John Dewey's Philosophy of Science Education for IoT-Supported Inquiry-Based Physics Learning: A Literature Review

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Abstract

In the era of the Internet of Things (IoT), physics education requires learning experiences that go beyond conceptual knowledge by actively engaging students in scientific inquiry supported by real-time empirical data. In this context, John Dewey's philosophy of science education, particularly reflective inquiry, provides a relevant philosophical foundation for inquiry-based physics learning. This integrative literature review examines the relevance of John Dewey's philosophy of education to inquiry-based physics learning supported by Internet of Things (IoT) technology. Relevant publications were sourced from the Scopus and Google Scholar databases, yielding 81 articles published between 2015 and 2025. Following the application of established inclusion and exclusion criteria, 17 articles were selected for further analysis through conceptual synthesis. Subsequently, deductive qualitative content analysis was employed to identify recurring themes concerning Dewey's philosophy, reflective inquiry, inquiry-based physics learning, and the utilization of IoT in an educational context. The synthesis results indicate that Dewey's core principles, namely experience, learning by doing, reflective inquiry, and educational democracy, are closely linked to the epistemological foundations of physics learning. The synthesis further demonstrates that IoT contributes to inquiry-based physics learning by facilitating real-time data collection, evidence-based investigation, and conceptual reflection, thereby enriching students' learning experiences without replacing the reflective nature of inquiry. This review proposes an integrated conceptual framework that connects Dewey's philosophy, inquiry-based physics learning, and IoT-supported experimentation, providing a theoretical reference for designing meaningful, technology-enhanced physics learning while identifying directions for future empirical research.

Keywords: John Dewey; philosophy of science education; inquiry-based physics learning; Internet of Things; literature review

INTRODUCTION

Physics learning in the 21st century extends beyond mastering concepts and mathematical procedures to fostering students' ability to investigate phenomena, construct scientific explanations, and engage in reflective thinking. This shift is consistent with contemporary science education, which views scientific inquiry as a process through which learners actively develop knowledge from evidence and experience rather than merely receiving information (Hodson, 1986). Nevertheless, classroom practices in physics education continue to be dominated by teacher-centered instruction, routine problem solving, and limited opportunities for authentic experimentation, reducing students' engagement in meaningful scientific inquiry (Worachak et al., 2023).

As a result, many students perceive physics as a collection of abstract equations disconnected from observable phenomena rather than a discipline for understanding the natural world through investigation. Previous studies have shown that insufficient inquiry-based and experimental activities limit conceptual understanding, scientific reasoning, and students' active participation during physics learning (Yulkifli et al., 2020; Novitra, 2021). Although recent advances in educational technology have introduced various digital tools to support physics instruction, many implementations continue to emphasize technological functionality rather than the learning processes through which students construct scientific understanding.

This situation indicates that the challenges in physics education are not merely pedagogical but are also rooted in the philosophical foundations underlying instructional design. The philosophy of science education provides essential epistemological and axiological grounds for understanding how scientific knowledge is generated, validated, and represented within the classroom learning process (Matthews, 2024). However, existing discourse tends to treat the philosophy of education and technology as separate realms. Research on inquiry-based learning generally focuses on instructional effectiveness, whereas studies on digital technology, including the Internet of Things (IoT), largely emphasize technological innovation. Consequently, relatively little attention has been paid to how philosophical perspectives can elucidate the educational role of IoT in supporting meaningful, inquiry-based physics learning (Sulistiawati, 2024).

John Dewey’s philosophy of science education offers a robust foundation for bridging this gap. Rooted in pragmatism, Dewey views learning as a process of reconstructing experience through reflective inquiry and meaningful interaction with real-world problems (Dewey, 1938; Sikandar, 2015). By emphasizing experience, reflection, and "learning by doing," Dewey’s philosophy positions students as active constructors of knowledge rather than mere passive recipients of information. Although Dewey’s ideas continue to exert a strong influence on contemporary educational practice, their application is often limited to using learning principles without a deep understanding of the underlying philosophical foundations (Williams, 2017). This perspective is increasingly relevant in the context of physics education supported by the Internet of Things (IoT), where interconnected sensors and real-time experimental data have the potential to enrich the inquiry experience by enabling students to observe empirical evidence, evaluate hypotheses, and reflect on scientific phenomena within authentic learning situations.

