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HUMAN-AI RESEARCH CREATION FRAMEWORK (HARCF): A QUALITATIVE EVIDENCE SYNTHESIS COLLABORATION IN SCIENTIFIC RESEARCH

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ABSTRACT

Objective: This study aims to investigate how Generative Artificial Intelligence (GenAI) contributes to the creation of scientific knowledge throughout the research lifecycle, as well as to develop the Human-AI Research Creation Framework (HARCF) as an integrated conceptual framework that explains human-AI collaboration in scientific research.

Research Design & Methods: This study employed a Qualitative Evidence Synthesis (QES) approach to analyze 17 empirical articles using open coding, axial coding, selective coding, cross-case synthesis, and theme development to identify patterns of human-AI collaboration and construct a conceptual framework.

Findings: The research findings indicate that the role of GenAI has shifted from merely a writing aid to a collaborator in the creation of research. Six main themes were identified: AI as a Research Ideation Partner, Knowledge Exploration and Synthesis, AI-Supported Research Design, Iterative Human-AI Co-Creation, Human Validation and Critical Judgment, and Responsible AI Governance. Based on this synthesis, HARCF was developed as a framework that describes the creation of research as a collaborative, iterative process that remains under human epistemic control.

Implications: HARCF provides conceptual guidelines for researchers, academic institutions, and journal editors on how to implement AI responsibly while maintaining transparency, research integrity, and human oversight.

Contribution & Value Added: This study proposes HARCF as a new conceptual framework that shifts the paradigm from AI-assisted writing to human-AI research creation, while also expanding Knowledge Creation Theory through the concept of human-AI co-creation as a new mechanism for the creation of scientific knowledge.

Keywords: Human-AI, Generative AI, Research Creation, Responsible AI.

JEL codes: O33, D83

Article type: research paper

INTRODUCTION

The rapid advancement of Generative Artificial Intelligence (GenAI) has fundamentally transformed the global scientific research landscape. Unlike earlier generations of artificial intelligence, which focused on automating specific tasks, modern foundation models and Large Language Models (LLMs) are capable of contextual reasoning, interdisciplinary knowledge synthesis, information interpretation, and generating coherent scientific text across various research domains. This progress is supported by massive computational and financial investments, thereby accelerating the adoption of GenAI in various research activities, ranging from literature exploration, data analysis, and method development to scientific discoveries in the fields of materials science, chemistry, health, and the social sciences (Li, 2021).

As these capabilities have improved, the role of GenAI in scientific research has also undergone a significant shift. Various studies show that models such as ChatGPT, Gemini, Claude, and Copilot are no longer used merely to correct grammar or draft academic papers, but are increasingly being employed to help identify research gaps, generate hypotheses, build conceptual frameworks, design methodologies, conduct qualitative analyses, and interpret research findings (Nguyen-Trung, 2025; Pigg, 2024; Yan et al., 2023). This transformation demonstrates that AI has evolved from a mere computational tool into a cognitive collaborator that interacts with

researchers' analytical, reflective, and creative abilities during the process of scientific knowledge creation (Park, 2026; Sandin-Esteban, 2026; Wan, 2026).

However, the adoption of GenAI in research practice is progressing much faster than the development of theories explaining the mechanisms of such collaboration. Most research still examines AI as a research assistant, focusing on improving the efficiency of academic writing, literature synthesis, data coding, or statistical analysis (Little et al., 2026; Xu et al., 2024). Various conceptualizations such as Artificial Intelligence as Research Tool (ART), Artificial Intelligence as Research Assistant (ARA), and Artificial Intelligence as Research Participant (ARP) generally still place AI as an instrument to support research activities (Little et al., 2026; Park, 2026; Wilson and Burleigh, 2026; Xiong et al., 2024).

Although a growing body of empirical evidence shows that GenAI has been used at nearly every stage of research from idea exploration to the drafting of publications there is still no conceptual framework capable of explaining how the interaction between researchers' tacit knowledge and the generative capabilities of AI systematically produces new scientific constructs (Cress and Kimmerle, 2023; Shet et al., 2026). In addition, most studies still evaluate AI outcomes based on increases in productivity or technical accuracy, while mechanisms for novelty creation, the development of conceptual frameworks, scientific validation, and the process of knowledge co-creation between humans and AI have been relatively little explored (He et al., 2026; Ren et al., 2026).

On the other hand, the adoption of GenAI in scientific research has outpaced the development of governance frameworks that regulate its responsible use. Various recent studies emphasize the importance of transparency in AI use, prompt documentation, researcher accountability, and human verification, as well as the principles of Responsible AI Governance to uphold scientific integrity and the reproducibility of research (Knöchel et al., 2025; Papagiannidis et al., 2025). This situation highlights the urgent need for an integrated framework that not only explains how humans and AI collaborate in generating scientific knowledge, but also addresses transparency, governance, and human oversight throughout the research lifecycle.

Given these circumstances, this study seeks to answer three main research questions, namely: (RQ1) how researchers collaborate with Generative AI throughout the process of creating scientific research; (RQ2) what role AI plays in helping to identify research gaps and develop innovations, and the generation of scientific contributions; and (RQ3) how a conceptual framework the Human-AI Research Creation Framework (HARCF) can be developed based on a synthesis of available empirical evidence. To answer this question, this study employs a Qualitative Evidence Synthesis (QES) approach, using seventeen empirical studies on the use of Generative AI in scientific research as units of analysis. All articles were analyzed through a process involving open coding, axial coding, selective coding, cross-case synthesis, theme development, and framework development to identify patterns of collaboration that consistently emerge across various disciplines.

This study makes three major contributions. First, from a theoretical perspective, this study expands the literature on Human-AI Collaboration by shifting the perspective on AI from that of a mere research assistant to that of a research co-creator who participates in the process of scientific knowledge creation. Second, from a methodological perspective, this study demonstrates how the Qualitative Evidence Synthesis approach can be used to develop new theories through a cross-case synthesis of empirical studies on human-AI collaboration. Third, from a practical standpoint, this study offers conceptual guidelines for researchers, academic institutions, journal editors, and policymakers on how to implement human-AI collaborations that are transparent, responsible, and uphold research integrity.

The main novelty of this study lies in the development of the Human-AI Research Creation Framework (HARCF), a conceptual framework that views research creation as a process of co-creation between humans and AI. Unlike previous studies, which generally focused on the use of AI for writing or partial data analysis, HARCF integrates all stages of the research process, from research motivation to knowledge exploration, identifying research gaps, developing innovations, formulating conceptual frameworks, designing methods, interpreting results, conducting scientific validation, and publishing findings all within a comprehensive, empirically grounded human-AI collaboration model.

LITERATURE REVIEW

Evolution of Generative AI in Scientific Research

Generative Artificial Intelligence (GenAI) represents the latest evolution in artificial intelligence, which has transformed the paradigm of scientific research (Chakravarty et al., 2025). Its development has shifted from rule-based systems to deep learning and Large Language Models (LLMs) capable of generating text, images, code, and multimodal information in a context-aware manner (Bhatt and Sharma, 2025). This advancement expands the role of AI from mere pattern recognition to a technology capable of synthesizing knowledge, conducting scientific simulations, and generating new content to support various research activities (Balasubramaniam et al., 2024; Chakravarty et al., 2025; Gatla et al., 2024).

