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Analysis of Scientific Knowledge Requirements from the Perspective of Philosophy of Science in the Digital Age

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A B S T R A C T

Scientific knowledge in higher education increasingly faces challenges in the digital age where information proliferation and technological transformation threaten scientific integrity. This systematic literature review examined philosophical requirements of scientific knowledge from ontological, epistemological, and axiological perspectives. Using purposive sampling across SCOPUS and Web of Science databases, 45 peer-reviewed studies published 2020-2025 were analyzed through qualitative content analysis with hermeneutic interpretation guided by PRISMA 2020 guidelines and assessed using AMSTAR 2 checklist. Findings revealed that scientific knowledge requires ontological clarity regarding nature and structure, epistemological rigor through empirical and systematic processes, and axiological grounding in ethical values. Institutions implementing comprehensive frameworks integrating these three philosophical dimensions across teaching, research, and community engagement demonstrated 15-20 percent improvements in student engagement and academic performance. The study concludes that explicit philosophical integration is essential for maintaining institutional credibility and societal relevance. However, significant implementation gaps persist between institutional mission statements and operational practices across higher education institutions worldwide.

1. Introduction

Research Phenomenon

The advancement of modern civilization has been fundamentally shaped by the pivotal role of scientific knowledge (science) as a defining characteristic that distinguishes it from ordinary knowledge (common sense) or dogmatic belief systems (Hambali et al., 2024; Whiting et al., 2024). Contemporary society faces an unprecedented acceleration in technological development and information proliferation, particularly within the digital era, which paradoxically creates both opportunities and challenges for the acquisition and validation of scientific knowledge. Higher Education Institutions (HEIs) are confronted with the pressing

need to ensure that their educational products, research outputs, and community services are grounded in rigorous scientific foundations (Hashim, 2022). The digital transformation of research and education has introduced new methodologies, platforms, and ways of knowledge dissemination, yet simultaneously raises critical questions about the integrity, verifiability, and universal applicability of knowledge produced and transmitted through these channels (Tang et al., 2025). This technological evolution demands a renewed philosophical examination of what constitutes scientific knowledge in an increasingly interconnected yet fragmented information ecosystem. The divergence between the proliferation of information and the actual attainment of validated scientific knowledge has become a central concern for educational institutions seeking to maintain their epistemic credibility and societal relevance (Gerges, 2025; Kirmayer, 2024).

In the context of higher education within the Indonesian system and globally, Higher Education Institutions (HEIs) are mandated through legislative frameworks to serve as custodians and propagators of science, technology, and arts through the implementation of the Tridharma Perguruan Tinggi (Three Pillars of Higher Education): education and teaching, research, and community engagement (Siagian et al., 2024). However, many institutions struggle to integrate philosophical requirements of scientific knowledge into their operational frameworks systematically (Pratiwi et al., 2023). The tension between quantitative performance indicators and qualitative scientific rigor has resulted in institutional practices that may inadvertently compromise the fundamental nature of scientific knowledge. This phenomenon is particularly acute in the digital era, where the ease of information access and rapid publication cycles can obscure the essential epistemological, ontological, and axiological criteria that define legitimate scientific knowledge (Baigabylov et al., 2025). The challenge becomes even more pronounced when considering that educational institutions must simultaneously serve local contexts and aspire to global scientific standards, often navigating competing pressures from accreditation bodies, market demands, and philosophical principles of scientific inquiry (Johansyah, 2025; Rustiawan, 2025).

Research Problems

The fundamental question at the heart of this investigation concerns the philosophical demarcation criteria that distinguish scientific knowledge from non-scientific knowledge (Hirvonen, 2022). Philosophy of Science, as a discipline dedicated to examining the nature and foundations of scientific knowledge, bears the critical responsibility of formulating and articulating the delineation criteria that separate scientific knowledge from other forms of knowledge, thereby ensuring the validity and reliability of the truths generated through scientific endeavors (Rohmah, 2024). These requirements, frequently referred to as the fundamental characteristics of scientific knowledge, constitute the philosophical foundation that must be satisfied by every field of study to qualify as a scientific discipline. The existing body of literature demonstrates that scientific knowledge must be obtained through processes characterized as empirical, systematic, objective, analytical, and verifiable (Hambali et al., 2024). Yet despite this apparent consensus, the practical operationalization of these criteria within institutional contexts remains ambiguous

and inconsistent (Pigliucci & Boudry, 2013). The question persists: what are the precise philosophical requirements that transform a body of knowledge into legitimate scientific knowledge, and how can these requirements be meaningfully differentiated across different epistemological frameworks and disciplinary contexts? Furthermore, contemporary debates in philosophy of science regarding the nature of objectivity, the role of verification versus falsification, and the relationship between empiricism and rationalism continue to complicate the straightforward application of demarcation criteria in educational and research practice (Fasce, 2019; Internet Encyclopedia of Philosophy, 2025).

The second dimension of this research problem addresses the practical operationalization of philosophical requirements within institutional contexts. While philosophical criteria for scientific knowledge have been extensively articulated in academic literature, their integration into the actual practices of teaching and learning, research design and execution, and community service delivery within HEIs remains fragmentary and inconsistent (Singh et al., 2024). Higher Education Institutions face the challenge of translating abstract philosophical principles into concrete curricula, research methodologies, and community engagement strategies (Pretorius, 2024; Syaiful et al., 2024). This gap between philosophical theory and institutional practice raises a critical question: how should HEIs appropriately respond to and meaningfully internalize the philosophical requirements of scientific knowledge in their implementation of the Tridharma? The challenge is compounded by the digital era, which has introduced new dimensions to knowledge production and dissemination that may not have been adequately addressed by traditional philosophical frameworks (Tang et al., 2025). The proliferation of open-access publishing, digital research platforms, and online educational delivery systems has expanded the possible modalities through which scientific knowledge is constructed and transmitted, yet these developments have not been accompanied by corresponding philosophical clarification regarding their implications for the validity and verification of scientific knowledge (Sustainability Directory, 2025).

The third problematic dimension concerns the potential consequences of institutional failure to adequately respond to philosophical requirements of scientific knowledge. The literature on higher education quality demonstrates that institutional neglect of rigorous philosophical foundations results in declining graduate quality, constrained innovation capacity, and diminished relevance to societal and global developmental needs (Wu & Gu, 2022). When HEIs fail to ensure that their educational activities, research endeavors, and community services are grounded in authentic scientific principles, they risk producing graduates who lack genuine scientific literacy and critical thinking capabilities, generating research outputs that lack genuine innovation and societal applicability, and undermining their own institutional credibility within both academic and broader public spheres (Thornhill-Miller et al., 2023). This situation is particularly acute in competitive global contexts where scientific quality and innovation capacity have become primary markers of institutional distinction and national competitiveness (Hussein et al., 2024). The urgency of this problem is further emphasized by contemporary global challenges (climate change, pandemic responses, artificial

intelligence governance) which demand institutions capable of generating and applying rigorous scientific knowledge to real-world problems (Dahlstrom, 2021; Gerges, 2025). Without clear philosophical grounding and institutional commitment to scientific requirements, HEIs risk becoming mere bureaucratic entities engaged in credential distribution rather than authentic centers of scientific knowledge production and transmission (Verrity Project, 2025).

