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Research Article

Elementary Science Learning at the Intersection of Educational Philosophies: Rethinking Pedagogical Paradigms and Practices

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ABSTRACT

Purpose of the study: This study aims to map how the educational philosophies of constructivism, progressivism, pragmatism, and humanism shape pedagogical paradigms and teaching practices in elementary science education. It also seeks to develop an integrative conceptual framework that supports meaningful and student-centered science learning in 21st-century primary education.

Methodology: This study employed a qualitative Systematic Literature Review (SLR) following PRISMA guidelines. Articles were retrieved from the Scopus and Web of Science (WoS) databases covering the 2015–2025 period. Ten peer-reviewed articles were selected after identification, screening, and eligibility stages. Data were analyzed using thematic analysis and narrative synthesis supported by a structured data extraction instrument.

Main Findings: Constructivism promotes active knowledge construction through inquiry-based approaches such as CIBSE. Progressivism emphasizes student-centered and adaptive learning environments supported by digital technology. Pragmatism integrates cultural and empirical knowledge through experiential reflection, while humanism supports holistic development by addressing affective and social dimensions. Effective science learning emerges from the interaction of these traditions rather than reliance on a single paradigm.

Novelty/Originality of this study: The study synthesizes four philosophical traditions into a unified Integrative Philosophical Framework, which has rarely been explored in previous SLR studies. The findings encourage educators to adopt a reflective multi-philosophical approach. However, the review is limited by its small sample size and reliance on predominantly English-language sources. Future research should involve longitudinal mixed-methods studies across a broader range of educational contexts.

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1. INTRODUCTION

Natural Science learning in elementary schools plays a strategic role in developing scientific literacy, critical thinking skills, and scientific attitudes in students from an early age. Science learning emphasizes not only conceptual mastery but also scientific processes involving observation, reasoning, and contextual problem-solving [1]-[3]. Therefore, science learning in elementary schools requires a meaningful pedagogical approach oriented toward students' learning experiences.

In practice, elementary school science instruction still tends to be solely focused on delivering material and achieving cognitive outcomes. The learning process often takes place in an expository manner, dominated by the teacher, while inquiry and experimental activities are limited [4], [5]. This situation indicates a fundamental problem in science instruction, which is not only technical but also related to the philosophical paradigm underlying educational practice.

Educational philosophy serves as a conceptual basis for determining educational goals, views on the nature of knowledge, and the relationship between teachers and students. Each learning approach implicitly reflects certain philosophical assumptions, whether consciously or unconsciously held by educational practitioners [6], [7]. In the context of elementary science learning, educational philosophy provides a framework that influences curriculum design, learning strategies, and evaluation systems.

Essentialism views education as a process of transmitting core knowledge deemed important and objective. In elementary science instruction, this paradigm is reflected in the emphasis on mastering basic concepts, the use of textbooks as the primary source, and standardized test-based evaluation [8]. While essentialism contributes to maintaining academic structure and standards, this approach is often criticized for not allowing enough space for active learning experiences for students. In contrast, progressivism and pragmatism place experiential learning at the center of the educational process. Science learning is seen as a means to help students understand and solve real-life problems [9]. This approach encourages the use of problem-based learning methods, projects, and simple experiments relevant to the context of elementary school students.

The development of modern learning theories demonstrates the dominance of the constructivist paradigm in science learning. Constructivism emphasizes that students actively construct knowledge through interactions with the environment and learning experiences [10]. In elementary science learning, this paradigm is realized through inquiry learning, discovery learning, and a scientific approach that demands active student involvement. Furthermore, humanistic educational philosophy emphasizes the importance of holistic student development, encompassing cognitive, affective, and social aspects. Science learning from a humanistic perspective aims not only to develop scientific understanding but also to foster curiosity, environmental awareness, and social responsibility [11]. This paradigm is increasingly relevant in the context of 21st-century education, which demands a balance between academic competence and character.

Although conceptually, constructivist and humanistic paradigms have been widely recommended, various studies have shown a gap between the philosophical paradigms adopted in education policy and the practice of science learning in the classroom. Teachers often face limited philosophical understanding, administrative demands, and inadequate learning resources, which impact the implementation of science learning in a less-than-optimal manner [12]. These challenges are not limited to philosophical misalignment alone. Empirical studies confirm that science learning environments lacking contextual grounding and active inquiry consistently produce lower student engagement and weaker scientific competencies [13], [14]. Furthermore, the integration of innovative pedagogical approaches whether through cultural contextualization or interdisciplinary frameworks has demonstrated measurable improvements in students' scientific literacy and conceptual understanding when learning is deliberately designed around students' real-world experiences [15], [16]. Similarly, the persistent dominance of analytical over creative pedagogical tasks in science education signals a broader pattern of philosophical underutilization, wherein learning practices remain narrowly focused on cognitive outcomes rather than holistic student development [17], [18].

Despite the growing body of literature on educational philosophy and science pedagogy, no systematic review has comprehensively examined how multiple philosophical schools simultaneously shape elementary science teaching practices, particularly within developing-country contexts where policy-practice misalignment remains a persistent and underexplored challenge. In the Indonesian context, the Independent Curriculum policy emphasizes the importance of student-centered learning, strengthening critical thinking skills, and contextual learning. This policy is philosophically aligned with constructivism and humanism [19], [20]. However, without a strong philosophical understanding, the policy's implementation has the potential to be procedural and may not fully transform science teaching practices in elementary schools.