This transformation has changed the research workflow, such that Generative AI is no longer used solely for data analysis or manuscript drafting, but also supports literature exploration, hypothesis development, method design, and interdisciplinary scientific collaboration (Bhatia et al., 2026; Fahad et al., 2025). This development indicates that the focus of AI evolution has shifted from task automation to cognitive collaboration between humans and AI, thereby opening up new opportunities for the creation of more innovative and adaptive scientific knowledge (Bhatt and Sharma, 2025; Krupitzer, 2024; Marin-Rodriguez et al., 2026).

Human-AI Collaboration in Knowledge Creation

Human-AI Collaboration is an approach that views humans and artificial intelligence as complementary partners in the process of knowledge creation, in which humans contribute through creativity, contextual understanding, and reflective reasoning, while AI provides capabilities in data analysis, pattern recognition, information synthesis, and large-scale knowledge processing (Chowdhury et al., 2022; Schleiger et al., 2024; Vishal et al., 2026). This concept evolved from the paradigms of collaborative intelligence, human-AI teaming, and distributed cognition, which view cognitive processes as the result of interactions between humans, AI, and the work environment to improve the quality of decision-making, generate new hypotheses, and accelerate scientific innovation (Ezer et al., 2019; Iga et al., 2024). In the context of scientific research, AI is no longer viewed as a passive tool, but rather as a cognitive collaborator that expands researchers' cognitive capacities, supports the exploration of ideas, the synthesis of knowledge, and the development of scientific contributions through collaborative mechanisms that still require human oversight and validation (Mohsin et al., 2026; Singh, 2026; Zaid et al., 2026).

Responsible AI Governance in Scientific Research

Responsible AI Governance is an approach that ensures artificial intelligence systems are developed, implemented, and utilized in an ethical, transparent, fair, and accountable manner throughout the scientific research cycle through the application of the principles of Fairness, Accountability, Transparency, and Ethics (FATE) (Keshap and Gadani, 2026; Okolo, 2026; Rama and Prinsloo, 2025). AI governance not only emphasizes compliance with ethical principles and regulations, but also requires human oversight, process documentation, validation of results, and accountability mechanisms to maintain scientific integrity and minimize the risk of bias and decision-making errors. Therefore, various AI governance frameworks encourage the implementation of continuous oversight, spanning the design, development, and implementation stages through to the evaluation of AI systems (Lee et al., 2026; Mohsin et al., 2026).

METHODS

Research Design

This study employs a Qualitative Evidence Synthesis (QES) design to develop a theoretical understanding of human-AI collaboration in scientific research. Unlike conventional systematic literature reviews that primarily summarize existing findings, QES aims to generate high-level conceptual interpretations through the synthesis of qualitative evidence across empirical studies. An interpretive perspective is adopted by treating each selected article as an individual qualitative case illustrating Human-AI interaction during the creation of scientific knowledge. To support theory development, the synthesis is integrated with Grounded Theory coding procedures, enabling the emergence of conceptual categories and the development of the proposed Human-AI Research Creation Framework (HARCF).

Data Sources and Case Selection

The literature search followed the PRISMA 2020 guidelines to ensure a transparent and reproducible evidence selection process. Scopus is used as the primary database due to its extensive coverage of peer-reviewed journals in the fields of artificial intelligence, information systems, education, and interdisciplinary research. The search utilized a combination of keywords related to Generative AI, Large Language Models, Human-AI Collaboration, Knowledge Creation, Responsible AI, and Scientific Research. Only peer-reviewed journal articles published between 2023 and 2026 were considered.

Studies were included if they (1) empirically investigated the application of Generative AI in scientific research, (2) described Human-AI interaction during the research process, and (3) provided sufficient methodological information for qualitative interpretation. Following title screening, abstract review, full-text assessment, and eligibility evaluation, 17 empirical studies were selected as the evidence base for this qualitative synthesis.

Evidence Extraction

A structured evidence extraction protocol was developed to ensure consistency across all selected studies. The extracted information included publication characteristics, research objectives, research methods, AI platforms,

AI-supported research stages, reported benefits, limitations, governance practices, and human-AI interaction mechanisms. The extracted information is organized into a standard evidence matrix, which serves as the primary dataset for qualitative analysis.

Data analysis

This analysis follows a coding process inspired by Grounded Theory, consisting of open coding, axial coding, and selective coding. Open coding identifies initial concepts describing Human-AI collaboration across the selected studies. Axial coding groups related concepts into broader categories by examining the relationships between emerging codes. Selective coding then integrates these categories into a coherent explanation of the creation of Human-AI research. To strengthen the theoretical abstraction, the coding process was complemented by cross-case synthesis, which compared recurring patterns across the 17 empirical cases. The resulting categories were refined into higher-level themes and subsequently synthesized into the Human-AI Research Creation Framework (HARCF), representing the study's primary theoretical outcome.