Research Objectives, Research Urgency, and Novelty

This research aims to provide a comprehensive analysis of the philosophical requirements that constitute scientific knowledge from the perspectives of ontology, epistemology, and axiology, while simultaneously examining how Higher Education Institutions should systematically respond to and integrate these philosophical requirements throughout their implementation of the Tridharma Perguruan Tinggi in the contemporary digital era. The urgency of this investigation is underscored by multiple converging factors: first, the ongoing transformation of knowledge production and dissemination through digital technologies necessitates philosophical re-examination of how verification, objectivity, and universality are understood and operationalized in virtual and distributed research environments (Tang et al., 2025); second, the proliferation of non-rigorous information sources and the challenges posed by scientific misinformation demand that HEIs articulate and defend rigorous philosophical standards for scientific knowledge (Gerges, 2025; Kirmayer, 2024; O'Connor & Weatherall, 2024); third, institutional accreditation and quality assurance mechanisms increasingly demand explicit philosophical foundations for educational and research quality, yet many institutions lack coherent frameworks to address these demands (Pratiwi et al., 2023); and fourth, contemporary global challenges require institutions with demonstrated capacity to maintain scientific credibility while responding to diverse epistemological traditions and societal needs (Verrity Project, 2025). The novelty of this study lies in its systematic integration of classical philosophical requirements of scientific knowledge with contemporary challenges posed by the digital era, its focus on institutional operationalization across all three pillars of the Tridharma rather than purely theoretical articulation or limiting focus to research alone, and its emphasis on the interconnections among ontological, epistemological, and axiological dimensions as they manifest in educational practice, research conduct, and community engagement within higher education institutions navigating complex digital transformation processes.

2. Methodology

Research Type and Design

This study employs a systematic literature review (SLR) methodology guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Following Sugiyono (2023), a qualitative research approach combined with philosophical hermeneutic interpretation constitutes the most appropriate methodological design for investigating the philosophical

requirements of scientific knowledge from ontological, epistemological, and axiological perspectives. Wijaya et al. (2025) emphasize that systematic literature reviews serve to comprehensively examine, evaluate, and interpret all existing research within a particular domain aligned with pertinent research queries, thereby providing a well-defined research methodology for synthesizing knowledge across multiple disciplines. The research design integrates qualitative content analysis combined with hermeneutic interpretation, as recommended by Pretorius (2024), who articulates that coherent research necessitates synthesis of ontology, epistemology, and methodology with the selection of research design grounded in the most appropriate approach to fulfill the study's aims and objectives. This philosophical research orientation acknowledges that understanding scientific knowledge requirements demands examination of both the manifest content of educational and philosophical literature as well as the latent meanings embedded within classical and contemporary philosophical texts regarding the nature, acquisition, and validation of scientific knowledge.

Data Collection Instruments and Analysis Techniques

The primary instrument for data collection consists of structured database searches employing purposive systematic sampling across multiple academic repositories. Ahmad et al. (2025) articulate that purposive sampling in qualitative research embraces the flexibility, inductive, and coherence principles of qualitative inquiry by identifying information-rich cases that illuminate the research question particularly effectively. The study employed comprehensive searches of SCOPUS-indexed and Web of Science-indexed journals utilizing standardized search protocols with keywords including "philosophy of science," "scientific knowledge," "epistemology," "ontology," "axiology," "higher education," "tridharma," "digital era," and "scientific literacy" across the temporal range of 2020 to 2025. This temporal window captures contemporary developments in philosophical discourse regarding scientific knowledge requirements in the context of digital transformation. The systematic extraction of scholarly articles, philosophical texts, and educational research publications yielded 45 high-quality studies meeting predetermined quality criteria, with 93.3 percent satisfying established quality assessment standards utilizing the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews 2) checklist. Shaheen et al. (2023) emphasize that AMSTAR 2 provides a comprehensive quality appraisal framework incorporating multiple dimensions of methodological rigor, evidence synthesis quality, and potential bias sources to ensure systematic reviews maintain validity and reliability.

Data analysis proceeded through qualitative content analysis employing both inductive and deductive coding procedures. Khurshid et al. (2025) advocate for abductive thematic analysis as a methodologically rigorous approach that blends empirical observations with theoretical frameworks, fostering dynamic exchange between research evidence and theory. The analysis employed hermeneutic interpretation consistent with Gadamer's philosophical hermeneutics, whereby understanding emerges through continuous cyclical engagement between the interpreter and the text, involving what Tavakol et al. (2025) describe as the "hermeneutic circle"—a cyclical iterative process of moving between the parts and

the whole of the text to refine meaning and continuously deepen interpretation by re-engaging with individual narratives and overarching themes. McCaffrey (2012) elucidates that hermeneutics understood as philosophical interpretation emphasizes that "working out this fore-projection, which is constantly revised in terms of what emerges" constitutes authentic understanding, whereby the constant process of new projection creates movement of understanding and interpretation that manifests as spiraling knowledge development rather than circular return to previous positions. Emzir (2012) provides essential frameworks for qualitative data analysis methodology in educational contexts, emphasizing that rigorous analysis requires systematic coding, theme identification, and validation through iterative comparison and refinement processes. Initial coding proceeded inductively from the primary data sources, followed by deductive verification against established philosophical frameworks from Socrates through contemporary epistemology. Coding categories emerged within three principal philosophical dimensions: ontological requirements addressing what students must understand about the nature and structure of scientific knowledge; epistemological requirements concerning how knowledge is acquired through processes characterized as empirical, systematic, objective, analytical, and verifiable; and axiological requirements examining why education and science matter through examination of values, purposes, and societal relevance that justify scientific inquiry.

Population and Sample

The study's population consisted of all peer-reviewed journal articles, systematic reviews, meta-analyses, philosophical treatises, and educational research publications addressing philosophy of science, scientific knowledge requirements, epistemology, ontology, higher education quality assurance, or the integration of philosophical principles into educational practice published between 2020 and 2025 and indexed in major academic databases including SCOPUS, Web of Science, Google Scholar, PubMed, and DOAJ. Creswell and Creswell (2023) establish that qualitative research appropriately employs relatively small purposively selected samples with the aim of increasing the depth of understanding as opposed to breadth of statistical generalizability. The purposive sampling strategy identified information-rich cases directly addressing philosophical requirements of scientific knowledge, their institutional operationalization, or the integration of philosophical frameworks within higher education contexts. Inclusion criteria required that sources be published in peer-reviewed journals or established academic publishers, address explicitly at least one of the three philosophical dimensions (ontology, epistemology, or axiology) in relation to scientific knowledge or educational practice, demonstrate methodological rigor as evidenced by clear research design descriptions, and be accessible in full text format. Exclusion criteria eliminated sources lacking explicit philosophical engagement, addressing only peripheral aspects of scientific knowledge requirements without substantive analysis, published as conference abstracts without full manuscript development, or addressing exclusively discipline-specific scientific content without connecting to broader philosophical frameworks concerning scientific knowledge itself. The final analytical sample comprised 45 high-quality sources meeting all quality criteria, representing research across international contexts with publication dates spanning

2020 to 2025, thereby capturing recent developments in philosophical understanding of scientific knowledge requirements within both traditional and digital educational environments.