Existing scholarship on educational philosophy and science pedagogy has grown considerably over the past decade; however, a critical gap remains in the literature. Most prior studies examine philosophical paradigms in isolation, focusing exclusively on a single school of thought such as constructivism, without exploring how multiple philosophical traditions simultaneously interact and shape science teaching practices at the elementary level. Furthermore, although the misalignment between policy-mandated pedagogical frameworks and actual classroom implementation has been widely acknowledged, it has rarely been investigated through a unified philosophical lens that integrates constructivism, progressivism, pragmatism, and humanism as a coherent analytical framework. This gap is particularly pronounced in the context of developing countries, where structural constraints, limited teacher professional development, and resource inequities further complicate the translation of philosophical ideals into meaningful classroom practice. Without a comprehensive synthesis that maps how these philosophical paradigms collectively influence elementary science learning, teachers and policymakers lack a theoretically grounded reference for designing pedagogical practices that are simultaneously academically rigorous, contextually responsive, and humanistically oriented.

To address the aforementioned gaps, this study is guided by the following research questions: (1) What educational philosophies underlie the pedagogical paradigms reflected in elementary science learning research from 2015 to 2025? (2) How are these philosophical paradigms manifested in science teaching strategies, curriculum design, and learning evaluation practices at the elementary school level? (3) What conceptual framework can be constructed from the intersection of multiple educational philosophies to inform more effective, meaningful, and humanistic science learning in elementary education?. Aligned with the research questions outlined above, this study pursues three interrelated objectives. First, it seeks to systematically map and analyze the educational philosophies that underpin pedagogical paradigms in elementary science learning as documented in peer-reviewed literature. Second, it aims to examine how these philosophical orientations are operationalized in actual teaching practices, curriculum frameworks, and assessment approaches within elementary science education. Third, this study endeavors to construct an integrative conceptual synthesis that bridges philosophical theory and pedagogical practice, thereby offering a theoretically grounded and practically applicable framework for teachers, curriculum developers, and educational policymakers committed to advancing the quality of elementary science education in the 21st century.

2. RESEARCH METHOD

This investigation adopts a qualitative research orientation, operationalized through a Systematic Literature Review (SLR) methodology designed to systematically identify, critically appraise, and synthesize empirical and theoretical findings pertaining to the influence of educational philosophy on science learning in elementary school contexts. The deliberate selection of a qualitative design over quantitative or mixed-method alternatives reflects the study's primary epistemological objective: to construct conceptual understanding and map theoretical landscapes rather than to quantify variables or validate hypotheses [21]. Within the domain of educational inquiry, this methodological orientation is particularly suited to investigations that aim to chart philosophical paradigms, identify pedagogical tendencies, and illuminate persistent research gaps [22].

The SLR framework employed in this study adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, which establishes rigorous standards for transparency and reproducibility across each stage of literature retrieval, appraisal, and synthesis [23]. The unit of analysis comprises peer-reviewed journal articles and academic books systematically retrieved from two internationally recognized scientific databases: Scopus and Web of Science (WoS). These databases were prioritized due to their stringent indexing standards, comprehensive coverage of high-impact educational and scientific journals, and capacity to ensure the scholarly credibility of the retrieved literature. Scopus was selected for its extensive multidisciplinary coverage spanning social sciences, education, and applied sciences, while WoS was chosen for its depth of indexing in peer-reviewed scientific and educational research alongside robust citation analysis capabilities. The application of PRISMA guidelines throughout this process functioned to minimize systematic selection bias and to strengthen the validity and reliability of the synthesized findings [24].

The literature search was conducted by deploying Boolean-structured keyword strings in both English and Indonesian across the selected databases. The search terms applied included: “philosophy of education,” “science learning in elementary school,” “constructivism in science education,” “elementary school science learning,” and “philosophy of education” AND “pedagogical paradigms.” These keyword combinations were applied across title, abstract, and keyword fields within Scopus and WoS to maximize retrieval coverage. The temporal boundary of the search was restricted to publications issued between 2015 and 2025, ensuring that the corpus reflects contemporary educational discourse and recent pedagogical developments [25].

To preserve thematic coherence and scholarly rigor, explicit inclusion and exclusion criteria were established prior to the screening process. The inclusion criteria encompassed: (1) journal articles or academic books addressing the philosophy of science education or related pedagogical paradigms; (2) studies situated within basic education contexts or demonstrating direct relevance to elementary schooling; (3) publications issued within the 2015–2025 timeframe; and (4) works that had undergone formal peer-review processes. Conversely, the exclusion criteria eliminated: (1) non-scientific or opinion-based publications lacking empirical or theoretical grounding; (2) research exclusively focused on secondary or tertiary education without transferable implications for elementary science learning; and (3) publications presenting insufficient or opaque methodological information. The establishment of these criteria is methodologically essential to ensure that the analytical corpus maintains consistent relevance and scholarly quality throughout the synthesis process [26],[27].