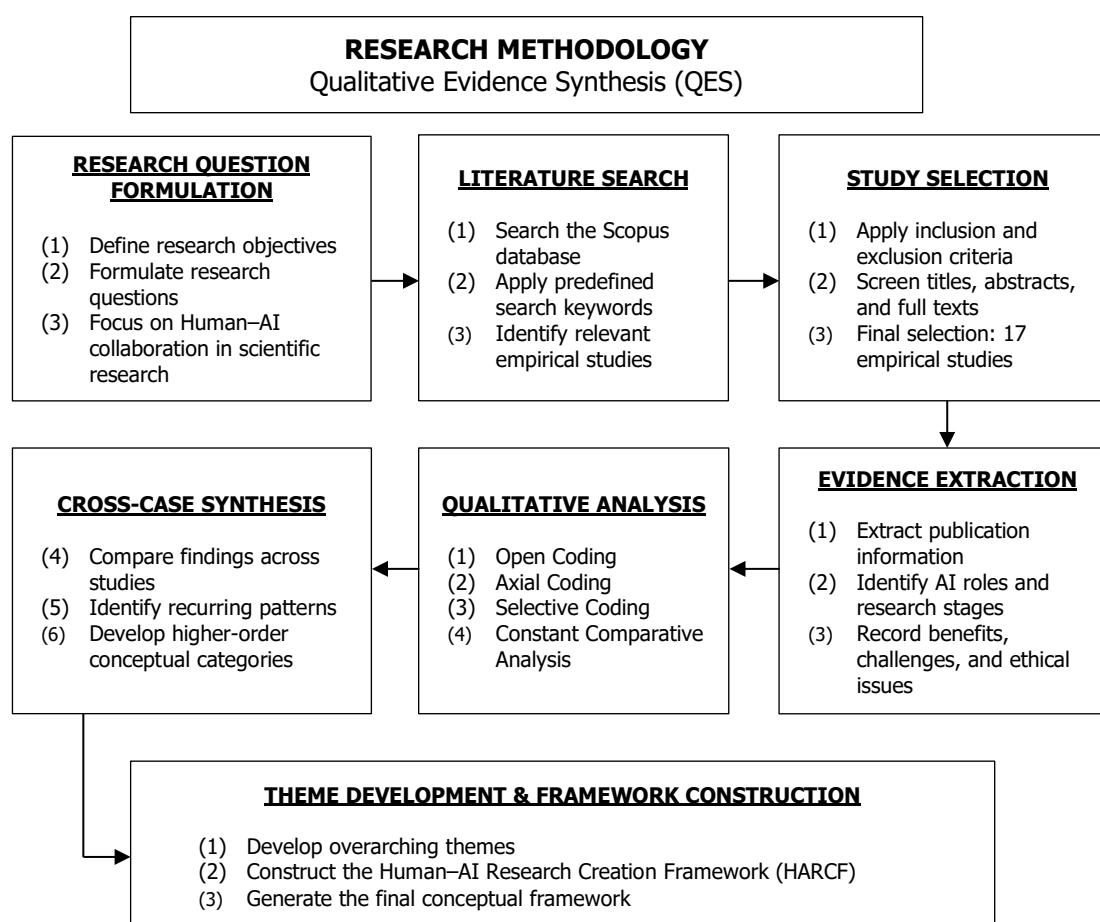


Figure 1. Research Framework

RESULT

Open Coding

The first stage of analysis involved an Open Coding process to identify initial concepts that consistently emerged from the seventeen empirical studies. Each article is treated as a single analytical case, while each piece of evidence illustrating the role of Generative Artificial Intelligence (GenAI) in the research process is treated as a unit of meaning. The analysis focuses on research activities, forms of human-AI collaboration, and AI cognitive functions that recur across various research contexts.

The analysis yielded a set of initial codes representing various AI-based research activities, ranging from idea generation, literature exploration, concept development, and methodology design to result interpretation and scientific validation. Concepts with similar meanings were subsequently retained under the same code, resulting in the formation of a preliminary codebook that represents the variations in Human-AI collaboration throughout the research cycle.

In contrast to previous studies that generally positioned AI as a writing assistant, the results of open coding indicate that AI has evolved into an intellectual collaborator supporting various high-level research activities. The role encompasses research ideation, literature exploration, identification of research gaps, development of a conceptual framework, methodological design, and interpretation of results, through to scientific validation. These findings consistently emerge across various disciplines, indicating a shift in the function of AI from automation toward collaborative knowledge creation.

Table 1. Open Coding Results of the 17 Primary Studies

Case	Empirical Evidence	Meaning Unit	Initial Code	Source
C1	AI generates novel insights through collaboration with researchers.	AI contributes to generating new research perspectives.	Insight Generation	(Epp and Humphreys, 2025)
C2	AI functions as an augmented mathematician under human supervision.	AI supports scientific reasoning while researchers retain control.	Research Copilot	(Henkel, 2025)
C3	Human verification remains essential in LLM-assisted qualitative coding.	AI outputs require critical validation.	Human Validation	(Kempny et al., 2026)
C4	SciSciGPT automates complex scientific workflows.	AI supports integrated research activities.	Workflow Automation	(Shao et al., 2026)
C5	ChatGPT assists comparative scientific analysis.	AI facilitates structured analytical comparison.	Comparative Analysis	(Karakose, Demirkol, Aslan, et al., 2023)
C6	Generative AI supports every stage of management research.	AI assists throughout the research lifecycle.	End-to-End Research Support	(Lorenz et al., 2026)
C7	UREKA streamlines UX research from ideation to insight generation.	AI accelerates iterative research processes.	Research Workflow Integration	(Chung et al., 2026)
C8	Academics use ChatGPT as inspiration for research ideas.	AI stimulates scientific creativity.	Research Ideation	(Livberber and Ayvaz, 2023)
C9	Prompt literacy develops through iterative interaction with AI.	Effective prompting becomes a research competency.	Prompt Literacy	(Kang and Lee, 2026)
C10	LLM-based Delphi establishes AI competency frameworks.	AI facilitates collaborative consensus building.	Consensus Development	(Petrova, 2026)
C11	AI identifies qualitative themes but requires expert verification.	Human expertise remains indispensable.	Hybrid Thematic Analysis	(Lucio et al., 2026)
C12	GPT-4 learns from experimental feedback.	AI improves through iterative human interaction.	Iterative Learning	(Zheng et al., 2023)
C13	Human-AI collaboration improves scientific accuracy.	Human oversight enhances AI reliability.	Human Oversight	(Tülübaş et al., 2023)
C14	GAIDeT classifies AI delegation across research stages.	AI contributions require transparent documentation.	AI Governance	(Suchikova et al., 2026)
C15	ChatGPT provides comprehensive conceptual explanations.	AI supports conceptual synthesis.	Knowledge Synthesis	(Karakose, Demirkol, Yirci, et al., 2023)
C16	Digital biopsy integrates AI across research and clinical knowledge ecosystems.	AI enables multidisciplinary knowledge integration.	Knowledge Ecosystem	(Zhou et al., 2025)
C17	AbductivAI positions AI as an epistemic research partner.	AI participates in abductive scientific reasoning.	Epistemic Collaboration	(Costa et al., 2025)

The open coding process yielded a number of initial codes describing both the technical and cognitive dimensions of human-AI collaboration. Although each study stems from a different discipline, several codes consistently emerge, such as Research Ideation, Knowledge Synthesis, Research Copilot, Human Validation, Prompt Literacy, Workflow Integration, Conceptual Development, and AI Governance. The recurring appearance of these codes indicates that AI is no longer viewed merely as an automation tool, but rather as an intellectual partner supporting the process of scientific knowledge creation.

In addition to the codes widely discussed in the literature, the analysis also identifies several relatively new concepts, such as Epistemic Collaboration, Knowledge Ecosystem, Iterative Learning, and Consensus Development. These findings indicate that the relationship between humans and AI is evolving toward an iterative, reflective, and human-validated co-creation process. These initial codes subsequently served as the basis for grouping conceptual categories during the Axial Coding stage to construct the Human-AI Research Creation Framework (HARCF).

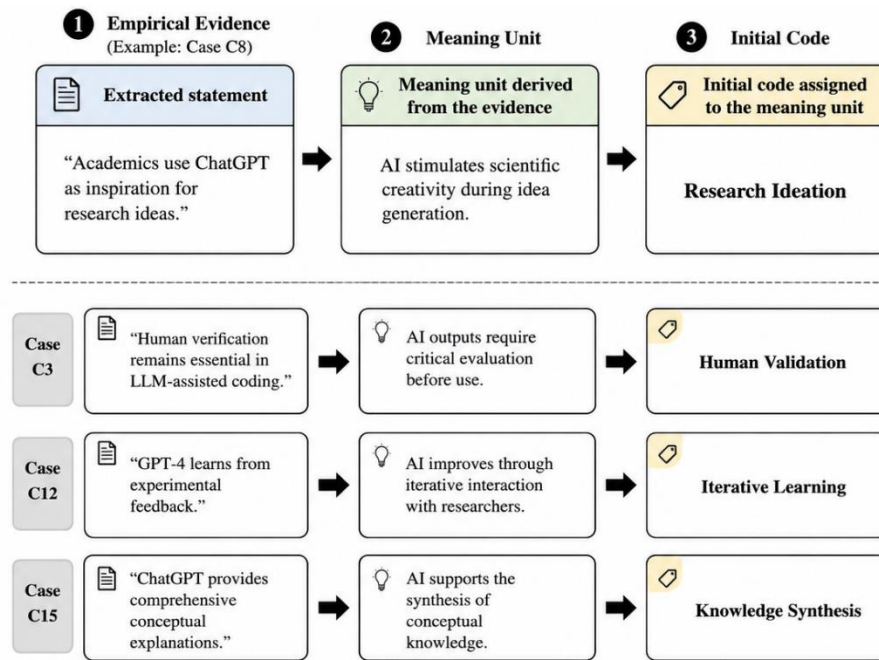


Figure 2. Examples of Open Coding Process

Axial Coding

The second stage of analysis reorganizes the initial codes into higher-level conceptual categories by identifying conceptual relationships among the seventeen empirical cases. Rather than examining individual codes in isolation, this stage reveals a broader dimension that explains how researchers and Generative AI collaboratively contribute to the creation of scientific knowledge throughout the research cycle.