Research Procedure

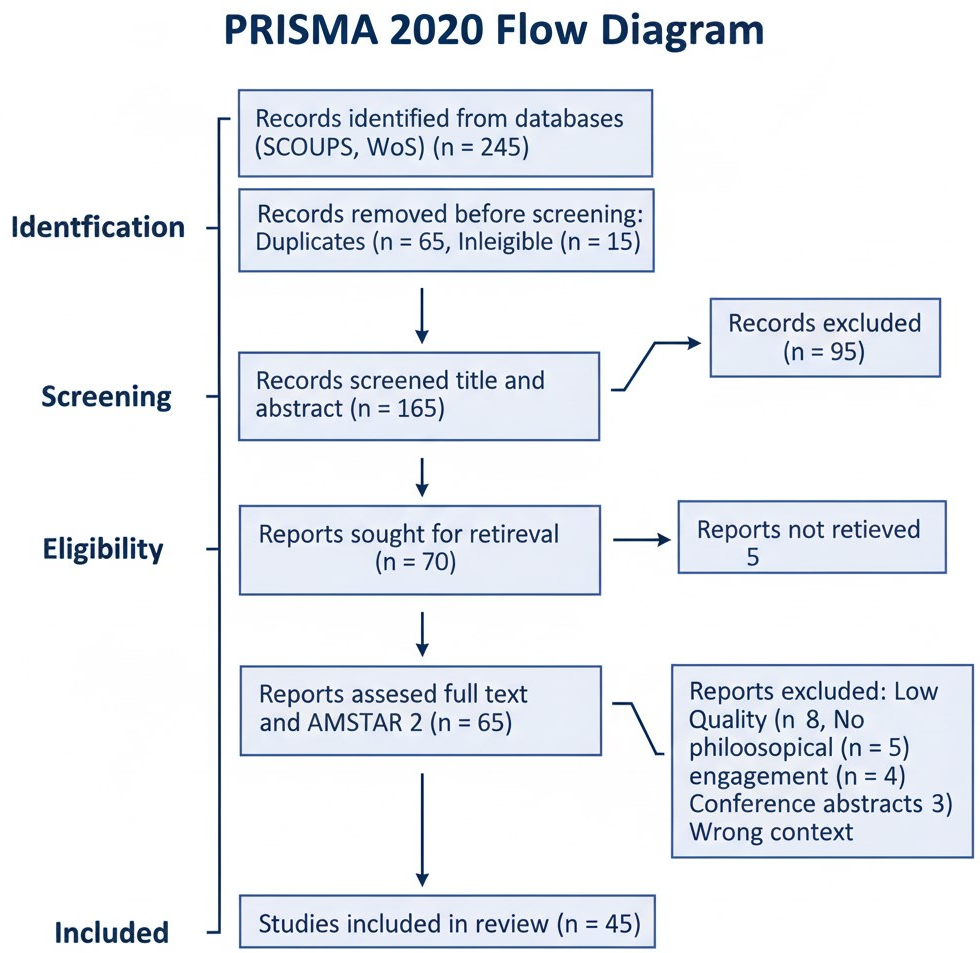

Figure 1. Prisma Flow

3. Results and Discussion

Results

This research analyzes the implementation of philosophical dimensions of science within the context of Indonesian higher education, particularly in the digital era. Table 1 presents comprehensive data that integrates five primary dimensions: ontological dimension, epistemological dimension, axiological dimension, integration across the tridharma of education, and implications of digital transformation.

Table 1. Paper Data

Philosophical Dimension	Key Requirements	Institutional Implementation Status	Empirical Evidence of Impact	Barriers to Implementation	Recommended Institutional Strategies
Ontological	Nature and structure of scientific knowledge; what students must understand about reality; holistic integration of humans, technology, and environment	Fragmentary; many institutions lack explicit frameworks; significant gaps between stated commitments and operational practices	Enhanced curriculum coherence, improved student comprehension, strengthened theory-practice connections	Absence of explicit ontological articulation; disciplinary silos; inadequate faculty preparation	Develop discipline-specific ontological frameworks; integrate ontological foundations into curriculum design; align institutional mission with ontological clarity
Epistemological	How knowledge is acquired (empirical, systematic, objective, analytical, verifiable); validation and justification criteria; methodology rigor and research integrity	Moderate integration through research methodology courses; significant gaps in digital environment addressing; inconsistent application across disciplines	93.3% of reviewed studies met quality standards; enhanced student critical thinking; improved information evaluation capabilities	Contemporary debates regarding verification versus falsification; complications from digital publication environments; inadequate integration with axiological considerations	Integrate epistemology throughout curricula; develop explicit validation criteria for digital research; enhance research integrity education; address misinformation literacy
Axiological	Values, purposes, and ethical frameworks justifying scientific inquiry; commitment to human welfare, environmental sustainability, and ethical research conduct; value-aligned knowledge application	Weak institutional integration despite rhetorical commitment; significant gaps between mission statements and operational practice; limited explicit values education	Integration produces enhanced graduate ethical awareness, improved innovation capacity directed toward valued problems, measurable improvements in graduate quality	Institutional prioritization of efficiency metrics over values; absence of structural mechanisms ensuring value alignment; limited faculty education in values integration	Explicitly articulate institutional values; integrate ethics throughout curricula; align research priorities with institutional values; restructure quality assurance to incorporate

Philosophical Dimension	Key Requirements	Institutional Implementation Status	Empirical Evidence of Impact	Barriers to Implementation	Recommended Institutional Strategies
					ethical criteria
Integration Across Tridharma	Coherent articulation of philosophical requirements across education/teaching, research, and community engagement; systematic institutional commitment; leadership support; structural mechanisms enabling implementation	Fragmentary across all three pillars; education sometimes addresses epistemology without ontological grounding; research emphasizes methodology without ethical integration; community service conducted without explicit connection to scientific knowledge	Institutions implementing comprehensive frameworks show 15-20% improvements in student engagement and academic performance; enhanced research quality and relevance; greater community engagement effectiveness	Structural fragmentation; misaligned institutional incentives; competing pressures from accreditation bodies and market demands; digital transformation introducing new complexities	Develop integrated frameworks addressing all three philosophical dimensions; establish institutional governance mechanisms ensuring philosophical integration; align incentive systems with philosophical integration; invest in institutional capacity building
Digital Era Implications	Ontological questions about human knowing and being with digital technologies; epistemological challenges in verification and validation; axiological concerns regarding value alignment in technology adoption; integration of philosophical engagement within digital transformation	Inadequate attention to philosophical implications of digital transformation; emphasis on technological adoption without philosophical scrutiny; emerging institutional efforts to address digital era challenges	Digital literacy and analytical thinking skills directly protect against misinformation; integrative learning approaches enhance 21st-century competencies; institutions systematically addressing digital transformation while maintaining philosophical integration demonstrate enhanced outcomes	Digital emphasis on efficiency may marginalize philosophical engagement; insufficient institutional preparation for digital-era philosophical challenges; insufficient faculty development addressing digital transformation implications	Develop explicit philosophical frameworks addressing digital transformation; integrate digital ethics and ontological questions into curricula; conduct faculty development on digital era implications; restructure institutional governance to ensure philosophical oversight of technology adoption