Dewey's concept of reflective inquiry provides a philosophical foundation for inquiry-based physics learning. He described inquiry as a process of reflective thinking that begins with encountering a problematic situation, proceeds through systematic investigation, and culminates in the reconstruction of meaning based on evidence and reflection (Dewey, 1910; D'agnese, 2017). From this perspective, uncertainty and doubt are not obstacles to learning but essential starting points for scientific inquiry because they encourage learners to question, investigate, and justify their conclusions (Bonecki, 2016). Nevertheless, inquiry in physics classrooms is frequently implemented as a sequence of procedural activities, while the reflective and epistemological dimensions emphasized by Dewey receive considerably less attention.

Extensive research indicates that inquiry-based physics learning fosters students' conceptual understanding while strengthening higher-order thinking skills, scientific attitudes, and long-term knowledge retention. Experimental activities integrated within inquiry learning have been reported to strengthen conceptual understanding (Thacker, 2023), improve learning outcomes and scientific engagement (Jacalan & Castillo, 2023), and foster scientific attitudes and character development (Sari & Oransa, 2025). Despite these positive findings, the existing literature predominantly evaluates instructional effectiveness, whereas relatively few studies discuss why inquiry-based learning is educationally meaningful from the perspective of Dewey's philosophy of science education. Consequently, the philosophical rationale underlying inquiry-based physics learning remains insufficiently explored.

The rapid advancement of educational technology has further expanded opportunities for implementing inquiry-based physics learning. Digital technologies such as mobile learning applications, cloud platforms, virtual laboratories, and immersive environments can facilitate collaborative investigation and enhance students' engagement during scientific inquiry (Deng et al., 2020; Tsivitanidou et al., 2021). However, these technologies primarily function as learning media. In contrast, the Internet of Things (IoT) offers distinctive affordances through interconnected sensors, automated measurements, and real-time data acquisition, enabling students to observe physical phenomena directly and continuously during experimental activities. Despite these capabilities, discussions of technology integration in physics education continue to focus largely on technical implementation and instructional efficiency rather than on how technology can support reflective inquiry and meaningful knowledge construction (Ogegbo & Ramnarain, 2022).

This limitation becomes more evident in studies investigating the application of IoT in physics education. Recent research highlights the potential of IoT-based learning environments to support experimentation through connected sensors and real-time empirical data, allowing students to collect, monitor, and analyze physical measurements more efficiently (Becker et al., 2020). Such capabilities are particularly relevant to Dewey's philosophy because immediate access to empirical evidence can facilitate each stage of reflective inquiry, from identifying problems and testing hypotheses to evaluating evidence and reconstructing understanding. Nevertheless, most existing studies emphasize media development or technological performance, while only limited attention has been given to the philosophical foundations that explain why IoT should function as a tool for inquiry rather than merely as a digital innovation (Roslan et al., 2023). This conceptual gap provides the rationale for the present literature review.

In response to this gap, this literature review examines John Dewey’s philosophy of science education and its implications for inquiry-based physics learning supported by the Internet of Things (IoT). The study synthesizes key principles of Dewey’s philosophy, including pragmatism, experience, reflective inquiry, learning by doing, and democracy in education, and relates them to the development of IoT-based physics learning in the modern educational era (Dewey, 1916, 1938). Unlike previous research that generally focuses on the pedagogical aspects of inquiry-based learning or the technological dimensions of IoT integration, this study offers a conceptual framework that views IoT as a means to facilitate reflective inquiry through real-time experimental data and authentic scientific experiences. Thus, the study provides a philosophical perspective intended to serve as a conceptual foundation for developing inquiry-based physics learning environments that integrate IoT technology in future research.

METHODS

This study employed an integrative literature review to examine John Dewey's philosophy of science education and its implications for IoT-supported inquiry-based physics learning. This study adopted an integrative literature review approach to combine philosophical perspectives, theoretical discussions, and empirical evidence into a unified conceptual framework. Such an approach enables a comprehensive examination of how Dewey's educational philosophy relates to inquiry-based learning and the integration of Internet of Things (IoT) technologies in physics education (Derman & Bezen, 2025).