Although they represent a variety of disciplines, including information systems, education, management, chemistry, health care, mathematics, and qualitative research, and the user experiences in these empirical cases consistently show similar patterns of human-AI collaboration. Across all academic disciplines, AI is viewed not merely as a tool for automated writing, but as an intellectual partner that supports cognitive, analytical, methodological, and creative research activities. These recurring similarities allow the initial codes to be grouped into broader axial categories that represent common research functions.

Table 2. Axial Coding Categories and Initial Codes

Axial Category	Initial Codes
Research Ideation and Creativity	Research Ideation, Insight Generation, Creativity
Knowledge Exploration and Synthesis	Literature Exploration, Knowledge Synthesis, Comparative Analysis
Research Design Support	Workflow Integration, Prompt Literacy, Research Copilot
Human Oversight and Critical Validation	Human Validation, Expert Judgment, Reflexivity
Iterative Human-AI Co-Creation	Iterative Learning, Prompt Engineering, AI Feedback
Responsible Research Governance	AI Governance, Transparency, Accountability

The first category describes AI's contributions during the early stages of scientific inquiry. Evidence from various cases shows that AI helps researchers generate research ideas, explore alternative perspectives, identify new findings, and stimulate scientific creativity before formal inquiry begins. Rather than replacing researchers, AI actually expands the cognitive search space where new research problems emerge.

The second category highlights AI's ability to support literature exploration, knowledge synthesis, conceptual explanations, and the identification of research gaps. In the various studies reviewed, AI serves as an intellectual assistant that accelerates the integration of information while enabling researchers to develop a broader conceptual understanding before conducting empirical investigations.

One of the most prominent patterns emerging across all empirical cases relates to the irreplaceable role of human oversight. Although generative AI significantly accelerates the process of knowledge creation, researchers remain responsible for evaluating contextual relevance, methodological appropriateness, theoretical consistency, and scientific validity. These findings suggest that human-AI collaboration is fundamentally characterized by cognitive enhancement, rather than autonomous scientific decision-making. Therefore, the creation of knowledge emerges as a repetitive dialogue, rather than as a linear sequence of results produced by artificial intelligence.

Therefore, governance is not an external layer of regulation, but rather an integral dimension embedded throughout the entire process of research and creation involving humans and artificial intelligence.

Overall, these six axial categories indicate that human–AI collaboration goes beyond isolated research activities and instead forms an interconnected system of cognitive, methodological, and governance processes. The relationships among these categories suggest the existence of an overarching explanatory phenomenon that describes how researchers and Generative AI jointly create scientific knowledge. This emerging central phenomenon becomes the focus of the next stage, Selective Coding, in which all categories are theoretically integrated into the Human-AI Research Creation Framework (HARCF).

Selective Coding

The selective coding process integrates six axial categories into a single explanatory phenomenon that describes how human-AI collaboration contributes to the creation of scientific knowledge across seventeen empirical studies. Rather than representing independent dimensions of research activity, these categories form an interconnected conceptual framework that explains the dynamic interaction between researchers and Generative Artificial Intelligence throughout the life cycle of scientific research. This integration transforms individual analytical categories into a unified theoretical account of the creation of Human-AI research.

A comparison of the cases reveals consistent patterns despite differences in academic discipline, research methodology, and AI platforms. Across studies in information systems, management, mathematics, chemistry, education, healthcare, qualitative research, and user experience, AI is consistently positioned as an active cognitive collaborator that supports various stages of scientific inquiry, while researchers remain responsible for interpretation, validation, ethical assessment, and final scientific decision-making. This recurring pattern suggests that the central phenomenon emerging from the evidence is not AI-assisted writing, but AI-assisted research creation.

Further analysis shows that the six axial categories collectively represent a cyclical process of knowledge creation rather than a linear research workflow. Research activities generally begin with research ideation and creativity, proceed through exploration and synthesis of knowledge as well as research design support, and are continuously refined through iterative human-AI collaboration. Throughout this process, Human Oversight and Critical Validation serve as the primary mechanisms for ensuring scientific rigor, contextual interpretation, and epistemic credibility, while Responsible Research Governance provides ethical, transparent, and accountable guidance at every stage of the collaboration. Together, these categories explain how researchers and AI progressively generate scientific knowledge through continuous interaction and refinement.

Based on the integration of these relationships, a single core category emerges that best explains the collective evidence across all empirical cases: “Human-AI Research Creation is a iterative knowledge-creation process in which human scientific reasoning and Generative Artificial Intelligence continuously interact to generate, refine, validate, and communicate scientific knowledge, while human researchers maintain epistemic authority, critical judgment, and ethical responsibility throughout the research lifecycle”. This category expands upon previous conceptualizations that primarily viewed AI as a writing assistant, analytical tool, or productivity enhancer. Instead, this synthesis demonstrates that generative AI is increasingly functioning as a cognitive research collaborator capable of supporting ideation, knowledge exploration, conceptual development, methodological planning, evidence synthesis, interpretation, and scientific contributions through iterative human-AI interactions.

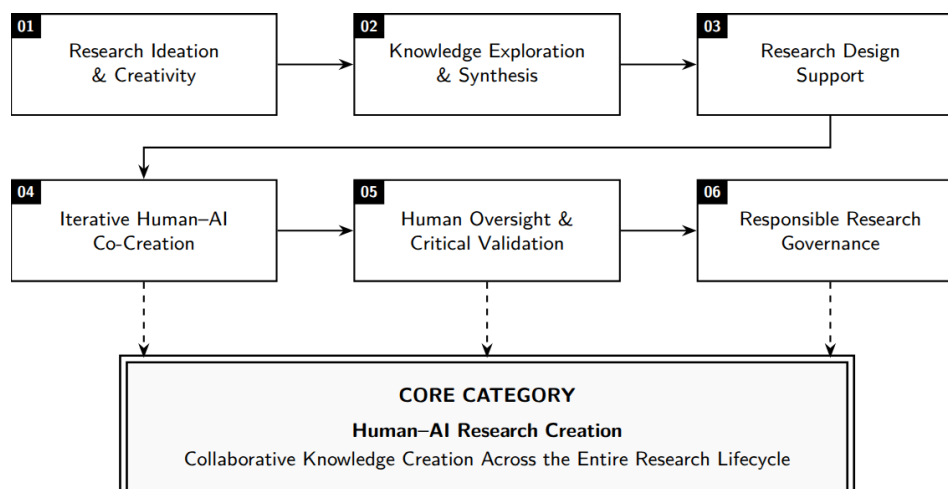


Figure 3. Selective Coding Integration

Cross-Case Synthesis

The comparative synthesis identified four higher-order patterns that consistently appeared across the seventeen empirical studies. Rather than representing isolated findings, these patterns describe how Human-AI collaboration has evolved across different disciplines and research contexts, revealing a common trajectory in the integration of Generative Artificial Intelligence within scientific research.