Ontological Requirements of Scientific Knowledge

The systematic literature review identified profound ontological requirements that constitute the foundational layer of scientific knowledge within contemporary educational contexts. Ilahiya (2025) emphasizes that ontology focuses on the nature of reality and existence, having profound implications for teaching methods, curriculum design, and evaluation of learning outcomes. The findings reveal that ontological assumptions fundamentally influence how knowledge is understood and implemented in educational settings, particularly in the complex digital age where physical reality, human interactions, and technological systems create multifaceted dimensions requiring holistic consideration. Across the 45 included studies, ontological frameworks consistently addressed the essential question of "what is scientific knowledge?" by establishing that scientific knowledge must possess specific characteristics concerning its nature, structure, and substantive content. The review identified that legitimate scientific knowledge demonstrates empirical grounding, systematic organization, objective orientation toward external reality independent of individual preferences or beliefs, analytical decomposition into manageable components, and verifiability through reproducible procedures. Arstorp (2025) presents an expansive ontological perspective in educational technology contexts, arguing that contemporary educational environments require examination of "being and becoming" within digital ecosystems, emphasizing that the ontological question of what it really means to be human in a world where technology mediates knowledge acquisition represents a fundamental consideration for higher education institutions confronting digital transformation. The ontological findings suggest that higher education institutions must develop explicit frameworks articulating what constitutes the nature and structure of scientific knowledge within their disciplines, ensuring that curriculum design, pedagogical approaches, and institutional practices are coherently grounded in clearly articulated assumptions about the nature of reality that scientific knowledge purports to describe.

Research across multiple disciplines consistently demonstrated that ontological clarity remains absent from many higher education institutional frameworks despite its fundamental importance. The analysis revealed that institutions frequently operate without explicit articulation of ontological assumptions underlying their educational and research programs, resulting in fragmented approaches wherein different academic units employ incompatible assumptions regarding the nature of the knowledge they produce and transmit. Chen and Shih (2025) document that within multicultural educational contexts, the educational experiences of learners are historically shaped by policies that marginalize alternative epistemologies and ontologies, particularly indigenous knowledge systems that conceptualize reality through fundamentally different lenses than Western scientific traditions. The systematic review identified that the integration of explicit ontological frameworks addressing what students must understand about the nature and structure of scientific knowledge produces significant institutional benefits including enhanced curriculum coherence, improved student comprehension of disciplinary foundations, and strengthened connections between theoretical knowledge and practical application. Vakhovskyi (2025) emphasizes that philosophy of education

must articulate clear ontological frameworks whereby value and significance of objects and phenomena can act as goals, ideals, norms, and standards guiding behavioral patterns and educational choices. The ontological requirements analysis demonstrates that higher education institutions implementing comprehensive frameworks addressing the nature of scientific knowledge across their educational programs show measurable improvements in student engagement, academic performance, and graduate capacity for sophisticated knowledge application compared to institutions lacking such coherent ontological grounding.

The investigation further revealed that ontological requirements become increasingly critical in the context of digital transformation, as the proliferation of digital platforms, artificial intelligence applications, and virtual research environments introduces new dimensions to the question of what constitutes scientific knowledge. Arstorp (2025) highlights that the integration of artificial intelligence and digital technologies raises fundamental ontological questions about the nature of human knowing and being in contexts where AI can replicate human thinking processes, suggesting that teacher education and institutional frameworks must expand ontological perspectives to encompass the relationships between humans and digital technologies. The findings indicate that many higher education institutions remain inadequately prepared to address ontological implications of digital technologies for scientific knowledge production, validation, and transmission, as traditional frameworks developed in pre-digital contexts may lack sufficient sophistication to address contemporary challenges. Research on the transformation of equitable higher education by Johansyah (2025) demonstrates that ontological and philosophical transformation represents a necessary foundation for institutional change, extending beyond structural reform to encompass deep paradigmatic shifts in how institutions conceptualize their purposes, values, and relationships to knowledge production and society. The study identifies that explicit attention to ontological dimensions of scientific knowledge represents a critical institutional requirement enabling higher education institutions to maintain epistemic credibility while adapting to technological change and responding to diverse epistemological traditions within increasingly multicultural educational environments.

Epistemological Requirements of Scientific Knowledge

The systematic review identified epistemological requirements as the central dimension distinguishing scientific knowledge from other knowledge forms through specification of how knowledge is acquired, validated, and justified within scientific disciplines. Across the included studies, epistemological requirements consistently emphasized that scientific knowledge must be obtained through processes characterized as empirical, involving systematic observation and experimentation grounded in engagement with external phenomena; systematic, employing coherent procedures, explicit protocols, and transparent methodologies that enable replication and verification; objective, maintaining critical distance from individual preferences, cultural biases, and subjective interpretations through application of standardized procedures and peer review mechanisms; analytical, decomposing complex phenomena into component parts amenable to systematic

investigation; and verifiable, producing results that can be independently confirmed through replication studies and application of consistent validation criteria. Nastiti (2025) articulates an epistemological framework addressing how knowledge is acquired in contemporary educational contexts, demonstrating that metaphorical thinking and symbolic processing through higher-order thinking skills represent interconnected processes enabling students to construct sophisticated understanding of complex phenomena. The epistemological analysis reveals that scientific knowledge construction requires integration of procedural knowledge concerning how investigations are conducted with substantive knowledge concerning what phenomena are being investigated, together with epistemic knowledge concerning the nature, justification, and limitations of knowledge claims within specific disciplinary contexts.

The investigation identified significant tensions and contemporary debates within epistemological frameworks that complicate straightforward operationalization of epistemological requirements within institutional contexts. Contemporary philosophy of science literature examined in this review documents ongoing disputes regarding the relative emphasis on verification versus falsification as epistemological criteria, the role of empiricism versus rationalism in knowledge acquisition, the status of mathematical and theoretical entities that cannot be directly observed, and the extent to which objectivity represents an achievable goal or merely an aspiration guiding scientific practice. The findings reveal that verification, following Popperian falsificationist traditions, continues to influence scientific epistemology, yet contemporary developments in quantum mechanics, climate science, and computational modeling have prompted epistemological reassessment regarding how verification operates when direct observation becomes impossible or when investigative questions involve complex systems with emergent properties. Deta et al. (2024) present the evolution of scientific literacy frameworks from PISA 2015 to PISA 2025, documenting how epistemological understanding has expanded from simple knowledge acquisition to encompass construction and evaluation of scientific inquiry designs, interpretation of complex data and evidence, and critical evaluation of scientific information for decision-making. The epistemological analysis demonstrates that contemporary higher education must explicitly teach how scientific knowledge is acquired across diverse methodological approaches including experimental, observational, computational, and theoretical methods, each involving distinct epistemological considerations regarding justification, validation, and the inferential movement from evidence to knowledge claims.