A literature search was conducted between March and July 2026 using the Scopus and Google Scholar databases. Both databases were utilized concurrently to ensure comprehensive literature coverage. Scopus was selected for its inclusion of repuTABLE, peer-reviewed international publications, while Google Scholar was used to broaden the search scope to include a wider range of educational literature. To identify all relevant research, the search employed a combination of keywords linked by Boolean operators: ("John Dewey" OR "Dewey's philosophy") AND ("inquiry-based learning" OR "scientific inquiry") AND ("physics education") AND ("Internet of Things" OR IoT). The initial search yielded 81 potentially relevant publications before the screening process. The overall literature review process encompassing identification, screening, eligibility assessment, and the conceptual synthesis of selected studies is illustrated in FIGURE 1.

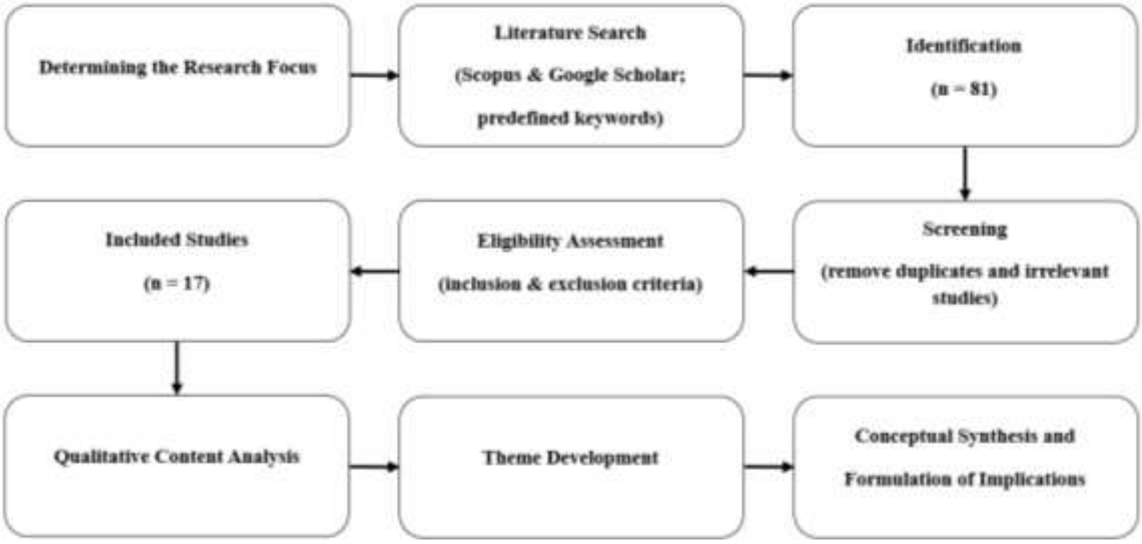

FIGURE 1. Flow of the literature review procedure adopted in this study

Following the literature search, all identified publications were screened against pre-established inclusion and exclusion criteria. A study was deemed to meet the inclusion criteria if it: (1) was a peer-reviewed journal article published between 2015 and 2025; (2) was written in English; (3) addressed John Dewey's philosophy of education, inquiry-based learning, physics education, or Internet of Things (IoT)-supported learning; and (4) held theoretical or empirical relevance to the study's objectives. Conversely, studies were excluded from the synthesis process if they consisted of conference proceedings, books, dissertations, duplicate articles identified during screening, or research focused solely on technical system development without examining educational or philosophical aspects. After the screening and eligibility assessment stages, 17 articles were selected for conceptual analysis, as they were considered the most representative in examining the interrelationships among John Dewey's philosophy, inquiry-based learning, and IoT-supported physics learning. Information regarding research focus, context, key findings, and conceptual contributions was extracted from each selected article and subsequently synthesized using qualitative content analysis. A summary of the literature search strategy, inclusion and exclusion criteria, and article selection process is presented in TABLE 1.