Pattern 1. Expansion of AI Across the Research Lifecycle

The first pattern demonstrates that the role of Generative AI has progressively expanded beyond isolated research tasks toward supporting the entire research lifecycle. While early applications primarily focused on manuscript preparation and language refinement, the reviewed studies show that AI is increasingly utilized during problem identification, literature exploration, novelty development, methodological planning, evidence synthesis, interpretation, and dissemination of research findings. This progression indicates that AI is becoming embedded across multiple phases of scientific inquiry rather than functioning as a stand-alone writing technology. Consequently, research activities are evolving into integrated Human-AI workflows that span from the emergence of research ideas to scientific publication.

Pattern 2. Human Expertise as the Source of Epistemic Authority

A second pattern reveals that, despite increasing AI capabilities, scientific knowledge remains fundamentally dependent on human expertise. Across all reviewed cases, researchers were consistently responsible for interpreting evidence, evaluating theoretical coherence, resolving contextual ambiguity, and making final scholarly judgments. AI contributed analytical support and cognitive augmentation, yet epistemic authority consistently remained under human control. This finding suggests that the advancement of AI in research does not diminish the role of researchers but instead reinforces the importance of human reasoning in ensuring scientific credibility and originality.

Pattern 3. Progressive Co-Evolution Between Researchers and AI

The third pattern indicates that Human-AI collaboration develops through progressive co-evolution rather than one-directional interaction. Researchers continuously adapted their prompting strategies, refined analytical questions, and modified research directions in response to AI-generated outputs, while AI responses became increasingly aligned with researchers' objectives through iterative interaction. This reciprocal adaptation enhanced both research quality and researchers' AI competency, demonstrating that effective collaboration depends not only on technological capability but also on the continuous development of human interaction skills.

Pattern 4. Institutionalization of Responsible AI in Scientific Research

The final pattern reflects a clear transition toward institutionalized Responsible AI practices. Recent studies increasingly emphasize standardized documentation of AI contributions, transparent reporting of prompt usage, governance mechanisms, ethical accountability, and reproducibility as integral elements of scientific research. Responsible AI is therefore no longer viewed merely as a regulatory consideration but as a foundational component of credible Human-AI collaboration that supports research integrity and public trust in AI-assisted scientific knowledge.

Taken together, these four cross-case patterns illustrate a coherent developmental trajectory of Human-AI collaboration in scientific research. The evidence suggests that Generative AI is progressively evolving into an integrated research partner capable of supporting cognitive and methodological activities across the research lifecycle, while researchers continue to provide scientific judgment, contextual understanding, and ethical governance. These recurring patterns provide the empirical basis for the subsequent development of the Human-AI Research Creation Framework (HARCF), which conceptualizes research creation as an adaptive, collaborative, and human-governed process of scientific knowledge generation.

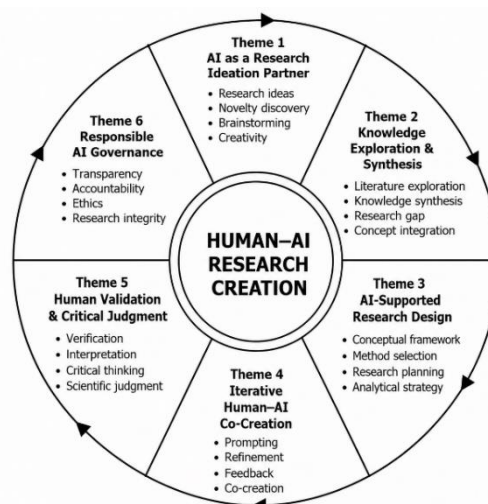


Figure 4. six themes illustrate a coherent process of human–AI collaboration

Taken together, these six themes illustrate a coherent process of human-AI collaboration that spans the entire life cycle of scientific research. This synthesis demonstrates that AI contributes not only to individual research tasks but also to the sequential stages of knowledge creation, beginning with idea generation, followed by literature synthesis and methodology development, and culminating in collaborative interpretation, validation, and the responsible dissemination of scientific findings. This integration provides empirical support for the proposed Human-AI Research Creation Framework (HARCF) by demonstrating that effective AI-assisted research depends on the ongoing interaction between AI capabilities and human intellectual, methodological, and ethical oversight. Rather than conceptualizing AI as a writing assistant, this thematic analysis positions AI as a collaborative research partner whose contributions are realized through iterative co-creation, guided by human expertise and responsible research practices.

DISCUSSION

From AI-Assisted Writing to AI-Assisted Research Creation

The findings of this study indicate that Generative Artificial Intelligence (GenAI) is reshaping scientific research by expanding its role beyond manuscript preparation to active participation in knowledge creation. Across the synthesized evidence, AI consistently supports idea generation, literature exploration, conceptual development, methodological planning, and the interpretation of research findings, indicating that its contributions span nearly the entire research lifecycle rather than being limited to isolated writing tasks. This evolution reflects a broader transition from AI-assisted writing to AI-assisted research creation, in which AI serves as a cognitive collaborator that enhances researchers' ability to explore, organize, and refine scientific knowledge (Al-Qudimat et al., 2025; Jadán-Guerrero et al., 2024; Lee et al., 2026).

This transition also underscores that the value of AI lies not only in increased efficiency but also in enhanced scientific reasoning. This is consistent with previous studies, which have primarily emphasized AI as a tool for drafting manuscripts, refining language, summarizing, and boosting productivity (U. M. Qureshi et al., 2025; Ruelas et al., 2025). Conversely, researchers are increasingly using AI during upstream research activities, including identifying research opportunities, synthesizing interdisciplinary knowledge, developing conceptual frameworks, and supporting analytical reasoning (Celik, 2025; Jadán-Guerrero et al., 2024; Roy et al., 2024). As a result, AI is gradually becoming an integral part of the cognitive workflow of scientific inquiry, rather than merely serving as a post-analysis writing assistant.

Although the role of AI is expanding, these findings consistently reinforce the notion that scientific authority remains under human control. Rather than replacing researchers, AI complements human expertise through iterative interactions involving rapid refinement, critical evaluation, validation, and contextual interpretation. This collaborative process allows researchers to devote more attention to high-level scientific reasoning while AI performs computationally intensive and repetitive cognitive tasks. Thus, the role of researchers has evolved from that of content producers to that of overseers, evaluators, and integrators of knowledge who are responsible for ensuring the originality, methodological rigor, and integrity of research.