The primary data extraction instrument employed in this study was a structured coding form adapted from the systematic evidence synthesis framework developed by Gough, Thomas, and Oliver [28], recognized as a standard tool in educational research synthesis. This extraction instrument was designed to systematically capture essential dimensions of each selected article, encompassing bibliographic identification, research focus, philosophical orientation, methodological design, principal findings, and relevance to the guiding research questions. To provide a clear and replicable account of the extraction procedure, the instrument grid is presented in Table 1.

Table 1. Data Extraction Instrument Grid

No	Extraction Component	Description
1	Author(s) & Year	Full author names and publication year
2	Article Title	Complete title of the article
3	Database Source	Scopus / Web of Science (WoS)
4	Research Focus	Main topic and research objective
5	Philosophical Orientation	Educational philosophy addressed
6	Research Method	Design and methodology used
7	Key Findings	Principal results and conclusions
8	Relevance to RQ	Direct connection to research questions

As delineated in Table 1, the extraction grid was applied uniformly across all ten selected articles to ensure consistency and minimize interpretive divergence between coders. To further strengthen the instrument's reliability, two independent coders reviewed a stratified subset of the articles. The resulting inter-rater reliability coefficient (Cohen's Kappa) yielded a value of $\kappa = 0.82$, signifying strong inter-coder agreement and confirming the instrument's suitability for qualitative coding within systematic educational research contexts.

To maintain the focus and quality of the literature analyzed, the article selection procedure was executed across four sequential stages as prescribed by the PRISMA framework: identification, screening, eligibility determination, and final inclusion. In the identification stage, all articles retrieved from the databases were compiled and duplicate records were systematically eliminated. The screening stage involved a thorough review of titles and abstracts to assess thematic suitability relative to the research focus. Subsequently, the eligibility stage required full-text reading of candidate articles to verify conformity with the predefined inclusion and exclusion criteria. Articles satisfying all requirements were advanced to the final inclusion stage for comprehensive in-depth analysis. This multi-stage procedure enabled researchers to screen the literature in a systematic and objective manner [27]. To provide a transparent account of this progressive selection process, the complete PRISMA-based article selection flow is presented in Table 2.

Table 2. Article Selection Flow

PRISMA Level	Number of Articles	Information
Identification	312	Initial articles retrieved from Scopus and Web of Science using keyword strings: “philosophy of education” AND “science learning elementary school” OR “constructivism in science education” AND “elementary school science learning”
Screening	198	Duplicate records removed; titles and abstracts reviewed for thematic suitability and relevance to the research focus
Eligibility	67	Full-text articles examined against predefined inclusion and exclusion criteria (2015–2025, elementary school relevance, peer-reviewed, adequate methodology)
Included (Selected)	10	Articles that satisfied all eligibility requirements and were incorporated into the final in-depth thematic synthesis

As illustrated in Table 2, the selection process commenced with 312 initially identified articles sourced from Scopus and WoS, progressively refined through systematic screening and eligibility assessment, ultimately yielding a final corpus of ten articles. This sample size is considered methodologically appropriate for a qualitative synthesis given the high specificity of the research focus and the rigorous multi-stage eligibility criteria applied throughout [20]. The ten selected articles collectively provide sufficient conceptual breadth and philosophical diversity to address the study’s central research questions regarding the intersection of educational philosophy and pedagogical practice in elementary science learning.

Data analysis was subsequently conducted through thematic analysis following the six-phase framework established by Braun and Clarke, contextually adapted to accommodate the demands of systematic literature synthesis. During the initial phase, researchers engaged in immersive reading of all selected articles to develop analytical familiarity and document preliminary impressions. The second phase entailed the systematic generation of initial codes by identifying and labeling meaningful informational units pertaining to educational philosophy and associated pedagogical practices. In the third phase, generated codes were aggregated into candidate themes representing overarching philosophical orientations, specifically constructivism, progressivism, pragmatism, and humanism. The fourth phase involved iterative review and refinement of these themes to establish internal coherence and maintain clear conceptual boundaries across categories. The fifth phase was dedicated to precisely defining and designating each theme, grounded simultaneously in the empirical evidence extracted from the articles and in established theoretical frameworks within educational philosophy. In the concluding sixth phase, synthesized findings were rendered through narrative synthesis, articulating the relationships between philosophical paradigms and their concrete manifestations in elementary science teaching and learning practices. An audit trail was sustained throughout the entire analytical process to reinforce the transparency, credibility, and trustworthiness of the qualitative outcomes. This commitment to methodological rigor ensures that the findings emerging from this SLR offer a substantive and dependable contribution to the scholarly understanding of educational philosophy's role in shaping elementary science education.

3. RESULTS AND DISCUSSION

The results of this study are synthesized based on a comprehensive analysis of ten selected articles examining the intersection of educational philosophy and pedagogical paradigms in science learning contexts. The extraction and synthesis of findings are organized according to the dominant educational philosophy and pedagogical orientation reflected in each reviewed work.

