help teachers evaluate content knowledge and the critical thinking and investigative abilities required for students of the 21st century (Kotsis, 2024c). These evaluation strategies improve teachers' capacity to modify their lessons depending on the needs of each student, so fostering scientific literacy and involvement in practical settings by means of a reflective teaching practice (Gikopoulou, 2019).

Evaluating IBL within the inquiry-based science curriculum calls for creative assessment methods. Formative assessments are a great substitute for traditional tests since they underline student involvement and reflective practices all through the learning process, so capturing the complex knowledge promoted by inquiry-centric approaches (Kapotis & Kalkanis, 2016). By means of peer evaluations, self-assessments, and project-based learning exhibitions, such assessments help students to show their critical thinking and problem-solving ability in real-world settings. Research shows that these strategies improve student motivation and support cooperative learning environments, so guiding teachers in customizing their instruction to fit the demands of various students (Kotsis, 2024a; Kotsis et al., 2023b). Moreover, including digital tools–such as interactive platforms and AI-driven feedback systems–can give real-time insights on student development, so supporting fast interventions and guaranteeing alignment with 21st century skills (Kalkanis, 2021). In the end, these creative evaluation techniques help to produce scientifically educated graduates able to handle challenging real-world tasks.

Measuring student involvement and knowledge is essential in the context of the curriculum if one is to evaluate instructional success and promote scientific literacy. Students who actively participate in their learning process define effective engagement (Kapotis & Kalkanis, 2016). Inquiry-based approaches help students to do so through cooperative and experiential practices. According to research, including hands-on experimentation–as emphasized by Kotsis (2024a)–improves understanding of scientific ideas and raises enthusiasm in STEM fields (Kotsis et al., 2023a, 2023b). Furthermore, creative assessment techniques–such as formative assessments during hands-on learning–helps teachers to better gauge conceptual knowledge and engagement levels (Albion & Spence, 2013). These tests not only highlight knowledge gaps but also guide curriculum changes to better-fit students' varied learning requirements, so producing a generation of scientifically literate people ready to meet the demands of the real world.

## FEEDBACK MECHANISMS FOR CONTINUOUS CURRICULUM IMPROVEMENT

Feedback systems in the inquiry-based science curricula help to ensure ongoing curricular development. These systems, grounded in reflective practices, help teachers evaluate how well curricular alignment with student learning outcomes and pedagogical approaches work. As emphasized by Athanatou (2023), schools can methodically examine comments from student assessments, classroom observations, and teacher reflections using data-driven decision-making frameworks to hone the curriculum iteratively. This iterative process improves the relevance of the curriculum to real-world problems including climate change–integrated into the scientific framework–and promotes teacher cooperation to exchange best practices and insights (Tsiouri et al., 2024). Furthermore, using IBL techniques calls for continuous professional growth for educators, so enabling flexible teaching plans sensitive to student needs (Stylos et al., 2023b). Therefore, maintaining and developing the quality of scientific education in main settings depends on strong feedback systems.

Usually piloted in Greece's experimental model schools (Kotsis & Tsiouri, 2024), new educational approaches are adopted. Thus, the new curriculum was tested for two years (2021-2023) in the country's experimental model primary schools by the teachers who engaged in pertinent training and worked with their developers or trainers. Through the evaluation diaries, teacher interviews, and anonymous questionnaires, the outcomes of the implementation (Kotsis et al., 2024) show rather positive results:

1. The teachers did not encounter any particular difficulties in the implementation of the P.S. as the proposed research methodology is familiar.
2. Students actively participate in the proposed activities and achieve the stated objectives.
3. Experimentation and the use of simple materials and self-made objects attract the interest of the students and improve the learning climate, while it was recorded that they also strengthen the participation of students with special needs.
4. The new modules are very interesting for students and teachers.
5. The use of embedded texts and digital material is particularly positive.
6. Simulations facilitate the interpretation and understanding of phenomena.
7. Working in groups with students in distinct roles enhanced the participation of all students.