TABLE 1. Literature Search Strategy and Selection Criteria

Item	Description
Databases	Scopus, Google Scholar
Search period	March – July 2026
Publication years	2015 – 2025
Search keywords	"John Dewey", "Inquiry-Based Learning", "Physics Education", "Internet of Things"
Boolean operators	AND, OR
Inclusion criteria	Peer-reviewed journal articles; English; theoretical or empirical studies; relevant to Dewey, inquiry-based learning, physics education, or IoT-supported learning
Exclusion criteria	Conference proceedings, books, dissertations, duplicate records, and studies focusing solely on technical development without educational or philosophical relevance
Initial records	81
Final selected studies	17

The selected studies were analyzed using deductive qualitative content analysis. In this approach, predefined conceptual categories derived from this review's objectives served as the initial coding framework. Each article was coded according to four main categories: (1) Dewey's philosophy of science education, (2) reflective inquiry, (3) inquiry-based physics learning, and (4) the educational role of IoT in supporting scientific investigation. Within these categories, the studies were further examined based on their study focus, key findings, and conceptual contribution. The coded data were then compared, organized into interrelated themes, and synthesized to develop an integrated conceptual framework that explains how IoT can function as a facilitator of reflective inquiry and meaningful learning experiences in physics education (Herman & Pinard, 2015).

RESULTS AND DISCUSSION

The deductive qualitative content analysis revealed several interrelated themes explaining the relationship between John Dewey's philosophy of science education, inquiry-based physics learning, and IoT-supported learning. Across the selected studies, Dewey's principles of experience, reflective inquiry, and democratic participation consistently emerged as key elements supporting meaningful knowledge construction through active engagement with scientific phenomena. Rather than viewing learning as the transmission of established knowledge, the analyzed studies emphasize that understanding develops through inquiry, reflection, and the continuous reconstruction of experience. This synthesis confirms that Dewey's philosophy remains highly relevant for contemporary physics education, particularly in fostering scientific thinking and conceptual understanding.

A review of the literature also indicates that technological advancements have expanded the application of inquiry-based physics learning without altering its underlying philosophical principles. Learning environments supported by mobile technology, cloud-based platforms, online simulations, virtual reality, and Internet of Things (IoT) technology offer students broader opportunities to observe phenomena, gather evidence, test hypotheses, and reflect on experimental results. From a Deweyan perspective, these technologies should not be viewed merely as digital tools, but as learning resources that enrich students' inquiry experiences while facilitating reflective thinking. In particular, IoT extends the inquiry process through real-time data collection capabilities and enables continuous interaction with physical phenomena, thereby further reinforcing the experiential nature of physics learning.

The synthesis further suggests that IoT-supported physics learning is philosophically consistent with Dewey's concept of reflective inquiry. Sensor-based experimentation and real-time data allow students to connect observations with evidence, interpret experimental results, and reconstruct scientific understanding through systematic reflection. The educational potential of IoT, therefore, depends not on the technology itself but on how it enables meaningful inquiry and evidence-based learning. This perspective distinguishes IoT-supported inquiry from technology-centered instruction by positioning digital technologies as facilitators of reflective scientific investigation.

Following a literature search and screening process, 81 publications were identified; these were subsequently narrowed down to 17 articles for in-depth analysis via conceptual synthesis. As summarized in TABLE 2, these articles were selected because they collectively provide the most comprehensive representation of the conceptual categories identified through deductive qualitative content analysis: John Dewey’s philosophy of science education, reflective inquiry, inquiry-based physics learning, and the educational role of the Internet of Things (IoT). Therefore, TABLE 2 is not intended as a summary of all reviewed publications but rather presents the articles that made the most significant conceptual contributions to the development of the conceptual framework in this study.