Table 3. Article Data Extraction Results

No	Authors	Article Title	Study Focus	Philosophy	Key Findings
1	Cappiali (2023) [29]	A Paradigm Shift for a More Inclusive, Equal, and Just Academia? Towards a Transformative-Emancipatory Pedagogy	Proposing a transformative-emancipatory pedagogical framework to address inclusivity and equity in diverse academic settings	Humanism / Transformative Pedagogy	Argues for replacing teacher-centered and student-centered models with transformative pedagogy that encompasses cognitive, practical, and affective dimensions while integrating intersectional and decolonial approaches
2	Kotsis (2025) [30]	Artificial Intelligence as a Catalyst for Changes in University-Level Science Education	Theoretical exploration of AI's transformative role across cognition, epistemology, pedagogy, institutional design, and ethics in science education	Constructivism / Progressivism	Intelligent systems such as adaptive tutors and generative models can support inquiry-based, student-centered environments aligned with scientific practices, though challenges around equity and algorithmic bias persist
3	Bakar (2021) [31]	Investigating the Dynamics of Contemporary Pedagogical Approaches in Higher Education through Innovations, Challenges, and Paradigm Shifts	Comprehensive analysis of contemporary pedagogical paradigms in higher education from traditional to student-centered approaches	Progressivism	Highlights the evolution from didactic instruction toward active, experiential, and technology-integrated learning, emphasizing student agency and adaptive curriculum design
4	Saleh et al. (2025) [32]	Paradigm of Integration of Islamic and Scientific Knowledge: Philosophical Reflection on Islamic	Conceptualizing the integration of Islamic and scientific knowledge within the elementary education context	Pragmatism / Constructivism	Proposes a six-step paradigm integrating Islamic epistemology and scientific knowledge through curriculum alignment,

No	Authors	Article Title	Study Focus	Philosophy	Key Findings
		Basic Education			contextual learning design, and reflective innovation
5	Tomczyk (2021) [33]	Research Trends in Media Pedagogy: Between the Paradigm of Risk and the Paradigm of Opportunity	Exploring dual paradigms in media pedagogy regarding ICT integration in education	Progressivism / Pragmatism	Identifies the tension between opportunity and risk paradigms in ICT-based learning, urging balanced research perspectives that avoid methodological anchoring to a single trend
6	Morris (2025) [34]	Rethinking Science Education Practices: Shifting from Investigation-Centric to Comprehensive Inquiry-Based Instruction	Introducing the CIBSE Framework to broaden inquiry-based science instruction beyond hands-on investigation	Constructivism	The CIBSE Framework, grounded in constructivism, cognitivism, and sociocultural theory, promotes student reasoning, explanation, and scaffolded inquiry to deepen conceptual understanding
7	Shuk and Leung (2022) [35]	Shifting the Teaching Beliefs of Preservice Science Teachers About Socioscientific Issues in a Teacher Education Course	Investigating belief transformation among preservice science teachers regarding socioscientific issues (SSI) instruction	Pragmatism / Constructivism	Preservice teachers' beliefs shifted from exclusion to embrace of SSI teaching through experiential reflection and structured pedagogical exposure over 12 weeks
8	Amna Saleem et al. (2021) [36]	Social Constructivism: A New Paradigm in Teaching and Learning Environment	Examining social constructivism as a learning theory and its pedagogical implications for collaborative learning environments	Constructivism	Social constructivism promotes collaborative, student-centered learning where knowledge is co-constructed through interaction, language, and shared inquiry rather than passive reception
9	Sebsibe et al. (2023) [37]	Swaying Pedagogy: A New Paradigm for Mathematics Teachers Education in Ethiopia	Developing a swaying pedagogy curriculum framework for postgraduate mathematics teacher education	Progressivism / Humanism	Proposes an adaptive pedagogical curriculum to overcome content and pedagogical knowledge gaps among mathematics teachers, supporting 21st-century competency development
10	Bell (2021) [38]	Underpinning the Entrepreneurship Educator's Toolkit: Conceptualising the Influence of Educational	Linking educational philosophy behaviourism, cognitivism, constructivism, and humanism to	Constructivism / Humanism	Demonstrates that aligning educational philosophy with teaching intentions enhances pedagogical coherence and learner

No	Authors	Article Title	Study Focus	Philosophy	Key Findings
		Philosophies and Theory	entrepreneurship education pedagogy		outcomes across diverse educational contexts

3.1 Constructivism in Science Learning and Inquiry-Based Practices

Constructivism emerges as the most extensively represented philosophical orientation across the reviewed literature, particularly in studies concerned with inquiry-based learning and collaborative knowledge construction in science education. Introduces the *Comprehensive Inquiry-Based Science Education* (CIBSE) Framework, which synthesizes constructivism, cognitivism, and sociocultural learning theory to address the limitations of investigation-centric science instruction. This framework argues that inquiry-based learning, as mandated by the *Next Generation Science Standards* (NGSS), has frequently been misinterpreted in practice, resulting in an overemphasis on hands-on activities at the expense of deeper conceptual reasoning and student explanation. By repositioning inquiry as a cognitively rich and scaffolded process, the CIBSE Framework advocates for science education that nurtures both scientific literacy and critical thinking competencies [34].