The emergence of the Human-AI Research Creation Framework (HARCF) offers a broader conceptual perspective than existing AI-assisted writing frameworks. Rather than limiting AI to language support, HARCF conceptualizes human-AI collaboration as a continuous knowledge-creation process that encompasses research

motivation, literature exploration, gap identification, novelty construction, research design, interpretation, validation, and scientific contribution. This perspective expands the current literature on knowledge creation by positioning AI as a cognitive collaborator within the research ecosystem while upholding human epistemic authority, ethical responsibility, and critical judgment. Therefore, the transitions identified in this study represent not only technological progress but also an epistemological shift in how scientific knowledge is created through collaborative human-AI interactions.

Human-AI Collaboration as a New Process of Knowledge Creation

The findings of this study indicate that collaboration between humans and Generative Artificial Intelligence (GenAI) has evolved into a new mechanism in the process of scientific knowledge creation. In contrast to the previous paradigm, which viewed AI as an automation tool to improve the efficiency of specific tasks, a synthesis of seventeen major studies shows that AI now serves as an intellectual partner that contributes to nearly every stage of research. The collaboration encompasses the exploration of research ideas, the identification of gaps in the literature, the development of a conceptual framework, the design of a methodology, the interpretation of findings, and the preparation of scientific contributions (Lorenz et al., 2026; Shao et al., 2026; Suchikova et al., 2026). Thus, the research process is no longer entirely human-centered, but has evolved into a collaborative ecosystem that seamlessly combines human analytical capabilities with the generative capabilities of AI (Costa et al., 2025; Henkel, 2025).

These findings expand the concept of Human-AI Collaboration, which has thus far been discussed primarily in the context of productivity, decision-making, or task automation. In the context of scientific research, such collaboration has distinct characteristics because it involves higher-order thinking activities such as scientific reasoning, conceptual reflection, critical evaluation, and theory development (Costa et al., 2025; Epp and Humphreys, 2025; Henkel, 2025). AI provides a variety of alternative ideas, synthesizes information, and identifies potential connections between concepts that might be difficult to discover through conventional literature searches. However, all of these alternatives still require scientific interpretation, validation, and evaluation by researchers in order to generate knowledge that has academic validity and theoretical significance (Karakose, Demirkol, Aslan, et al., 2023; Livberber and Ayvaz, 2023; Lucio et al., 2026).

These findings also offer a new perspective on the Knowledge Creation Theory proposed by Nonaka and Takeuchi (1995). In the SECI model (Socialization, Externalization, Combination, and Internalization), knowledge creation is understood as a dynamic process that occurs through interactions among individuals as they transform tacit knowledge into explicit knowledge and vice versa. The findings of this study indicate that the presence of AI does not replace these mechanisms but rather expands the processes of Combination and Externalization. AI is capable of accelerating the integration of various knowledge sources, generating conceptual syntheses, formulating alternative arguments, and helping to externalize abstract ideas into a more systematic form (Karakose, Demirkol, Aslan, et al., 2023; Shao et al., 2026; Zhou et al., 2025). Meanwhile, the processes of interpretation, critical reflection, and internalization of meaning remain the primary domain of researchers as the holders of knowledge (Costa et al., 2025; Henkel, 2025).

In addition, the study's findings show that the relationship between humans and AI is iterative rather than linear. Researchers do not simply give the AI a single instruction; instead, they engage in a repetitive dialogue process involving the formulation of prompts, evaluation of outputs, refinement of questions, and revision of the results obtained (Kang and Lee, 2026; Zheng et al., 2023). Each cycle of interaction yields new insights, which are then used to refine the research process in the next stage. Therefore, knowledge creation in the age of AI is no longer understood as a one-way transfer of information, but as a process of co-creation that evolves through an ongoing dialogue between human reflective abilities and the computational capabilities of AI (Chung et al., 2026; Costa et al., 2025).

Although AI is demonstrating increasingly advanced capabilities in generating information and synthesizing knowledge, all of the studies analyzed consistently confirm that scientific authority remains with humans. Researchers are responsible for determining the relevance of theories, evaluating the quality of evidence, verifying the accuracy of information, identifying potential hallucinations, and ensuring that all methodological decisions and interpretations of results meet standards of research integrity (Kempny et al., 2026; Lucio et al., 2026; Tülübaş et al., 2023). Thus, AI serves as a cognitive collaborator that expands researchers' intellectual capacity, while humans remain the primary actors who determine the direction, quality, and meaning of the scientific knowledge produced (Chung et al., 2026; Karakose, Demirkol, Yirci, et al., 2023).

Based on these findings, this study proposes that human-AI collaboration should be viewed as a new paradigm in the creation of scientific knowledge. This paradigm no longer positions AI as a technical aid (research support tool), but rather as a collaborative partner that participates in the entire research cycle through an iterative, reflective, and human-centered process of interaction (Shao et al., 2026; Suchikova et al., 2026). This perspective serves as the conceptual foundation for the Human-AI Research Creation Framework (HARCF) developed in this study, in which knowledge creation is understood as the result of integrating AI's generative capabilities with human critical reasoning, experience, and epistemic responsibility (Henkel, 2025). Thus, HARCF not only offers a new

model of collaboration in scientific research but also broadens our understanding of how knowledge can be created in a more adaptive, creative, and responsible manner in the era of generative artificial intelligence (Lorenz et al., 2026; Zhou et al., 2025).

AI Enhances Scientific Creativity and Research Innovation

One of the most significant contributions of Generative Artificial Intelligence (GenAI) is its ability to enhance scientific creativity and drive innovation throughout the entire research process. AI is not only used to speed up the completion of routine tasks, but also serves as a source of intellectual inspiration that helps researchers generate new perspectives, explore alternative solutions, establish previously unseen connections between concepts, and formulate research novelty in a more systematic manner (Epp and Humphreys, 2025; Livberber and Ayvaz, 2023; Lorenz et al., 2026; Shao et al., 2026). This indicates that AI has evolved from merely a tool for boosting productivity to a technology that supports creative thinking in scientific research.

Furthermore, the creativity generated through human-AI collaboration does not arise automatically from the capabilities of large language models (LLMs), but rather stems from an exploratory and reflective process of interaction. Researchers use AI to test various theoretical possibilities, compare methodological approaches, generate counterarguments, and simulate various research scenarios before making scientific decisions (Costa et al., 2025; Henkel, 2025; Karakose, Demirkol, Aslan, et al., 2023). Thus, AI serves as a cognitive amplifier, expanding the scope of intellectual exploration available to researchers.

This finding is consistent with the Scientific Creativity Theory, which explains that scientific creativity is the result of a combination of a researcher's knowledge, divergent thinking skills, and the process of critically evaluating various alternative solutions. In the context of this research, AI enriches the divergent thinking process by generating a variety of potential ideas, synthesizing the literature, and identifying conceptual relationships that can serve as starting points for research development (Epp and Humphreys, 2025; Livberber and Ayvaz, 2023; Petrova, 2026). In other words, AI expands the possibilities for creative thinking, while humans determine the scientific quality of that creativity through critical reasoning and academic experience (Costa et al., 2025; Lucio et al., 2026; Tülübaş et al., 2023).