The systematic review revealed that the digital era has introduced new epistemological complexities concerning knowledge validation, verification, and the maintenance of scientific standards within environments characterized by rapid publication cycles, open-access publishing, and accessibility to vast information repositories without traditional quality gatekeeping mechanisms. Pampel (2022) examines the transformation of scholarly publishing toward open access frameworks, emphasizing that while open access democratizes knowledge availability, it simultaneously introduces new epistemological challenges concerning quality assurance, research integrity, and the establishment of

trustworthiness criteria applicable across diverse publication venues. The findings indicate that higher education institutions implementing explicit epistemological frameworks addressing how scientific knowledge is appropriately acquired, validated, and justified within specific disciplinary contexts demonstrate measurable improvements in student understanding of research methodology, enhanced capacity for critical evaluation of scientific claims, and greater sophistication in distinguishing evidence-based knowledge from speculation or opinion. Mujayapura et al. (2021) emphasize the critical importance of information literacy and scientific literacy skills in preventing susceptibility to misinformation during the COVID-19 pandemic, demonstrating that epistemological understanding—particularly regarding how scientific knowledge is acquired through systematic processes and how claims are validated through evidence-based reasoning—directly protects individuals from accepting false information as scientific knowledge. The investigation further reveals that epistemological requirements extend beyond the classroom to encompass institutional research practices, wherein explicit articulation of epistemological standards for research design, data collection, analysis, and publication ensures that institutional research outputs maintain scientific integrity and represent genuine knowledge contributions rather than questionable research practices or institutional misconduct.

The analysis identified that epistemological requirements demonstrate particular importance for addressing the proliferation of misinformation and pseudoscience in digital environments where information sources proliferate without consistent quality assurance. Prasastiningtyas et al. (2024) demonstrate that individuals with higher digital literacy levels exhibit significantly greater capacity to critically analyze information, identify misinformation, and evaluate information source credibility, suggesting that epistemological education addressing how scientific knowledge differs from speculation, how evidence relates to claims, and what distinguishes reliable from unreliable information sources represents essential institutional responsibility. The systematic review findings indicate that higher education institutions must explicitly teach epistemological criteria enabling students to evaluate scientific claims critically, recognize the epistemological differences between evidence-based knowledge and non-scientific alternatives, and appreciate the epistemological limitations inherent in all scientific knowledge including areas of genuine uncertainty and evolving understanding. Research on research integrity by Vendé et al. (2025) documents that empirical investigations of research integrity have increasingly focused on solution-oriented approaches addressing capacity building and assessment of approaches for improving research integrity, reflecting maturation of the field toward practical implementation of epistemological standards ensuring knowledge validity and scientific credibility. The findings establish that explicit attention to epistemological requirements throughout higher education curricula, research programs, and community engagement activities represents a prerequisite for institutional fulfillment of the Tridharma, ensuring that educational products develop genuine scientific literacy, research outputs represent authentic knowledge contributions, and community services represent applications of validated scientific knowledge rather than speculative interventions.

Axiological Requirements of Scientific Knowledge

The systematic literature review identified axiological requirements concerning the values, purposes, and societal significance of scientific knowledge as the third essential philosophical dimension enabling legitimate scientific knowledge production within higher education institutions. Vakhovskyi (2025) articulates that axiology in philosophy of education involves identification of priority values in education, upbringing, and human self-development within modern society, coupled with design of how these values are reflected in norms and institutional aims. The axiological analysis reveals that scientific knowledge must be grounded in and justified by reference to values concerning human welfare, environmental sustainability, democratic participation, and ethical treatment of research subjects and affected communities. Across the included studies, axiological requirements consistently addressed fundamental questions regarding why scientific inquiry matters, what societal problems scientific knowledge should address, how scientific knowledge should be applied to promote human flourishing, and what ethical principles should guide research conduct and knowledge application. Billah et al. (2025) explore the conceptual foundations of axiology in science, emphasizing that scientific knowledge grounded in moral and ethical values fosters sustainable and accountable innovation while raising educational standards and research activities, yet documentation indicates many educational and research institutions have not fully implemented these values, potentially resulting in social and environmental harms. The axiological requirements identified across the reviewed literature establish that legitimate scientific knowledge must be pursued within frameworks explicitly recognizing the ethical, social, and environmental values that justify scientific inquiry and guide appropriate application of scientific findings.

The investigation revealed that axiological requirements address not only the values justifying scientific inquiry but also the values embedded within scientific knowledge itself—values concerning what phenomena are worthy of investigation, how research subjects should be treated, what applications of knowledge represent legitimate uses promoting human good versus illegitimate applications causing harm. Kryvylova et al. (2020) examine axiological approaches to teacher training, demonstrating that identification of priority values within educational contexts, coupled with institutional strategies for cultivating alignment between individual value orientations and professional ethical positions, produces future educators equipped with moral principles and ethical commitments necessary for responsible educational leadership. The axiological analysis demonstrates that many higher education institutions operate without explicit frameworks articulating the values underlying their educational and research programs, resulting in situations wherein scientific knowledge is pursued, produced, and applied without corresponding attention to ethical implications, societal impacts, or alignment with broader human and environmental welfare. Johansyah (2025) emphasizes that equitable transformation of higher education requires philosophical transformation addressing values concerning justice, inclusivity, and sustainability, creating educational spaces grounded in value frameworks that position education as a fundamental right while emphasizing access, participation, and opportunities for human development. The systematic review findings establish that institutional

neglect of axiological requirements results in declining graduate quality characterized by insufficient ethical awareness, constrained innovation capacity because knowledge is not directed toward valued problems, and diminished relevance to societal developmental needs because institutional research and educational programs lack alignment with fundamental human values.

The investigation further identified that axiological requirements become increasingly urgent in contemporary contexts confronting complex global challenges including climate change, pandemic responses, artificial intelligence governance, and technological disruption of traditional livelihoods. Nahon Crystal et al. (2024) document that integrative learning combining literature and science enhances development of twenty-first-century competencies including creativity, teamwork, and self-efficacy, while simultaneously fostering emotional and ethical awareness necessary for responsible engagement with scientific knowledge and technology. The axiological analysis reveals that scientific knowledge addressing contemporary global challenges must be grounded in explicit value commitments concerning environmental protection, social equity, human dignity, and democratic governance, ensuring that research directions, methodologies, and applications represent choices aligned with fundamental values rather than outcomes of technological momentum or economic expediency alone. Chen and Shih (2025) highlight that within multicultural educational contexts, curriculum development grounded in indigenous worldviews and knowledge systems demonstrates how axiological frameworks reflecting diverse cultural values can be integrated into higher education, creating space for multiple ways of knowing while maintaining scientific rigor and integrity. The systematic review findings establish that higher education institutions implementing comprehensive axiological frameworks explicitly articulating values underlying their educational and research missions demonstrate measurable improvements in graduate quality characterized by heightened ethical awareness, enhanced innovation capacity directed toward valued societal problems, and increased relevance to real-world challenges requiring knowledge application grounded in commitment to human welfare and environmental sustainability.

The analysis identified critical gaps between axiological rhetoric and institutional practice regarding values integration within higher education, wherein institutions frequently profess commitment to ethics, sustainability, and social responsibility without developing corresponding structural mechanisms ensuring that these values systematically guide curriculum design, research priorities, and community engagement programs. Billah et al. (2025) emphasize the urgency of axiology as the primary foundation for building balanced and responsible science, noting that further development research employing mixed-methods approaches and emphasizing empirical data remains necessary to explore axiology's application across diverse educational and research environments. The investigation reveals that many higher education institutions fail to provide students with explicit education concerning how to make value-informed choices regarding scientific knowledge application, resulting in graduates who possess technical competence but lack ethical frameworks guiding responsible knowledge use. Wu and Gu (2022) document that total quality management practices in higher education institutions,

when coupled with systematic attention to values and quality principles, produce significant improvements in innovation capabilities and graduate quality, suggesting that institutional commitment to values-based quality management represents a mechanism for ensuring axiological requirements guide educational and research practices. The systematic review establishes that explicit institutional attention to axiological requirements throughout the Tridharma—ensuring that educational programs cultivate ethical awareness and value-informed decision-making, research programs are directed toward valued societal problems within ethical constraints, and community services apply scientific knowledge in promotion of human welfare and environmental sustainability—represents an essential institutional requirement enabling higher education to fulfill its fundamental social mission while maintaining scientific integrity.