Complementing this perspective, elaborates on social constructivism as a transformative paradigm for the teaching and learning environment. According to this view, knowledge is never universal or pre-given, but is socially negotiated through language, dialogue, and collaborative interaction. The implications for science classrooms are significant: teachers are repositioned as facilitators rather than transmitters of knowledge, while students co-construct understanding through group problem-solving, discussion, and active inquiry. This collaborative architecture of knowledge-building reflects the epistemological core of constructivism, wherein learners build internal representations of reality through meaningful engagement with their social and material environment [31].

Furthermore, extends the constructivist framework into the digital era by examining how artificial intelligence can support inquiry-based, student-centered learning environments in science education. Adaptive tutoring systems, learning analytics platforms, and generative AI models are identified as tools that can facilitate personalized knowledge construction aligned with authentic scientific practices. That the integration of such technologies raises critical issues pertaining to teacher autonomy [35], algorithmic bias, and institutional equity—dimensions that constructivist pedagogy must address if technology is to serve genuine epistemic empowerment rather than merely simulate engagement. Demonstrates that constructivist principles underpin the transformation of preservice science teachers' pedagogical beliefs when exposed to *socioscientific issues* (SSI) instruction. Through structured reflection and experiential engagement over a 12-week teacher education course, participants progressively shifted from viewing SSI as extraneous to embracing it as an essential dimension of science teaching, indicating that constructivist learning processes operate not only among students but also within professional teacher development.

Constructivism underpins the view that knowledge is actively built by learners through engagement, reflection, and collaboration rather than passively acquired from teachers. Within the context of elementary science learning, this philosophy aligns closely with the cognitive developmental characteristics of young learners, who learn best through direct interaction with their environment and social dialogue. Findings from the reviewed Scopus and Web of Science studies confirm that constructivist-oriented instructional designs foster deeper conceptual understanding, curiosity, and sustained engagement in scientific inquiry [39]. [34], emphasizes that the Comprehensive Inquiry-Based Science Education (CIBSE) framework effectively integrates constructivist, cognitivist, and sociocultural perspectives, demonstrating that scientific reasoning should move beyond experimentation to emphasize sense-making, metacognition, and explanatory discourse. This approach ensures that inquiry-based learning in elementary education develops analytical reasoning and scientific literacy through guided exploration and reflection rather than rote experimentation. Highlight social constructivism as foundational to creating participatory learning environments, where students co-develop knowledge through peer dialogue and teacher-guided interactions. Collaborative learning structures within this framework enable learners to articulate ideas, challenge alternative explanations, and co-construct understanding of scientific phenomena, key indicators of conceptual change and scientific reasoning.

The integration of constructivism with emerging technologies has become increasingly evident in recent research. Shows how AI-assisted tools such as adaptive tutoring systems and generative learning platforms can support constructivist pedagogy by offering personalized inquiry experiences [40]. Digital technologies enable elementary students to simulate phenomena such as planetary motion or ecological systems, previously inaccessible through traditional experiments. However, researchers caution that technology must not replace cognitive engagement but rather function as scaffolding for reflective exploration and inquiry [41].

Another critical dimension of constructivism lies in differentiated learning and scaffolding [38], ensuring that instruction meets diverse learner needs. Studies underscore that when teachers apply scaffolding techniques, gradually transferring responsibility to learners while providing supportive questioning and feedback, students become autonomous constructors of knowledge [42]. Moreover, constructivism informs assessment practices; rather than relying solely on standardized tests, performance-based assessments and portfolio tasks more accurately capture students' inquiry processes and conceptual growth. These reflective and process-oriented evaluations embody constructivism's emphasis on learning as a dynamic, iterative process [35] Overall, constructivism in elementary science education advances a transformative vision in which learning is active, dialogic, and authentic. It redefines the teacher's role as a facilitator who orchestrates knowledge-building experiences and cultivates reflective learners capable of scientific reasoning.

3.2 Progressivism and Student-Centered Learning Environments

Progressivist orientations are prominently reflected in studies emphasizing the transformation of pedagogical structures from teacher-directed to student-driven models. Provides a panoramic analysis of contemporary pedagogical evolution in higher education, tracing the historical and philosophical trajectory from conventional didactic instruction toward active learning, experiential learning, flipped classrooms, and project-based learning. This shift is characterized not merely as a methodological preference but as a philosophical reorientation that positions students as active agents in their own educational journey. The integration of technology within this paradigm has catalyzed greater accessibility and personalization, though also foregrounds challenges related to equitable technology access and the need for responsive faculty development [33].

Contributes a nuanced analysis of progressivist tendencies in media pedagogy, identifying two competing research paradigms: the opportunity paradigm, which foregrounds the educational possibilities of ICT, and the risk paradigm, which highlights potential harms arising from digital immersion in schooling. The progressivist spirit is evident in the opportunity paradigm's endorsement of technology as a vehicle for student empowerment, creative engagement, and real-world knowledge construction. That research in this domain avoid methodological reductionism by anchoring investigations exclusively to one paradigmatic lens, advocating instead for integrative approaches that capture the full complexity of ICT's role in contemporary science and general education [36].

In the context of teacher education, demonstrates progressivist commitments in their proposal of a swaying pedagogy curriculum for postgraduate mathematics teacher education in Ethiopia. The study reveals that students' deteriorating achievement in mathematics is substantially linked to teachers' insufficient exposure to contemporary pedagogical advancements and persistent content knowledge gaps. The swaying pedagogy framework, by emphasizing adaptive, context-responsive instructional design and ongoing professional learning, reflects the progressivist conviction that educational systems must continuously evolve to remain relevant to learners' real and changing needs [36].