TABLE 2. Characteristics and Main Contributions of the Selected Studies

Author (Year)	Study Focus	Main Findings	Contribution to This Review
Herman & Pinard (2015)	Dewey's philosophy and inquiry-based learning	Inquiry reflects Dewey's pragmatic approach to learning.	Provides the philosophical foundation for inquiry-based learning.
D'agnese (2017)	Reflective thinking in Dewey's philosophy	Doubt initiates reflective thinking and scientific inquiry.	Describes the philosophical foundation of reflective inquiry.
Frank (2017)	Democratic science education	Democratic learning communities foster reflective and collaborative inquiry.	Explores the contribution of democratic values to inquiry-based learning.
Lee & Brown (2018)	Inquiry and values in science education	Deweyan inquiry integrates scientific investigation with educational values.	Supports the integration of inquiry and Dewey's educational philosophy.
Deng et al. (2020)	Progressive inquiry with cloud-based technology	Technology-supported inquiry improves conceptual understanding and collaboration.	Illustrates the integration of technology into inquiry-based physics learning.
Rodriguez et al. (2020)	Inquiry-based learning in quantum physics	Contextual inquiry enhances understanding of abstract physics concepts.	Supports the effectiveness of inquiry in physics learning.
Jufrida et al. (2021)	Student responses to inquiry learning	Inquiry promotes active participation and scientific attitudes.	Highlights students' positive responses to inquiry-based learning.
Chou et al. (2022)	Online inquiry with physics simulations	Online inquiry improves students' scientific inquiry performance.	Shows the effectiveness of digital inquiry environments in physics.
Thacker (2023)	Inquiry-based experimental physics	Laboratory inquiry strengthens conceptual understanding and scientific reasoning.	Reinforces the value of experimental inquiry in physics education.
Jacalan & Castillo (2023)	Inquiry-based learning and physics achievement	Inquiry-based learning improves students' academic performance.	Provides empirical evidence of inquiry effectiveness in physics learning.
Roslan et al. (2023)	Challenges of implementing inquiry-based learning	Successful inquiry requires adequate pedagogical readiness and instructional support.	Highlights barriers to effective inquiry implementation.
Liana (2020)	IoT-based physics learning with a problem-solving approach	IoT-based learning improves higher-order thinking skills in physics.	Supports the educational benefits of IoT in physics learning.
Davies et al. (2020)	IoT to enhance inquiry in schools	IoT enables real-time data collection and scientific investigation.	Reinforces IoT as a facilitator of reflective inquiry.
Kusmin (2019)	IoT kits for inquiry-based STEM learning	IoT kits support hands-on inquiry and collaborative learning.	Supports IoT as a tool for experiential inquiry.
Ga et al. (2024)	Teachers' challenges in IoT-supported inquiry	Successful IoT integration depends on teachers' technical and pedagogical readiness.	Highlights implementation challenges of IoT-based inquiry.
Liu et al. (2025)	IoT-supported physics laboratories	IoT laboratories provide real-time data for authentic experiments.	Demonstrates IoT's potential to strengthen physics inquiry.

Nasution et al. (2025)	Development of IoT-based physics teaching aids	IoT teaching aids provide real-time data and improve practical learning.	Demonstrates the effectiveness of IoT for inquiry-based physics experiments.

The synthesis presented in TABLE 2 demonstrates that the selected studies consistently position inquiry as the central mechanism through which meaningful learning occurs in physics education. Across the philosophical, pedagogical, and technological perspectives, inquiry is characterized by active investigation, evidence-based reasoning, and reflective thinking. These findings reinforce Dewey's view that scientific knowledge is constructed through continuous interaction with experience rather than acquired through passive transmission (Dewey, 1938). Through inquiry-based physics learning, students build conceptual understanding by exploring physical phenomena, carrying out scientific investigations, evaluating evidence, and reflecting on the knowledge constructed during the learning process.

The reviewed studies further indicate that recent technological developments have expanded the implementation of inquiry without changing its philosophical foundation. Access to cloud-based platforms, online simulations, and Internet of Things (IoT) technologies strengthens scientific inquiry by allowing students to observe physical phenomena continuously, acquire real-time empirical evidence, and base their investigations on objective data. From a Deweyan perspective, the educational significance of IoT lies not in the technology itself but in its ability to enrich reflective inquiry by connecting direct experience with systematic observation, data interpretation, and conceptual reconstruction. Thus, IoT functions as a facilitator of inquiry rather than a substitute for the learning process.

Insights derived from the conceptual synthesis were used to construct a conceptual model that illustrates the role of Dewey's educational philosophy in shaping IoT-supported inquiry-based physics learning. As presented in FIGURE 2, the model depicts reflective inquiry as a continuous cycle beginning with a problematic experience, followed by the emergence of doubt, problem formulation, IoT-supported scientific inquiry, reflection, and knowledge reconstruction. Within this framework, IoT enhances the inquiry process by providing real-time experimental data that supports observation, evidence analysis, and reflective decision-making while preserving the experiential and student-centered nature of learning emphasized in Dewey's philosophy.