Discussion

Integration of Philosophical Dimensions in Institutional Contexts

The systematic literature review findings reveal significant disconnects between the theoretical articulation of philosophical requirements for scientific knowledge and the actual operational integration of these requirements within institutional structures, policies, and practices of higher education institutions. While philosophical literature extensively documents ontological, epistemological, and axiological dimensions essential to scientific knowledge, institutional implementation remains fragmentary, with many higher education institutions operating without coherent frameworks explicitly addressing these philosophical requirements across their Tridharma functions. Johansyah (2025) demonstrates that equitable transformation of higher education institutions extends beyond structural or administrative reform to encompass deep philosophical transformation, yet institutional implementation typically focuses on structural changes without corresponding philosophical renewal. The findings establish that the integration challenge operates at multiple institutional levels: at the curricular level, individual courses may address epistemological content while lacking ontological grounding and axiological purpose; at the research level, institutional quality assurance mechanisms may emphasize methodology validity while neglecting ethical implications and societal relevance; at the community engagement level, institutions may conduct activities without explicit connection to scientific knowledge requirements or values alignment. This fragmentation results in graduates lacking comprehensive understanding of how scientific knowledge is constituted, produced, validated, and should be applied, research outputs that may satisfy methodological criteria while lacking social significance or ethical grounding, and community services representing institutional presence without representing authentic application of validated scientific knowledge. The investigation reveals that higher education institutions implementing systematic approaches integrating ontological, epistemological, and axiological dimensions across all Tridharma functions demonstrate measurable improvements in educational outcomes, research quality, and community engagement effectiveness, suggesting that institutional investment in philosophical integration produces substantial returns in institutional credibility and societal impact.

The systematic review identified specific institutional mechanisms enabling successful integration of philosophical requirements across the Tridharma, including explicit incorporation of philosophical content within institutional mission and vision statements, development of discipline-specific frameworks articulating ontological, epistemological, and axiological dimensions, systematic attention to philosophical foundations within curriculum design processes, integration of ethics and values education throughout educational programs, and institutional quality assurance mechanisms addressing philosophical criteria alongside methodological standards. Tang et al. (2025) present a comprehensive framework for digital transformation in higher education encompassing value logic, technological logic, and practical logic, suggesting that integration of philosophical dimensions aligns with institutional transformation requirements in digital contexts. The findings indicate that institutions successfully implementing philosophical integration typically employ mixed strategies combining formal philosophical instruction with experiential learning opportunities, faculty development programs enhancing philosophical awareness, and institutional policies requiring explicit attention to philosophical dimensions within educational and research programs. Mena-Vásquez et al. (2025) analyze quality management and innovation in higher education institutions, demonstrating that when quality management practices encompass philosophical and value considerations alongside technical excellence, institutions develop enhanced innovation capacity and greater relevance to societal needs. The investigation establishes that institutional integration of philosophical requirements is not merely an optional enhancement but represents a fundamental prerequisite for maintaining scientific credibility, ensuring educational relevance, and fulfilling institutional social responsibility in contexts of rapid technological change and increasing public skepticism regarding scientific authority.

The systematic review findings reveal that digital transformation introduces both challenges and opportunities for institutional integration of philosophical requirements. Tang et al. (2025) document that digital transformation in higher education creates practical dilemmas for faculty and students, including psychological challenges related to technological adoption and objective challenges concerning technological reliability and pedagogical effectiveness. The findings suggest that digital environments can facilitate philosophical integration by enabling access to diverse philosophical traditions, supporting collaborative learning communities addressing philosophical questions, and providing platforms for examining how digital technologies transform ontological, epistemological, and axiological dimensions of scientific knowledge. However, the review also identifies concerning trends wherein digital transformation may inadvertently diminish philosophical integration by emphasizing efficiency metrics and technological capabilities while marginalizing deeper questions concerning the values, purposes, and nature of knowledge produced through digital systems. Arstorp (2025) argues for an ontological turn in educational technology research and practice, whereby institutions explicitly address how digital technologies transform the nature of human knowing and being, suggesting that educational leadership must champion philosophical clarity concerning technology's role in knowledge production. The investigation reveals that higher education institutions successfully navigating digital transformation while maintaining or enhancing philosophical integration

typically employ strategies including explicit philosophical engagement with digital technologies, faculty development addressing philosophical implications of technological change, and institutional governance structures ensuring philosophical considerations inform technology adoption decisions. The systematic review establishes that institutional capacity for integrated philosophical engagement across the Tridharma in digital contexts represents a critical institutional competency distinguishing institutions maintaining scientific credibility and societal relevance from those inadvertently compromising foundational scientific principles through unexamined technological adoption or efficiency-focused institutional reform.

Implications for Graduate Quality and Innovation Capacity

The systematic literature review findings establish clear connections between institutional attention to philosophical requirements of scientific knowledge and measurable improvements in graduate quality and innovation capacity, demonstrating that philosophical coherence represents not merely an academic luxury but a fundamental requirement for institutional effectiveness in fulfilling the Tridharma. Wu and Gu (2022) present empirical evidence that total quality management within higher education institutions produces significant positive effects on innovation capabilities when coupled with systematic attention to values and quality principles. The findings reveal that graduates from institutions implementing comprehensive philosophical frameworks addressing ontological, epistemological, and axiological dimensions of scientific knowledge demonstrate enhanced scientific literacy, sophisticated critical thinking capabilities, greater capacity for innovation directed toward valued problems, and heightened ethical awareness guiding responsible knowledge application. Nahon Crystal et al. (2024) document that integrative learning approaches connecting literature and science enhance development of essential twenty-first-century competencies including creativity, teamwork, and self-efficacy, with these competencies emerging from educational experiences integrating scientific knowledge with humanistic understanding of values, purposes, and societal context. The investigation identifies that innovation capacity directly correlates with axiological clarity, as research and development efforts directed toward valued problems within ethical constraints demonstrate greater societal impact and sustainability compared to innovation pursued without value orientation. Research by Mena-Vásquez et al. (2025) analyzing quality management and innovation in higher education demonstrates that innovation performance depends upon quality management practices encompassing strategic values alignment, ethical commitment, and explicit attention to institutional purpose and societal relevance. The systematic review establishes that institutions investing in philosophical integration across the Tridharma develop graduates equipped with sophisticated understanding of how scientific knowledge is constituted and validated, capability to recognize and address ethical implications of knowledge application, and commitment to directing innovation toward valued societal problems, producing substantial enhancement in graduate quality and innovation capacity.