Progressivism situates science learning as an experiential and evolving process deeply connected to students' everyday lives. This philosophical orientation emphasizes contextual problem-solving, interdisciplinary integration, and continuous adaptation of pedagogy to students' developmental needs [35] . Within elementary science classrooms, progressivism manifests through active participation and discovery-based approaches that empower learners as co-investigators of the natural world [43]. Outlines the intellectual trajectory of progressivism as a movement away from rigid, transmission-based education toward a learner-centered and experience-driven paradigm. Within science education, this manifests in hands-on exploration, project work, and reflective inquiry that cultivate intrinsic motivation and intellectual curiosity [44]. Progressivist practices, such as Project-Based Learning (PBL) and experiential inquiry frameworks, transform science from abstract content into a practical and meaningful tool for investigating real phenomena [37].

Extends this principle through media and digital pedagogy, arguing that technology-rich science learning environments can catalyze engagement and personalized understanding when guided by progressivist principles. The "opportunity paradigm" encourages students to explore technology as a scientific instrument that nurtures creativity, experimentation, and knowledge construction [45]. However, calls for balanced implementation to avoid narrowing inquiry to a single methodological trend. His findings underline that progressivism's strength lies in flexibility, the willingness to integrate diverse strategies in service of authentic understanding. Also contribute to this discourse through their "swaying pedagogy," which reflects progressivist ideals of adaptability and responsiveness. Applied to mathematics and science education, swaying pedagogy emphasizes iterative learning through feedback, collaborative exploration, and contextualized instruction [46]. For elementary students, this translates into science curricula that nurture cognitive and emotional growth simultaneously, encouraging learners to explore real-life issues such as environmental sustainability and health through guided inquiry. Within elementary education settings indexed in Scopus and Web of Science, empirical studies consistently indicate that progressivist science instruction heightens engagement, strengthens conceptual retention, and cultivates scientific identity. By embedding science within meaningful contexts, environmental stewardship, everyday observations, or problem-solving activities, students internalize knowledge as part of lived experience. In this regard, progressivism serves not only as pedagogy but also as a philosophical affirmation that learning must remain relevant to the learners' world.

3.3 Pragmatism and Knowledge Grounded in Real-World Experience

Pragmatist philosophy is represented most clearly in studies that foreground the contextual applicability of knowledge and the role of experiential engagement in generating meaningful learning. Saleh et al. presents a compelling case for pragmatically oriented curriculum integration within Islamic elementary education, proposing a six-step paradigm that bridges Islamic epistemology and empirical scientific knowledge [32]. This integration is enacted through curriculum alignment, the identification of conceptual intersections between Islamic and scientific disciplines, reflective learning design, and continuous innovation each of which reflects the pragmatist principle that knowledge acquires its validity through practical application and contextual relevance [35]. The model positions elementary science learning not as an abstract cognitive exercise but as a meaningful encounter between lived values, cultural context, and empirical inquiry.

Shuk and Leung similarly reflects pragmatist assumptions in examining how preservice teachers come to embrace socioscientific issues as legitimate content within science education [35]. The pedagogical transformation observed in participants was not driven by theoretical instruction alone, but by direct experiential engagement with SSI scenarios from both learner and teacher perspectives, a methodological design that operationalizes the pragmatist claim that beliefs are reshaped through purposeful, reflective action in real or simulated practice contexts [35]. This alignment between philosophical conviction and instructional design underscores pragmatism's enduring relevance to science teacher education.

Pragmatism contributes a distinct epistemological perspective to elementary science education, framing knowledge as an evolving construct validated through experience and practical application. Within this philosophical standpoint, learning becomes a reflective process in which understanding gains meaning through experimentation, action, and problem resolution [33]. Demonstrate how pragmatism bridges theoretical learning and lived experience through the integration of indigenous, religious, and empirical knowledge frameworks. Their study emphasizes that science learning should not be dissociated from cultural or spiritual contexts; rather, it must harmonize abstract reasoning with practical, context-based innovation. Applied to elementary learning, this paradigm demonstrates that children comprehend science more meaningfully when they see its applicability within their daily experiences. Simple investigations, observing plant growth or analyzing local weather become vehicles for cultivating critical reflection and contextual reasoning.

Similarly supports this pragmatist orientation, showing that preservice teachers’ engagement with socioscientific issues transformed their pedagogical beliefs through experiential reflection. This finding reinforces the pragmatist assertion that knowledge is consolidated through action, and belief shifts occur via practice-based encounters rather than theoretical exposition alone [34]. Transposed to the elementary classroom, pragmatism inspires instructional approaches such as Problem-Based Learning (PBL) and Experiential Learning Cycles, where students encounter problems, hypothesize solutions, test outcomes, and reflect on consequences. The pragmatist foundation in elementary science emphasizes adaptability: scientific concepts must be continuously reconstructed as students test and revise understandings through new experiences. Consequently, teachers assume the role of guides who contextualize science within students’ immediate social, cultural, and environmental settings. By rooting learning in lived contexts, community gardening, environmental conservation, or health practices, students internalize inquiry as a means of engaging with and improving their world [29]. Pragmatism thus ensures that science education retains its practical vitality and relevance, cultivating thinkers who view knowledge as a transformative, applied force rather than inert information.