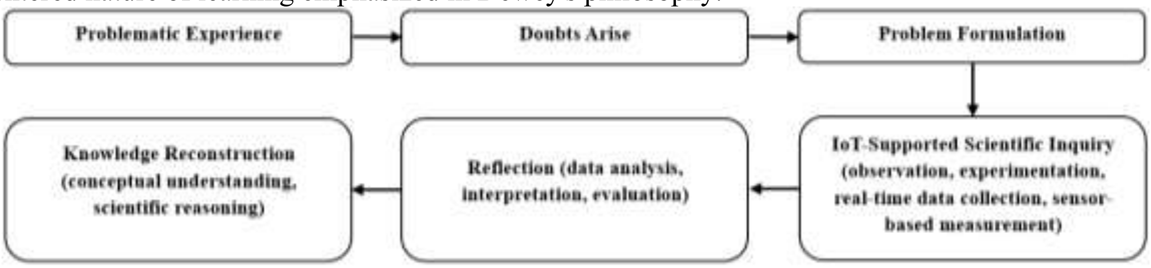

FIGURE 2. Conceptual Model of Dewey's Reflective Inquiry in IoT-Supported Physics Learning

The conceptual model presented in FIGURE 2 synthesizes the reviewed literature by illustrating Dewey's reflective inquiry as a continuous cycle of scientific thinking. Rather than describing learning as a linear sequence of activities, the model emphasizes that knowledge develops through an ongoing interaction between experience, reflection, and action. Across the selected studies, reflective inquiry consistently begins with a problematic situation that generates doubt, motivating learners to formulate questions, investigate evidence, and reconstruct their understanding through reflective evaluation. This interpretation reinforces Dewey's view that scientific knowledge is continuously refined through inquiry rather than passively acquired (Herman & Pinard, 2015; D'agnese, 2017).

The synthesized model is particularly relevant to physics education because the discipline relies on observation, experimentation, measurement, and evidence-based reasoning to explain natural phenomena. According to the reviewed evidence, inquiry-based approaches to physics education foster conceptual understanding by encouraging students to examine physical problems systematically and construct explanations from experimental evidence. In this context, Dewey's philosophy extends beyond a pedagogical strategy by providing an epistemological foundation in which scientific knowledge emerges from reflective interaction with empirical experiences. Consequently, each stage of the model represents an interconnected process that supports both scientific reasoning and meaningful conceptual development.

A review of the literature indicates that Dewey's philosophy focuses not only on epistemological aspects but is also grounded in democratic participation and social interaction as equally important elements. From this perspective, inquiry is understood as a collaborative process that enables students to exchange and develop ideas, defend their interpretations based on empirical evidence, and construct shared understanding through reflective discussion. Such a learning environment fosters the development of a scientific attitude, intellectual responsibility, and openness to alternative explanations. These findings demonstrate that reflective inquiry contributes not only to conceptual mastery but also to the cultivation of values that underpin scientific practice (Frank, 2017; Lee & Brown, 2018). Thus, the results of this study further underscore the relevance of Dewey's philosophy within the context of contemporary science education.

The study results indicate that integrating Internet of Things (IoT) technology into physics instruction reinforces the application of Dewey's reflective inquiry without altering its underlying philosophical foundation. Empirical evidence obtained in real-time via IoT-based sensors and interconnected devices enriches students' investigative experiences by supporting systematic observation, experimental inquiry, and the formulation of evidence-based scientific explanations. Rather than replacing hands-on inquiry activities, IoT helps students make more accurate observations, interpret quantitative evidence, and reflect more deeply on experimental results. Consequently, within the conceptual framework developed in this study, IoT is positioned as a facilitator of reflective inquiry that strengthens the connections between direct experience, scientific evidence, and the process of conceptual reconstruction (Davies et al., 2020; Kusmin, 2019; Liana, 2020; Nasution et al., 2025).