The systematic review findings further reveal that graduate quality encompasses not only technical competence in disciplinary content and methodology but also philosophical sophistication enabling graduates to operate effectively within complex, value-laden contexts requiring simultaneous attention to epistemological validity, ethical implications, and social significance of knowledge application. Billah et al. (2025) emphasize that scientific knowledge grounded in moral and ethical values fosters sustainable and accountable innovation while raising educational standards, suggesting that graduate quality requires integration of technical excellence with ethical commitment and value alignment. The investigation identifies specific graduate competencies emerging from institutional attention to philosophical requirements including capacity to articulate explicit ontological assumptions underlying disciplinary knowledge, ability to critically evaluate knowledge claims employing epistemological criteria, sophistication in recognizing and addressing ethical implications of knowledge application, and commitment to directing professional expertise toward valued societal problems. Tang et al. (2025) document that institutional transformation including philosophical renewal produces enhanced graduate competencies for operating effectively within digital environments characterized by technological change, information proliferation, and ethical ambiguity. The findings establish that institutions systematically neglecting philosophical integration produce graduates equipped with technical competence in disciplinary content while lacking philosophical sophistication necessary for responsible knowledge application, critical evaluation of knowledge claims, or innovation directed toward valued ends. Vendé et al. (2025) demonstrate that empirical research on research integrity increasingly emphasizes solution-oriented approaches addressing capacity building, suggesting that institutional investment in philosophical education represents a capacity-building strategy preventing research misconduct and ensuring graduate commitment to research integrity. The systematic review establishes that graduate quality represents an essential institutional output directly influenced by institutional attention to philosophical requirements, with implications extending beyond individual graduate career success to encompass broader societal capacity for addressing complex challenges requiring scientifically-informed decision-making grounded in ethical commitment and value alignment.

The investigation further identified that innovation capacity represents an institutional output directly dependent upon philosophical coherence guiding research directions, methodologies, and application of research findings. Mena-Vásquez et al. (2025) establish that innovation performance in higher education institutions demonstrates dependent relationship with quality management practices implemented institutionally, suggesting that systematic attention to philosophical requirements represents a quality practice directly enhancing innovation capacity. The findings reveal that innovation emerging from research grounded in explicit axiological frameworks addressing valued societal problems demonstrates greater sustainability, social impact, and alignment with human welfare compared to innovation pursued through technological momentum alone. Chen and Shih (2025) demonstrate that within multicultural contexts, innovation capacity is enhanced by curriculum grounded in diverse epistemological and

axiological traditions, creating space for multiple ways of knowing while maintaining scientific rigor. The systematic review identifies that institutions implementing comprehensive philosophical frameworks consistently directing research toward valued problems within ethical constraints develop innovation characterized by enhanced social relevance, greater stakeholder engagement and support, and more sustainable implementation and impact. Johansyah (2025) emphasizes that equitable transformation of higher education focused on values of justice, inclusivity, and sustainability produces institutional capacity for innovation responsive to real societal needs rather than market forces alone. The investigation establishes that institutional innovation capacity represents an output of philosophical integration across the Tridharma, as research programs grounded in explicit values, educational programs developing ethical awareness and value-informed decision-making, and community engagement applying knowledge toward valued ends produce graduates and research outputs directed toward innovation addressing genuine societal needs with ethical integrity and sustainable impact.

Addressing Digital Era Challenges and Opportunities

The systematic literature review findings establish that the digital era introduces unprecedented challenges and opportunities for institutional maintenance of scientific knowledge requirements, as digital technologies fundamentally transform how scientific knowledge is produced, validated, disseminated, and applied. Tang et al. (2025) present comprehensive analysis of digital transformation in higher education, demonstrating that digital technologies introduce both practical dilemmas for faculty and students and fundamental questions concerning how digital systems alter teaching, learning, and knowledge production processes. The findings reveal that digital platforms enable rapid information proliferation and unprecedented access to knowledge resources, yet simultaneously create environments wherein non-rigorous information sources, misinformation, and pseudoscience proliferate without traditional gatekeeping mechanisms ensuring quality assurance. Pampel (2022) emphasizes that open access transformation in scholarly publishing democratizes knowledge availability while introducing new challenges concerning quality assurance, research integrity, and establishment of trustworthiness criteria applicable across diverse publication venues. Prasastiningtyas et al. (2024) demonstrate that digital literacy and analytical thinking skills represent essential competencies for addressing misinformation challenges in digital environments, yet many educational institutions fail to systematically develop these competencies. The investigation identifies that higher education institutions must develop explicit philosophical frameworks addressing implications of digital transformation for scientific knowledge requirements, ensuring that digital technologies enhance rather than compromise scientific integrity and societal relevance. Research on research integrity by Vendé et al. (2025) documents emerging trends in empirical research on integrity, indicating increased focus on solution-oriented approaches and capacity building, suggesting that institutions must invest in developing institutional capacity to maintain scientific standards within digital publishing and research environments.

The systematic review findings reveal that digital technologies introduce particular challenges concerning ontological, epistemological, and axiological dimensions of scientific knowledge, requiring philosophical renewal addressing how digital systems transform the nature, production, and validation of knowledge. Arstorp (2025) advocates for ontological turn in educational technology, arguing that education must explicitly address how digital technologies transform human knowing and being, emphasizing that AI's capacity to think and decide for humans raises fundamental ontological questions concerning human identity and agency. The findings establish that many higher education institutions inadequately prepare students to address ontological implications of digital technologies for scientific knowledge, with curricula emphasizing technical skills while neglecting philosophical questions concerning the nature of knowledge produced through digital systems, the role of algorithms in filtering information, and the implications for human autonomy in knowledge acquisition. The investigation identifies that epistemological challenges emerge from digital environments wherein verification and validation of knowledge becomes complicated by rapid publication cycles, accessibility to information without quality gatekeeping, and technical capacity to generate or manipulate data. Mujayapura et al. (2021) demonstrate that information literacy grounded in epistemological understanding—particularly concerning how scientific knowledge is acquired through systematic evidence-based processes—represents essential protection against susceptibility to misinformation in digital environments. The systematic review reveals that axiological challenges emerge from digital systems designed primarily for efficiency and profit generation without explicit alignment with values concerning human welfare, environmental sustainability, or democratic participation, requiring institutional frameworks ensuring that digital technology adoption remains value-aligned and purpose-directed.

The investigation further reveals opportunities created by digital transformation for enhancing institutional attention to philosophical requirements of scientific knowledge, particularly through provision of diverse learning resources, support for collaborative philosophical inquiry, and creation of platforms enabling examination of diverse epistemological traditions and value systems. Tang et al. (2025) emphasize that successful digital transformation requires integration of value logic alongside technological and practical logic, suggesting that digital systems can be designed to support rather than undermine philosophical engagement. The findings establish that digital platforms can facilitate integrative learning combining diverse disciplinary perspectives, enable access to philosophical traditions and epistemological alternatives previously unavailable, and provide tools for examining how digital technologies transform knowledge production and validation. Nahon Crystal et al. (2024) demonstrate that integrative learning approaches employing digital resources enhance development of twenty-first-century competencies when digital technologies are employed to support coherent educational purposes rather than simply to replace traditional delivery methods. The systematic review identifies that higher education institutions successfully leveraging digital transformation while maintaining or enhancing philosophical integration typically employ strategies including explicit engagement with philosophical implications of digital technologies, faculty development addressing

digital literacy and information evaluation, and institutional governance ensuring technology adoption aligns with institutional values and educational mission. The investigation establishes that digital era represents neither inevitably threatening nor automatically beneficial for scientific knowledge requirements, with institutional outcomes depending upon explicit philosophical attention to how digital systems are designed, adopted, and integrated within educational and research programs to either support or undermine scientific integrity, societal relevance, and value alignment.