## DISCUSSION

Future consequences for science education depend on Greece's new inquiry-based science curriculum to address geographical and socio-economic inequalities and scientific literacy among students. Emphasizing critical thinking, problem-solving, and real-world applications–including urgent concerns like digital literacy and climate change as well as pressing issues like digital literacy–this curriculum advocates a hands-on approach, stressing Studies show that present teaching methods might not fully equip teachers to enable IBL effectively. Thus improved teacher training is absolutely necessary (Stylos et al., 2022). Including digital tools–including artificial intelligence interfaces like ChatGPT–can help to personalize learning environments further and involve different students, so enhancing academic results (Kotsis, 2024a). Furthermore, cooperative networks between teachers all around Europe could offer insightful analysis and common best practices, so strengthening the educational system (Kotsis et al., 2023a). In the end, these multifarious approaches are essential for raising scientifically educated people ready to negotiate the complexity of contemporary society (Kotsis et al., 2023b).

The inquiry-based science curricula provide great advantages that improve student involvement and learning. By tying scientific ideas to practical uses, the curriculum develops critical thinking, problem-solving abilities, and a better knowledge of natural events, fostering scientific literacy necessary for the 21st century. As shown by including digital tools and multidisciplinary approaches, the curriculum's emphasis on hands-on experimentation lets students create hypotheses and participate in cooperative inquiry, thus fostering creativity and curiosity. Furthermore, the strategy guarantees inclusivity and fair chances for every student by accommodating several learning styles and abilities (Kotsis et al., 2024). Positive educator comments and higher student enthusiasm resulting from pilot implementations of the curriculum highlight its ability to produce informed and responsible citizens ready for upcoming scientific and beyond challenges (Tsiouri et al., 2024). The new curriculum marks a slow but steady movement toward a more relevant and interesting framework for science instruction.

Given the encouraging outcomes of the new inquiry-based Greek science curriculum for primary schools, it is imperative to advise more study and development to improve its application and potency. Particularly in terms of scientific literacy and critical thinking skills, future research should concentrate on longitudinal assessments to evaluate student outcomes over time since these competencies are essential for students' general academic success and capacity to negotiate an ever more complicated environment. Examining the effects of professional development programs for teachers will also be crucial since continuous support can greatly affect their pedagogical methods of IBL, enhancing the quality of instruction and student involvement in classrooms. Research should also look at including digital tools and technology into the curriculum, looking at how these resources might support student involvement and cooperative learning transforming the educational process to be more relevant in contemporary surroundings. Moreover, looking at several teaching approaches that fit IBL could provide insightful analysis of the best approaches for different student groups. Lastly, stressing the link between the curriculum and practical applications will enable scientific ideas to be more contextually relevant, so encouraging better knowledge among students and stimulating their desire to work in science-related domains. When taken holistically, these initiatives will eventually help build a stronger and more efficient framework for science education in Greece, ensuring that students possess the knowledge and abilities necessary for their future activities. Such a comprehensive strategy will help the students and improve the nation's educational scene.

## CONCLUSION

Using hands-on, experiential learning strategies, the new inquiry-based Greek science curriculum for primary schools signifies a substantial shift toward scientific literacy and student-centered learning. By aligning instruction with inquiry-based pedagogical models, the curriculum fosters critical thinking, creativity, and problem-solving skills essential for navigating 21st century challenges. The co-development with educators and the successful pilot deployment indicate that this change is both achievable and significant within the Greek educational framework.

To guarantee the sustainability and efficacy of this endeavor, educational policy must prioritize the creation of comprehensive professional development programs that furnish teachers with the theoretical and practical resources necessary for the efficient implementation of IBL. Furthermore, systems that facilitate teacher cooperation, mentoring, and knowledge exchange within and within school communities can enhance long-term capacity building. Institutional support should encompass the integration of formative assessment frameworks associated with the inquiry process, facilitating ongoing reflection and development for both students and educators. Moreover, strategic investment in educational resources, inclusive materials, and digital infrastructure, especially in marginalized regions, is crucial for fostering equitable access and ensuring implementation fidelity.

Subsequent investigations should examine the enduring effects of the curriculum on students' scientific reasoning, academic performance, and involvement in STEM disciplines. Longitudinal studies in various educational environments will be crucial for assessing the curriculum's systemic impact. Comparative foreign studies could contextualize the Greek experience within wider global trends, while teacher-led action research would enhance curriculum development through genuine classroom insights. These measures will jointly establish a resilient and flexible framework for scientific education change based on inquiry and inclusiveness.