3.4 Humanism and the Development of Individual and Collective Potential

Humanistic philosophy is articulated in studies that center the dignity, autonomy, and holistic development of learners and increasingly, the structural conditions required to realize these aims. [29] advances a transformative-emancipatory pedagogy as a response to the perceived insufficiency of both teacher-centered and student-centered models in addressing power asymmetries within diverse academic contexts. Drawing on intersectional and decolonial frameworks, this approach challenges entrenched hierarchies in the classroom and foregrounds students’ cognitive, practical, and affective dimensions as equally legitimate sites of pedagogical engagement. The humanistic foundation is evident in its insistence that education must serve not only intellectual growth but also students’ individual and collective emancipatory goals [39].

Bell complements this perspective by demonstrating how humanist educational philosophy, alongside behaviourism, cognitivism, and constructivism, can be systematically integrated into the design of entrepreneurship education pedagogy [38]. The argument is made that educators' philosophical orientations whether consciously held or implicitly enacted fundamentally shape their instructional choices, assessment strategies, and relationships with learners. Humanism in this context emphasizes learner empowerment, intrinsic motivation, and the cultivation of personal meaning as central outcomes of effective teaching [38]. This resonates with the broader claim that science education, when informed by humanist values, is better positioned to nurture not only knowledge acquisition but also students’ sense of agency, identity, and well-being.

Humanism in education focuses on the holistic development of learners as autonomous, creative, and emotionally balanced individuals [47]. In the context of elementary science education, humanism enriches cognitive-oriented philosophies by reinstating affective and social dimensions as integral to learning. This perspective urges educators to design learning experiences that promote self-expression, empathy, and cooperative inquiry, thereby nurturing both intellectual and personal growth. Introduces a transformative-emancipatory pedagogy grounded in humanist and decolonial values that challenge hierarchies within educational practice. For elementary science, this translates to classroom environments where learners' voices are validated, and science learning becomes an avenue for empowerment and cultural recognition. Such classrooms promote inclusivity, encourage questioning, and cultivate moral awareness in scientific inquiry. Students are invited to connect science learning with ethical reasoning, developing both cognitive understanding and human empathy [30].

Adds that when educational philosophy is consciously aligned with instructional design, teaching becomes more coherent and responsive. Humanist-inspired pedagogies prioritize intrinsic motivation, self-directed learning, and meaningful engagement, principles that are indispensable in early science education where curiosity and wonder must be nurtured rather than constrained [48]. By emphasizing emotional safety, collaboration, and mutual respect, humanistic pedagogy facilitates deeper conceptual engagement and long-term interest in science learning. Furthermore, classrooms that embody humanistic principles tend to demonstrate improved social cohesion and emotional well-being among students. Studies included in the Scopus and Web of Science corpus underscore that emotionally supportive learning environments foster higher self-regulation, resilience, and engagement with science as an enjoyable pursuit [38]. Teachers adopting a humanistic stance design instruction that validates students' experiences while connecting them to the larger pursuit of understanding human-environment relationships, a perspective increasingly vital in 21st-century science learning.

3.5 Synthesis of Findings

Collectively, the ten reviewed articles affirm that educational philosophy is not a peripheral concern but a constitutive force in shaping pedagogical paradigms and science learning practices. Constructivism, as evidenced by [34], provides the epistemological foundation for inquiry-based, collaborative, and technologically enhanced science learning. Progressivism, as articulated by [31], drives the structural transformation of educational environments toward student agency, adaptability, and contextual relevance. Pragmatism, reflected in [32], grounds science learning in lived experience, experimentation, and the integration of knowledge across cultural and disciplinary boundaries. Humanism, as championed by [38], recenters education on learner potential, equity, and emancipatory development.

These findings collectively suggest that no single philosophical paradigm is sufficient to address the multidimensional demands of contemporary science education. Rather, effective pedagogical practice at the intersection of science and educational philosophy requires an integrative, adaptive orientation, one that draws upon the cognitive emphases of constructivism, the contextual responsiveness of progressivism, the experiential grounding of pragmatism, and the humanizing commitments of humanism in coherent and intentional dialogue.

The synthesized findings reveal that elementary science education thrives at the intersection of four philosophical traditions, constructivism, progressivism, pragmatism, and humanism each contributing distinct yet complementary insights. Constructivism provides the foundation for understanding how learners actively generate meaning through inquiry and collaboration. Progressivism extends this by embedding learning within authentic contexts, ensuring that science education relates directly to students' lived experiences. Pragmatism, with its emphasis on experience and reflection, reinforces the practical application of scientific understanding. Humanism completes the pedagogical spectrum by ensuring that cognitive development is balanced with affective growth and ethical awareness [32], [49]. While each philosophy contributes unique pedagogical value, their convergence signals the necessity for integrative approaches. Constructivism and progressivism together form the epistemic core of inquiry-oriented pedagogy, equipping students with the tools to explore and question phenomena independently. However, without pragmatism's insistence on experiential validation, inquiry risks remaining detached from practical significance. Humanism, finally, ensures this entire process remains ethically grounded, socially inclusive, and emotionally enriching.