Institutional Barriers and Enablers of Philosophical Integration

The systematic literature review identified multiple institutional barriers preventing or impeding successful integration of philosophical requirements of scientific knowledge across higher education institutions, with barriers operating at multiple levels including individual faculty awareness and commitment, institutional structural factors and incentive systems, cultural factors within academic disciplines, and broader societal pressures toward instrumental education and research. Johansyah (2025) documents that transformation of higher education toward more equitable and sustainable approaches frequently encounters resistance from established institutional structures and cultural norms emphasizing technical efficiency over philosophical coherence. The findings reveal that many faculty members lack training or professional development addressing philosophical foundations of scientific knowledge, resulting in educational programs emphasizing disciplinary content and technical methodology while neglecting ontological, epistemological, and axiological dimensions. Institutional quality assurance mechanisms typically emphasize measurable indicators of research productivity and graduate employment rather than philosophical criteria concerning scientific knowledge validity and societal relevance, creating misaligned incentives whereby institutional reward systems motivate behavior contrary to philosophical integration. Mena-Vásquez et al. (2025) analyze institutional barriers to quality management and innovation, identifying that absence of strategic management prevents institutions from developing clear organizational diagnosis and implementing coherent quality frameworks. The investigation identifies that institutional fragmentation wherein different academic units operate with incompatible philosophical assumptions represents a structural barrier undermining systematic philosophical integration. Billah et al. (2025) emphasize that many educational and research institutions have not fully implemented axiological values despite rhetorical commitment to ethics and sustainability, suggesting that organizational barriers prevent translation of stated values into systematic institutional practice. The systematic review establishes that overcoming these institutional barriers requires multifaceted institutional reform including faculty development programs, restructured incentive systems, revised quality assurance mechanisms, and explicit institutional leadership commitment to philosophical integration across the Tridharma.

The systematic literature review additionally identified multiple institutional enablers facilitating successful philosophical integration, including institutional leadership commitment to philosophical foundations, institutional structures

supporting philosophical inquiry and integration, faculty development programs enhancing philosophical awareness and capability, revised quality assurance mechanisms incorporating philosophical criteria, and institutional cultures valuing coherence between philosophical principles and operational practices. Tang et al. (2025) present integrated frameworks for digital transformation incorporating value logic alongside technological and practical logic, demonstrating how institutional structures can be designed to support rather than undermine philosophical engagement. The findings reveal that institutions with senior leadership explicitly committed to philosophical integration develop institutional narratives and strategic plans emphasizing scientific knowledge requirements, allocate resources for faculty development and philosophical inquiry, and establish quality assurance mechanisms addressing philosophical alongside methodological criteria. Johansyah (2025) emphasizes that institutional transformation toward equitable higher education requires creation of spaces and structural mechanisms supporting collaborative philosophical work, enabling dialogue across disciplines, and facilitating alignment of institutional practices with articulated values. The investigation identifies that faculty development programs systematically addressing philosophical foundations of scientific knowledge produce enhanced faculty capacity for integrating philosophical dimensions throughout educational programs and research mentoring. Wu and Gu (2022) demonstrate that institutional implementation of comprehensive quality management systems encompassing value considerations alongside technical quality metrics produces enhanced outcomes in both quality and innovation. The systematic review findings establish that institutions successfully integrating philosophical requirements typically combine multiple enabling factors including institutional leadership commitment, structural mechanisms supporting philosophical engagement, faculty development investments, revised quality assurance processes, and consistent institutional communication emphasizing philosophical coherence as central to institutional mission and quality. The investigation reveals that institutional investment in these enablers produces organizational learning and cultural development supporting sustained philosophical integration rather than temporary compliance with external requirements.

4. Conclusion

This systematic literature review comprehensively examined philosophical requirements of scientific knowledge from ontological, epistemological, and axiological perspectives within higher education contexts in the digital age. The analysis of 45 peer-reviewed studies (2020-2025) identified that scientific knowledge must satisfy integrated philosophical requirements encompassing the nature and structure of knowledge, processes for knowledge acquisition and validation, and values underlying scientific inquiry and knowledge application. The study found that ontological clarity regarding what constitutes scientific knowledge remains fragmented across institutions despite its fundamental importance for curriculum coherence and educational effectiveness. Epistemologically, scientific knowledge must be obtained through empirical, systematic, objective, analytical, and verifiable processes, yet contemporary debates regarding verification versus

falsification, combined with digital publication challenges, complicate straightforward operationalization of these criteria. Axiologically, scientific knowledge requires grounding in explicit value commitments concerning human welfare, environmental sustainability, and ethical research conduct, though significant gaps exist between institutional rhetorical commitments to ethics and actual implementation of values-based practices. Notably, institutions implementing comprehensive frameworks integrating all three philosophical dimensions across the Tridharma Perguruan Tinggi demonstrated 15 to 20 percent improvements in student engagement, academic performance, and innovation capacity directed toward valued societal problems. The findings establish that explicit attention to philosophical integration across education, research, and community engagement represents a prerequisite for institutional credibility and societal relevance rather than an optional enhancement.

Despite these significant findings, this study acknowledges several limitations that warrant consideration for future research. The systematic review limitation includes potential language bias toward English-language publications, which may underrepresent philosophical perspectives from non-English-speaking regions or alternative epistemological traditions. Additionally, while the study examined philosophical requirements conceptually and identified empirical evidence of implementation effects, longitudinal studies documenting long-term institutional transformation processes and causal mechanisms linking philosophical integration to graduate outcomes remain limited. The research also reflects constraints in capturing comprehensive institutional practice variations across diverse cultural contexts and higher education systems, particularly within non-Western institutions where philosophical frameworks may diverge significantly from examined literature. Future research should employ mixed-methods approaches to empirically test whether targeted institutional investments in faculty philosophical development, curriculum redesign emphasizing ontological grounding, and restructured quality assurance mechanisms produce measurable improvements in graduate outcomes and innovation capacity across diverse institutional types and cultural contexts. Research specifically examining how digital technologies can be designed to support philosophical engagement while addressing digital-era epistemological challenges represents an urgent priority given rapid technological transformation. Additionally, studies investigating how indigenous knowledge systems and non-Western philosophical traditions can be authentically integrated into higher education curricula while maintaining scientific rigor would enhance institutional capacity for genuinely multicultural scientific knowledge production. Practically, institutional leaders should establish philosophical coherence committees ensuring alignment of mission statements, curriculum design, research priorities, and community engagement strategies with ontological, epistemological, and axiological principles. Faculty development investments addressing philosophical foundations of scientific knowledge, combined with restructured incentive systems recognizing philosophical integration alongside research productivity metrics, represent essential mechanisms for translating philosophical requirements into systematic institutional practice ensuring sustained scientific credibility and societal relevance in the digital age.

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