In addition, AI contributes to increased research innovation by accelerating the knowledge development cycle. Various studies show that AI helps researchers accelerate the process of literature review, conceptual framework development, methodology development, data analysis, and interpretation of research results (Lorenz et al., 2026; Shao et al., 2026; Suchikova et al., 2026). This efficiency allows researchers to devote more time to activities of greater scientific value, such as theory development, conceptual reflection, and the preparation of research contributions (Chung et al., 2026; Karakose, Demirkol, Aslan, et al., 2023). Thus, the resulting innovations stem not merely from AI's ability to generate new information, but from its ability to accelerate the exploration process, enabling researchers to develop more creative and evidence-based solutions.

Nevertheless, all of the studies emphasize that AI outputs have the potential to generate information that is generic, biased, lacking in context, and may even contain hallucinations if used without an adequate evaluation process (Kang and Lee, 2026; Kempny et al., 2026; Tülübaş et al., 2023). Therefore, high-quality scientific creativity does not depend solely on the capabilities of AI, but on researchers' ability to design effective prompts, critically evaluate results, and integrate AI outputs with theory, empirical data, and their own scientific experience (Kang and Lee, 2026; Karakose, Demirkol, Yirci, et al., 2023; Lucio et al., 2026). Creativity in the age of AI is the result of a collaboration between computational intelligence and human intelligence, not an automatic outcome of using technology. Research innovation in the era of Generative AI is no longer determined solely by the capabilities of individual researchers, but by the quality of the interactions established between humans and AI. The better researchers are at strategically leveraging AI, the greater the opportunity to generate new ideas, accelerate theoretical development, and enhance the scientific impact of their research.

Human Oversight Remains the Foundation of Research Integrity

Advances in Generative Artificial Intelligence (GenAI) do not diminish the importance of the human role in ensuring the quality of scientific research. AI outputs cannot be accepted directly without first undergoing an evaluation and validation process by researchers (Epp and Humphreys, 2025; Lucio et al., 2026). Thus, human oversight is not merely a mechanism for monitoring the use of technology, but rather the cornerstone that ensures the scientific validity, academic integrity, and credibility of the knowledge produced.

The synthesis results indicate that the validation process is carried out at various stages of the research. Researchers are responsible for verifying the accuracy of the information generated by AI, evaluating the appropriateness of the theories used, examining the consistency of the arguments, identifying potential hallucinations, and ensuring that all interpretations are supported by relevant empirical evidence. Some studies even show that AI can generate inaccurate references, overgeneralize, or provide explanations that seem convincing but lack a solid scientific basis (Henkel, 2025; Karakose, Demirkol, Yirci, et al., 2023; Tülübaş et al., 2023). Therefore, the quality of research is not determined by AI's ability to generate quick answers, but by the researcher's ability to critically evaluate each output generated.

These findings show that the role of researchers has transformed from that of mere knowledge producers to that of knowledge validators and knowledge curators. In an AI-supported research environment, researchers no longer merely generate information on their own, but are also responsible for filtering, evaluating, integrating, and contextualizing AI-generated information within an appropriate scientific framework. This shift indicates that the use of AI actually increases the need for critical thinking skills, scientific reflection, and theoretical mastery, as there are more and more sources of information to choose from and account for academically (Kang and Lee, 2026; Kempny et al., 2026; Livberber and Ayzaz, 2023).

This perspective aligns with the concept of Human-in-the-Loop Artificial Intelligence, which positions humans as the primary decision-makers at every stage of an AI-based system. In the context of scientific research, AI serves as an alternative source of knowledge (knowledge generator), while humans retain the authority to determine the relevance, validity, and scientific contribution of that information. Thus, the relationship between humans and AI is not one of substitution, but rather one of complementarity (Chung et al., 2026; Shao et al., 2026; Zheng et al., 2023). AI expands the capacity for knowledge exploration, while humans ensure that the results of that exploration meet the methodological, epistemological, and ethical standards accepted by the scientific community.

In addition to ensuring the quality of research, human oversight also plays a crucial role in maintaining academic integrity. The use of AI presents various new challenges, such as the potential for plagiarism, algorithmic bias, a lack of transparency in the information-generation process, and difficulties in determining scientific accountability (Livberber and Ayzaz, 2023; Petrova, 2026; Suchikova et al., 2026). Therefore, researchers are responsible not only for the content of their research but also for how AI is used throughout the research process. Practices such as documenting prompts, transparently reporting AI use, verifying primary sources, and conducting independent evaluations of AI outputs are becoming increasingly important in ensuring that research continues to adhere to the principles of research integrity. Furthermore, the results of this study indicate that the higher the level of AI involvement in the research process, the greater the need for human involvement in the oversight process. This relationship is one of complementarity, not substitution. AI can accelerate the exploration and analysis processes, but these efficiency gains must be balanced by improvements in the quality of scientific evaluation by researchers.

Responsible AI Governance Across the Research Lifecycle

The use of Generative Artificial Intelligence (GenAI) in various stages of scientific research not only presents opportunities to enhance research efficiency and creativity but also creates a growing need for responsible AI governance (Responsible AI Governance). The success of collaboration between humans and AI is determined not only by the technical capabilities of AI models, but also by governance mechanisms that ensure the entire research process is conducted in an ethical, transparent, and accountable manner. In line with the principles of Fairness, Accountability, Transparency, and Ethics (FATE), responsible AI governance ensures that these values serve as the cornerstone of every stage of AI development and deployment (Keshap and Gadani, 2026; Okolo, 2026; Rama and Prinsloo, 2025).

During the research problem identification phase, researchers not only determine the scientific relevance of a topic but also need to consider the social implications, potential biases, and ethical risks that may arise from the use of AI. This approach is consistent with the principle of human-centered AI, which emphasizes that the primary goal of using AI is to support human well-being and generate benefits that align with the interests of society (K.Bennouk et al., 2026; Keshap and Gadani, 2026). Thus, the process of formulating a research problem is no longer oriented solely toward scientific novelty, but also toward the social responsibility of the research being conducted.

During the literature review and data collection phase, this study found that AI can accelerate the processes of information retrieval, literature synthesis, and the organization of research data. However, various studies have also shown that the use of AI at this stage has the potential to result in information bias, the use of invalid references, or the dissemination of unverifiable information if it is not accompanied by an evaluation process conducted by researchers. Therefore, responsible governance practices require transparency regarding data sources, privacy protection, documentation of the data collection process, and verification of all information generated by AI (Rama and Prinsloo, 2025; Shabbir, 2026). These findings reinforce the conclusions of previous syntheses that the quality of research is not determined by the speed with which AI generates information, but by researchers' ability to ensure the validity of the scientific evidence used.

Furthermore, during the stage of developing conceptual models and research methodologies, AI is increasingly being used to generate alternative theoretical frameworks, formulate research designs, and develop analytical procedures. Nevertheless, the results of the synthesis indicate that all methodological decisions remain under the researcher's control. At this stage, responsible AI governance is implemented through the application of the principles of fairness, transparency, and accountability, as well as the use of explainable AI methods (Pria et al., 2026). Thus, AI serves as an alternative source of intellectual input, while humans remain responsible for determining the methodology best suited to the research context.