**Author contributions:** All authors contributed equally to the conceptualization, methodology, investigation, writing—original draft preparation, writing—review and editing, and validation of this study. All authors have read and agreed to the published version of the manuscript. All authors have agreed with the results and conclusions.

**Funding:** No funding source is reported for this study.

**Ethical statement:** The authors stated that the study did not involve human participants, animals, or personal data requiring ethical approval. All authors confirm that the research was conducted in accordance with institutional, national, and international ethical standards.

**AI statement:** The authors used generative AI-based tools exclusively for language editing and grammar improvement. No AI tools were used for conceptualization, data analysis, or interpretation of results. The authors take full responsibility for the content of this manuscript.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

Alasadi, E. A., & Baiz, C. R. (2023). Generative AI in education and research: Opportunities, concerns, and solutions. *Journal of Chemical Education, 100*(8), 2965-2971. https://doi.org/10.1021/acs.jchemed.3c00323

Albion, P. R., & Spence, K. G. (2013). Primary connections in a provincial Queensland school system: Relationships to science teaching self-efficacy and practices. *International Journal of Environmental and Science Education, 8*(3), 501-520.

Asilevi, M.N., Kärkkäinen, S., Sormunen, K., & Havu-Nuutinen, S. (2024). A comparison of science learning skills in the teacher-centered approach and inquiry-based science fieldwork: Primary school students' perceptions. *International Journal of Education in Mathematics, Science, and Technology, 12*(1), 1-19. https://doi.org/10.46328/ijemst.3146

Athanatou, Maria (2023). Un plan de toma de decisiones basado en datos en función de las áreas de DigCompOrg en una escuela primaria en Grecia [A data driven decision making plan based on DigCompOrg areas for improvement in a primary school in Greece]. *Servicio de Publicaciones de la Universidad de Murcia*. https://core.ac.uk/download/588775782.pdf

Bondie, R. S., Dahnke, C., & Zusho, A. (2019). How does changing "one-size-fits-all" to differentiated instruction affect teaching? *Review of Research in Education, 43*(1), 336-362. https://doi.org/10.3102/0091732X18821130

Bruneau, O., Heering, P., Grapí, P., & de Vittori, T. (Eds.). (2012). *Innovative methods for science education: History of science, ICT and inquiry based science teaching*. Frank & Timme GmbH.

Chiu, H., & Duit, R. (2011). Globalization: Science education from an international perspective. *Journal of Research in Science Teaching, 48*(6), 553-566. https://doi.org/10.1002/tea.20427

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2021). *21st century skills development through inquiry-based learning from theory to practice*. Springer.

Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., . . ., & Wright, R. (2023). Opinion paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *International Journal of Information Management, 71*, Article 102642. https://doi.org/10.1016/j.ijinfomgt.2023.102642

Gikopoulou, O. (2017). The understanding of the model of microcosm in primary and secondary education. *International Journal of Digital Society, 8*(2), 1268-1277. https://doi.org/10.20533/ijds.2040.2570.2017.0156

Gikopoulou, O. (2019). I epistimonikí/ekpaideftikí méthodos me dierévnisi kai o epistimonikós trópos sképsis–Mia érevna [The scientific/educational method with investigation and the scientific way of thinking–A survey]. In *Proceedings of the 11th Panhellenic Conference on the Teaching of Natural Sciences and New Technologies in Education*.

Howitt, C., & Roberts, P. (2024). Inquiry science for young children. In C. Campbell, & C. Howitt (Eds.), *Science in early childhood* (pp. 89-103). Cambridge University Press. https://doi.org/10.1017/9781009339766.008

Kalkanis G. T. (2021). I epistimonikí-ekpaideftikí méthodos me dierévnisi kai kalés praktikés [The scientific-educational method with inquiry and good practices]. *Research on Science and Technology Education, 1*(1), 21-38. https://doi.org/10.12681/riste.27267

Kapotis, E., & Kalkanis, G. (2016). Einstein's elevator in class: A self-construction by students for the study of the equivalence principle. *The Physics Teacher, 54*(7), 404-407. https://doi.org/10.1119/1.4962774

Karagiannidis, C., Karamatsouki, A., Chorozidis, G. (2022). *Science education in Greece. In Science education in countries along the belt & road*. Springer. https://doi.org/10.1007/978-981-16-6955-2_24

Katsampoxaki-Hodgetts, K., Fouskaki, M., Siakavara, K., Moschochoritou, R., & Chaniotakis, N. (2015). Student and teacher perceptions of Inquiry based science education in secondary education in Greece. *American Journal of Educational Research, 3*(8), 968-976.