From a Deweyan perspective, IoT should be understood as a means of supporting reflective inquiry rather than as an end in itself. The reviewed studies indicate that IoT enriches students' learning experiences by enabling continuous observation, real-time data collection, and evidence-based experimentation. These technological capabilities encourage learners to formulate questions, test hypotheses, and evaluate findings through systematic reflection, thereby extending the experiential nature of inquiry emphasized in Dewey's philosophy (Davies et al., 2020; Kusmin, 2019). Consequently, the educational value of IoT lies in its capacity to facilitate meaningful scientific investigation rather than merely introducing digital technologies into the classroom.

The synthesis of the reviewed literature also suggests practical implications for the design of physics learning. Integrating Dewey's reflective inquiry with IoT-supported teaching aids enables each stage of inquiry to be supported by authentic experimental evidence. For example, sensor-based physics apparatus can provide real-time measurements of physical variables, allowing students to observe phenomena, analyze quantitative data, and reconstruct scientific concepts through reflective investigation. Such learning environments strengthen conceptual understanding by connecting theoretical principles with direct empirical experiences (Nasution et al., 2025; Liu et al., 2025).

While offering various learning benefits, the studies reviewed also identify several challenges in implementing IoT-supported inquiry-based learning. Meaningful technology integration relies not only on providing digital resources but also on teachers possessing strong pedagogical competence to guide the inquiry process as a reflective process of knowledge reconstruction. Without a sound philosophical foundation, there is a risk that IoT will be utilized merely for technological enhancement rather than as a means to support meaningful scientific inquiry. Therefore, aligning IoT implementation with Dewey's educational philosophy is crucial to ensure that technology strengthens rather than replaces reflective learning experiences (Ga et al., 2024).

The conceptual synthesis derived from the deductive qualitative content analysis is summarized in TABLE 3, which presents the major implications identified across the selected studies. The synthesis demonstrates that Dewey's philosophy provides the epistemological foundation for inquiry-based physics learning, while IoT functions as a technological facilitator that enriches reflective inquiry through real-time empirical evidence. Together, these findings form an integrated conceptual framework that supports meaningful, experience-based, and technology-enhanced physics learning in response to the demands of contemporary science education.

TABLE 3. Conceptual Synthesis of Dewey's Philosophy and IoT-Supported Inquiry-Based Physics Learning

Conceptual Themes	Conceptual Implications for IoT-Supported Physics Learning
Dewey's Epistemology	Positions learning as the reconstruction of experience through reflective inquiry, where knowledge is developed from active investigation and critical reflection.
Educational values and democracy	Promotes scientific dialogue, collaboration, democratic participation, and shared meaning-making during inquiry activities.
Physics experimental inquiry	Supports conceptual understanding and scientific reasoning through observation, experimentation, interpretation of evidence, and reflective discussion.
Technology and IoT	Positions IoT as a tool for reflective inquiry by enabling real-time data collection, sensor-based observation, and evidence-based scientific investigation.
Implementation challenges	Highlights the importance of teachers' pedagogical readiness and philosophical understanding to ensure meaningful integration of IoT into inquiry-based learning.
Indonesian educational context	Demonstrates the potential of integrating Dewey's philosophy and IoT-supported inquiry to strengthen conceptual understanding, scientific character, and 21st-century competencies in physics education.

Based on the conceptual synthesis presented in TABLE 3, inquiry-based physics learning in the Internet of Things (IoT) era is theoretically grounded in John Dewey’s philosophy of science education, which provides a coherent conceptual framework for understanding contemporary technology-enhanced learning practices. Across the studies reviewed, Dewey’s principles of experiential learning and reflective inquiry consistently view knowledge as the product of students' active engagement with scientific phenomena, rather than mere passive reception of information (Dewey, 1938; Herman & Pinard, 2015; D'agnese, 2017). This perspective indicates that physics learning should be designed as an inquiry process in which students construct conceptual understanding through observation, experimentation, reflection, and evidence-based reasoning, aligning with the epistemological characteristics of science education (Lee & Brown, 2018; Thacker, 2023).

The reviewed literature further demonstrates that Dewey's philosophy is closely aligned with the epistemological nature of physics as an empirical science. Scientific knowledge develops by identifying problems, conducting systematic investigations, interpreting evidence, and continuously refining explanations through reflection (Rodriguez et al., 2020; Chou et al., 2022). These characteristics closely parallel Dewey's concept of reflective inquiry, indicating that inquiry is not merely an instructional strategy but a fundamental process through which scientific understanding is developed (Herman & Pinard, 2015; D'agnese, 2017). This synthesis confirms the relevance of Dewey's philosophy as a conceptual framework for designing meaningful and authentic physics learning environments.