This synthesis suggests that effective elementary science pedagogy must operate eclectically drawing from multiple philosophical sources to cultivate balanced learning environments. Rather than viewing these philosophies as competing paradigms, educators should regard them as complementary dimensions within a unified pedagogical continuum. Constructivist inquiry fosters reasoning; progressivist design ensures relevance; pragmatist reflection validates meaning; and humanist sensitivity sustains motivation and empathy. Together, they establish a holistic model of science education consistent with 21st-century demands for adaptive, interdisciplinary, and socially conscious learning.

This study distinguishes itself methodologically and conceptually by developing an integrative analytical framework grounded exclusively in literature indexed in Scopus and Web of Science, ensuring academic rigor and international credibility. Unlike earlier reviews that isolated a single philosophy, often constructivism or progressivism, this systematic synthesis concurrently maps the intersections of four dominant schools within the domain of elementary science learning. By operationalizing qualitative SLR procedures through PRISMA and adopting thematic analysis guided by Braun and Clarke, the research bridges theoretical philosophy with empirically grounded pedagogical evidence. Its novelty lies in revealing how these philosophical orientations dynamically interact within real-world classroom practices, offering a meta-theoretical foundation for rethinking curriculum and instruction in early science education across diverse contexts [32].

Despite its methodological rigor, several limitations warrant acknowledgment. The selected corpus, ten Scopus and Web of Science–indexed articles, though methodologically sufficient for qualitative synthesis, may not exhaust the full diversity of global research on the topic. The studies predominantly reflect English-language scholarship, potentially underrepresenting perspectives from non-English-speaking regions where alternative philosophical syntheses may exist. Additionally, constructivist and progressivist approaches dominate the corpus, while pragmatist and humanist applications appear comparatively fewer, possibly due to publication tendencies within the sampled databases. Finally, the reliance on published, peer-reviewed articles may exclude innovative pedagogical practices documented in grey literature, teacher-led initiatives, or local educational reports indexed outside major databases [50].

The findings underscore an urgent need for pedagogical and policy transformations rooted in philosophical integration. For practicing teachers, an eclectic and reflective approach is essential, one that consciously harmonizes constructivist inquiry, progressivist contextualization, pragmatist application, and humanist care within daily classroom practice. Science teachers should act as designers of learning experiences that balance discovery and reflection, analysis and empathy, context and principle. For curriculum developers, it is recommended that philosophical grounding be made explicit within national and institutional frameworks. Science curricula should articulate not only learning outcomes but also the philosophical rationales guiding them, ensuring coherence between epistemology, pedagogy, and assessment design. For researchers, further empirical studies are encouraged to test the impact of integrative philosophical pedagogies on student outcomes particularly in cross-cultural and resource-diverse elementary settings. Mixed-method or longitudinal designs may be particularly valuable in evaluating how the synergy of constructivism, progressivism, pragmatism, and humanism influences knowledge retention, scientific reasoning, and socio-emotional growth [38]. Ultimately, the intersection of educational philosophies invites a paradigm of reflective synthesis rather than dichotomous choice, offering a cohesive vision of elementary science learning as both intellectually rigorous and profoundly human.

4. CONCLUSION

This systematic literature review, drawing from peer-reviewed articles indexed in Scopus and Web of Science (WoS), reveals that constructivism, progressivism, pragmatism, and humanism converge to reshape elementary science learning through inquiry-based, student-centered, experiential, and holistic pedagogies. Key findings demonstrate constructivism's dominance in fostering collaborative knowledge construction and AI-enhanced inquiry (e.g., CIBSE framework), progressivism's emphasis on adaptive, technology-integrated environments, pragmatism's integration of cultural-scientific knowledge, and humanism's focus on equity and affective development. These paradigms collectively advocate an eclectic approach, transcending isolated applications to cultivate scientific literacy, critical reasoning, and socio-emotional growth amid 21st-century demands. Implications include enhanced teacher training for philosophical reflexivity and curriculum redesign prioritizing integrative practices; however, limitations encompass the corpus's English-centric bias, underrepresentation of non-Western perspectives, and scarcity of pragmatist/humanist studies, potentially overlooking grey literature and diverse global contexts. Recommendations urge educators to adopt reflective, multi-philosophical synthesis in daily instruction, harmonizing cognitive inquiry with ethical empathy. Policymakers should embed explicit philosophical rationales in curricula, promoting PRISMA-guided assessments of pedagogical efficacy. For future research, longitudinal mixed-methods studies are essential to empirically validate integrative models' impacts on diverse elementary cohorts, exploring underrepresented regions, digital equity challenges, and cross-cultural adaptations of socioscientific issues (SSI) pedagogies. Such investigations, expanding beyond WoS/Scopus to include indigenous epistemologies, will refine transformative-emancipatory frameworks for inclusive science education.

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AUTHOR CONTRIBUTIONS

Supriyati Fatma Rabia contributed to conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing the original draft, and project administration. Wahono Widodo and Hendratno contributed to supervision, guidance, and writing review and editing. Suryanti contributed to institutional support and resources. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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