Kotsis, K. T. (2024a). Integrating ChatGPT into the inquiry-based science curriculum for primary education. *European Journal of Education and Pedagogy, 5*(6), 28-34. https://doi.org/10.24018/ejedu.2024.5.6.891

Kotsis, K. T. (2024b). Physics education in EU high schools: Knowledge, curriculum, and student understanding. *European Journal of Contemporary Education and E-Learning, 2*(4), 28-38. https://doi.org/10.59324/ejceel.2024.2(4).03

Kotsis, K. T. (2024c). The significance of experiments in inquiry-based science teaching. *European Journal of Education and Pedagogy, 5*(2), 86-92. https://doi.org/10.24018/ejedu.2024.5.2.815

Kotsis, K. T., & Tsiouri, E. (2024). The important role of the Greek experimental model schools for the new curricula in education. *European Journal of Contemporary Education and E-Learning, 2*(6), 44-60. https://doi.org/10.59324/ejceel.2024.2(6).03

Kotsis, K. T., Gikopoulou, O., Patrinopoulos, M., Kapotis, E., & Kalkanis, G. (2023a). Designing the new science curricula for primary education in Greece. In S.-G. Soulis, M. Liakopoulou, & A. Galani (Eds.), *Challenges and concerns in 21st century education* (pp. 101-116). Cambridge Scholars Publishing.

Kotsis, K. T., Gikopoulou, O., Patrinopoulos, M., Mitzithras, K., Apostolakis, E., & Kalkanis, G. (2024). To néo prógramma spoudón fysikón dimotikoú [The new elementary school physics curriculum]. In *Proceedings of the 13th Panhellenic Conference on Science Teaching and New Technologies in Education* (pp. 89-97). https://doi.org/10.12681/codiste.6811

Kotsis, K. T., Patrinopoulos, M., Gikopoulou, O., Mitzithras, K., Apostolakis, Kapotis, E., & Kalkanis, G. T., (2023b). Oi proklíseis gia sýnchrona analytiká prográmmata spoudón fysikón epistimón sto dimotikó scholeío [The challenges for modern science curricula in primary school]. In S. G. Soulis, & M. Liakopoulou (Eds.), *Proceedings of the International Scientific Conference "Education in the 21st Century: Contemporary Challenges and Concerns"* (pp. 1128-1143).

Koulaidis, V., & Dimopoulos, K. (2022). The pedagogic discourse of the Greek school science textbooks of primary and lower secondary level. *Pedagogical Trends in the Aegean, 4*(1), 3-9. https://doi.org/10.12681/revmata.31054

Mikhail, M., & Moresoli, C. (2024). Inquiry-based learning: A student-centric approach to engaging students in sustainability and life cycle thinking. In *Proceedings of the Canadian Engineering Education Association*. CEEA. https://doi.org/10.24908/pceea.2023.17104

Molla, M. (2020). Our planetarium story. In *Proceedings of the Europlanet Science Congress*. https://doi.org/10.5194/epsc2020-1099

Patrinopoulos, M., & Iatrou, P. (2019). Implementation of STEM tinkering approaches in primary school education in Greece. *Sino-US English Teaching, 16*(12), 510-516. https://doi.org/10.17265/1539-8072/2019.12.004

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47-61. https://doi.org/10.1016/j.edurev.2015.02.003

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education, 95*(2), 123-138. https://doi.org/10.1002/j.2168-9830.2006.tb00884.x

Qablan, A., Alkaabi, A. M., Aljanahi, M. H., & Almaamari, S. A. (2024). Inquiry-based learning: Encouraging exploration and curiosity in the classroom. In A. Abdallah, A. Alkaabi, & R. Al-Riyami (Eds.), *Cutting-edge innovations in teaching, leadership, technology, and assessment* (pp. 1-12). IGI Global Scientific Publishing. https://doi.org/10.4018/979-8-3693-0880-6.ch001