Further analysis of the literature indicates that Dewey’s philosophy contributes to instructional practice by emphasizing inquiry as an active process of knowledge construction. In this approach, students build understanding through meaningful experiences, collaborative dialogue, and reflective evaluation, rather than through passive information transfer (Jufrida et al., 2021; Jacalan & Castillo, 2023). Consequently, learning becomes more contextual and meaningful as students are encouraged to connect theoretical concepts with empirical evidence obtained through scientific inquiry activities. Furthermore, collaborative inquiry activities help strengthen students' scientific attitudes and democratic participation during the learning process (Frank, 2017; Lee & Brown, 2018). Building on these epistemological and pedagogical foundations, integrating digital technology offers additional opportunities to enhance the application of reflective inquiry in contemporary physics education.

In addition to its epistemological and pedagogical contributions, the reviewed literature highlights the importance of the value dimension in Dewey's philosophy of science education. Dewey viewed inquiry as a collaborative process in which scientific understanding is developed through dialogue, shared reflection, and collective responsibility. The reviewed literature portrays inquiry-based physics learning as a collaborative environment that nurtures democratic values by involving students in scientific communication, collective interpretation of evidence, and the formulation of empirically supported conclusions (Frank, 2017; Lee & Brown, 2018). The contribution of inquiry extends well beyond conceptual knowledge. By engaging students in collaborative investigation and reflection, it promotes scientific attitudes, nurtures intellectual responsibility, and develops the collaborative problem-solving competencies required for effective science learning.

The literature further suggests that these philosophical principles remain highly relevant in the Internet of Things (IoT) era. Rather than functioning solely as a technological innovation, IoT can strengthen reflective inquiry by enabling students to collect real-time experimental data, analyze scientific evidence, and connect observations with conceptual explanations. When integrated within an inquiry-based learning environment, IoT supports learning through experience by providing authentic opportunities for experimentation and reflection. The educational importance of IoT extends beyond its technical functionality. Its value is realized when the technology creates conditions for meaningful scientific inquiry that embody the core principles of Dewey's educational philosophy (Davies et al., 2020; Kusmin, 2019; Liana, 2020; Nasution et al., 2025).

Overall, the conceptual synthesis summarized in TABLE 3 demonstrates that John Dewey's philosophy, inquiry-based physics learning, and IoT-supported educational innovation are complementary rather than separate perspectives. Dewey's philosophy provides the epistemological foundation for inquiry, while IoT extends students' opportunities to engage with authentic empirical evidence through real-time experimentation and reflective analysis. This integration represents the principal contribution of the present review by offering a conceptual framework that explains how philosophical principles and technological innovation can be aligned to support meaningful, inquiry-oriented, and experience-based physics learning. This conceptual framework is expected to inform future research by providing theoretical guidance for the development and implementation of inquiry-based physics learning environments supported by Internet of Things (IoT) technologies.

CONCLUSION

This integrative literature review concludes that John Dewey’s philosophy of science education remains a relevant philosophical foundation for inquiry-based physics learning supported by Internet of Things (IoT) technology. The conceptual framework developed in this study is grounded in the alignment between Dewey’s educational philosophy and the epistemological principles of physics learning. Dewey’s emphasis on experience, reflective inquiry, learning by doing, and democratic education forms the theoretical basis of the framework, while IoT serves as a pedagogical support providing real-time empirical evidence that enriches the reflective inquiry process rather than merely acting as a digital learning medium. This framework offers practical implications for designing meaningful, experience-based, and technology-enhanced physics instruction that supports scientific inquiry activities and students' conceptual understanding. A significant limitation of this study is that the developed conceptual framework relies on a theoretical synthesis and has not yet undergone empirical testing to evaluate its validity in educational practice. Therefore, future research should examine the framework's implementation through empirical studies, design-based research, or experimental research across various physics topics to assess its effectiveness in supporting inquiry processes, reflective thinking skills, and conceptual learning.

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