The evaluation, interpretation, and validation stages received the most attention in the studies analyzed. Nearly all of the articles emphasized that AI outputs must undergo a verification process by researchers before they can be used as the basis for scientific decision-making. This validation process includes examining the consistency of the theory, evaluating the quality of the arguments, identifying potential hallucinations, and assessing the relevance of the empirical evidence. In addition, several studies have also emphasized the importance of stakeholder engagement and ethical review to ensure that research utilizing AI continues to meet standards of academic integrity (Duke, 2023; Kim et al., 2024). These findings indicate that human oversight and responsible AI governance are two complementary mechanisms for ensuring the quality of scientific research.

Furthermore, the responsibility for AI governance does not end with the publication of research results. In line with the rapid pace of AI development, various governance frameworks emphasize the importance of continuous monitoring of the impacts of AI use, the assessment of new risks that may arise, and the adaptation of policies in accordance with technological advancements and societal needs (K.Bennouk et al., 2026; Okolo, 2026). The findings of this study indicate that AI-based research processes should be understood as a dynamic cycle, in which governance is continuously evaluated and updated to ensure the relevance, security, and trustworthiness of research results.

Although various AI governance guidelines and frameworks have been developed, the synthesis also identifies a number of implementation challenges. Several studies report that there remains uncertainty regarding the division of responsibilities among researchers, AI model developers, academic institutions, and scientific publishers in managing the use of AI during the research process (Kuehnert et al., 2025). In addition, there remains a significant gap between the various governance principles that have been formulated and their implementation in day-to-day research practice. The rapid advancement of AI technology has also led to regulatory frameworks often lagging behind the capabilities of ever-evolving AI models, particularly in high-risk research fields such as health, biomedicine, and the social sciences (Kim et al., 2024; O. A. Qureshi and Saoud, 2025). Therefore, AI governance must be designed to be adaptive so that it can keep pace with the dynamic evolution of technology while maintaining ethical standards in research.

Theoretical Implications of the Human-AI Research Creation Framework (HARCF)

One of the key contributions of this study is the development of the Human-AI Research Creation Framework (HARCF) as a conceptual framework that explains how collaboration between humans and Generative Artificial Intelligence (GenAI) unfolds systematically throughout the scientific research cycle. In contrast to previous research which generally positions AI as a tool at certain stages, such as academic writing, data analysis, or literature synthesis, HARCF views research as an integrated knowledge creation process, where AI and humans interact collaboratively from problem identification to dissemination of research results. Thus, HARCF not only explains the role of AI in research but also provides an explanation of the collaborative mechanisms that generate scientific knowledge responsibly.

The first theoretical implication of HARCF lies in its ability to decompose the complex research process into interconnected stages, encompassing topic identification, literature exploration, research gap discovery, development of novelty, formulation of a conceptual framework, methodology design, human-AI collaboration, interpretation, and validation, through to publication. This structure enables researchers to understand AI's contribution at each stage without losing sight of the interconnections between stages, aligning with the principle of problem decomposition within a hierarchical framework for solving complex problems. In the context of HARCF, this decomposition enables researchers to understand AI's contribution at each stage of the research without losing sight of the interconnections between stages in the knowledge creation process.

The second implication concerns the multi-level abstraction involved in the research process. HARCF demonstrates that human-AI collaboration evolves progressively, ranging from the exploration of ideas and knowledge to the formulation of conceptual frameworks and methodologies, as well as the interpretation of research findings. This approach illustrates that the contribution of AI evolves in line with the complexity of research activities, thereby supporting an adaptive and sustainable knowledge creation process. These findings are consistent with the concepts of structural and temporal abstraction in modern hierarchical frameworks.

The subsequent implication is an increase in the efficiency of knowledge exploration and research adaptability. HARCF demonstrates that AI accelerates literature synthesis, connects cross-disciplinary concepts, and generates methodological alternatives, thereby enabling researchers to focus more on theory development, critical evaluation, and conceptual synthesis. Therefore, the integration of AI not only enhances research productivity but also strengthens researchers' ability to respond to the evolving complexities of science. This perspective aligns with research on hierarchical frameworks that emphasizes learning efficiency and generalization capabilities through modular structures.

HARCF also enhances the interpretability and modularity of the research process by explicitly mapping AI's contributions at each stage of the research. This modular structure allows each activity to be analyzed independently while maintaining logical relationships between stages, thereby facilitating the implementation, evaluation, and

development of AI-based research. This characteristic aligns with the principles of interpretability and modularity that underpin various modern hierarchical frameworks.

The final theoretical implication is the extension of Knowledge Creation Theory through the concept of human-AI co-creation. HARCF demonstrates that AI can be positioned as a cognitive actor that expands the exploration, synthesis, and development of knowledge, while humans retain epistemic authority through interpretation, validation, reflection, and ethical deliberation. Thus, knowledge creation is understood as the result of synergy between AI's computational capabilities and human scientific reasoning, yielding a research process that is more adaptive, transparent, and innovative.

CONCLUSION

This study aims to understand how Generative Artificial Intelligence (GenAI) collaborates with researchers throughout the scientific research process and to develop a conceptual framework capable of systematically explaining the mechanisms of such collaboration. Using a Qualitative Evidence Synthesis (QES) approach applied to seventeen empirical studies, this research demonstrates that the role of AI has evolved from a mere writing aid into a cognitive collaborator that supports various stages of knowledge creation, ranging from exploring research topics, synthesizing literature, identifying research gaps, developing novelty, and formulating conceptual frameworks to designing methodology, interpreting results, and articulating scientific contributions. These findings indicate that the creation of scientific knowledge is increasingly shifting toward a process of human-AI co-creation, in which AI expands researchers' analytical capacities without replacing human epistemic authority.

The primary contribution of this research is the development of the Human-AI Research Creation Framework (HARCF) as a conceptual framework that integrates all research stages into a single human-AI collaboration cycle. Unlike previous research, which generally views AI as a tool to support specific activities, HARCF characterizes research as an iterative, collaborative, and human-centered process. This framework asserts that the effectiveness of AI utilization is determined not only by technological capabilities but also by the active involvement of researchers through processes of validation, interpretation, critical reflection, and scientific decision-making at every stage of the research.

Theoretically, HARCF extends the perspective of Knowledge Creation Theory by introducing the mechanism of human-AI co-creation as a new form of knowledge creation in the era of generative artificial intelligence. This framework also provides a conceptual foundation for how AI can be systematically integrated into research activities without compromising scientific integrity. In practical terms, HARCF provides guidance for researchers, academic institutions, journal editors, and policymakers on the responsible implementation of AI, grounded in the principles of transparency, accountability, human validation, and sustainable AI governance.

Nevertheless, this study has several limitations. The synthesis is largely derived from the context of using Large Language Models (LLMs) in academic research, consequently, it does not yet fully represent the full spectrum of human-AI collaboration or the diversity of academic disciplines. Furthermore, the HARCF remains a conceptual framework developed through qualitative synthesis, thus requiring further empirical testing.

Future research is recommended to empirically validate the HARCF through case studies, surveys, or quantitative approaches using Structural Equation Modeling (SEM) or mixed methods. Furthermore, future research could explore the application of HARCF across various disciplines, compare collaboration characteristics among Generative AI platforms, and develop measurement indicators to evaluate the effectiveness, quality, and governance of human-AI collaboration in the process of scientific knowledge creation.

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