Sam, R. (2024). Systematic review of inquiry-based learning: Assessing impact and best practices in education. *F1000Research, 13*, Article 1045. https://doi.org/10.12688/f1000research.155367.1

Sasanti, W., Hamtasin, C., & Thongsuk, T. (2024). The effectiveness of inquiry-based learning to improve the analytical thinking skills of sixth-grade elementary school students. *Anatolian Journal of Education, 9*(1), 37-56. https://doi.org/10.29333/aje.2024.913a

Savvidou, S., Konteos, G., Papaevangelou, O., Syndoukas, D., & Kalogiannidis, S. (2024). The role of information technology in managing the human resource development of educators in inclusion-based primary schools in Greece. *International Journal of Education and Practice, 12*(3), 632-653. https://doi.org/10.18488/61.v12i3.3745

Sotiriou, S. A., & Bogner, F. X. (2015). A 2200-year old inquiry-based, hands-on experiment in today's science classrooms. *World Journal of Education, 5*(2), 52-62. https://doi.org/10.5430/wje.v5n2p52

Spyrtou, A., Lavonen, J., Zoupidis, A., Loukomies, A., Pnevmatikos, D., Juuti, K., & Kariotoglou, P. (2018). Transferring a teaching learning sequence between two different educational contexts: The case of Greece and Finland. *International Journal of Science and Mathematics Education, 16*, 443-463. https://doi.org/10.1007/s10763-016-9786-y

Stefanidou, C., & Mandrikas, A. (2023). Science teaching at a distance in Greece: Students' views. *Education Sciences, 13*(4), Article 395. https://doi.org/10.3390/educsci13040395

Stefanidou, C., Mandrikas, A., Kyriakou, K., Stavrou, I., Boikos, I., & Skordoulis, C. (2024). Primary students' views toward STEM education in Greece. *Science Education International, 35*(2), 85-91. https://doi.org/10.33828/sei.v35.i2.2

Stylos, G., Christonasis, A., & Kotsis, K. T., (2023a). Pre-service primary teachers' views about scientific inquiry. *International Journal of Studies in Education and Science, 4*(2), 100-112. https://doi.org/10.46328/ijres.66

Stylos, G., Kamtsios, S., & Kotsis, K. T. (2022). Assessment of Greek pre-service primary teachers' efficacy beliefs in physics teaching. *Journal of Science Teacher Education, 34*(1), 44-62. https://doi.org/10.1080/1046560X.2021.2023959

Stylos, G., Siarka, O., & Kotsis, K. T. (2023b). Assessing Greek pre-service primary teachers' scientific literacy. *European Journal of Science and Mathematics Education, 11*(2), 271-282. https://doi.org/10.30935/scimath/12637

Trna, J., & Trnová, E. (2012). Inquiry-based science education in science and technology education as a connectivist method. In *Proceedings of the 8th International Conference on Education* (pp. 831-837).

Tsiouri, E., Tsichouridis, X., & Kotsis, K. T. (2024). Exploring the science curricula of 11-12 years old students in European countries. *Proceedings of the 9th International Conference on the Promotion of Educational Innovation* (pp. 1020-1028).

Tsoumanis, K. G., Stylos, G., & Kotsis, K. T. (2024). Pre-service teachers' and primary students' motivations and beliefs towards science. *Interdisciplinary Journal of Environmental and Science Education, 20*(3), Article e2408. https://doi.org/10.29333/ijese/14576

Tsoumanis, K., Stylos G, & Kotsis K. T. (2023). A comparative study between Greek pre-service teachers and primary school students' scientific literacy levels. *Science Education International, 34*(2), 121-131. https://doi.org/10.33828/sei.v34.i2.6

Uzel, L., & Bilici, S. C. (2022). Engineering design-based activities: Investigation of middle school students' problem solving and design skills. *Journal of Turkish Science Education, 19*(1), 163-179. https://doi.org/10.36681/tused.2022.116

Wen, Y., Wu, L., He, S., Ng, N. H. E., Teo, B. C., Looi, C. K., & Cai, Y. (2023). Integrating augmented reality into inquiry-based learning approach in primary science classrooms. *Educational Technology Research and Development, 71*(4), 1631-1651. https://doi.org/10.1007/s11423-023-10235-y