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CAPilot Model: Human–AI Co-Piloting Between World and Knowledge

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Research Article

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Title

CAPilot Model: Human–AI Co-Piloting Between World and Knowledge

Subtitle

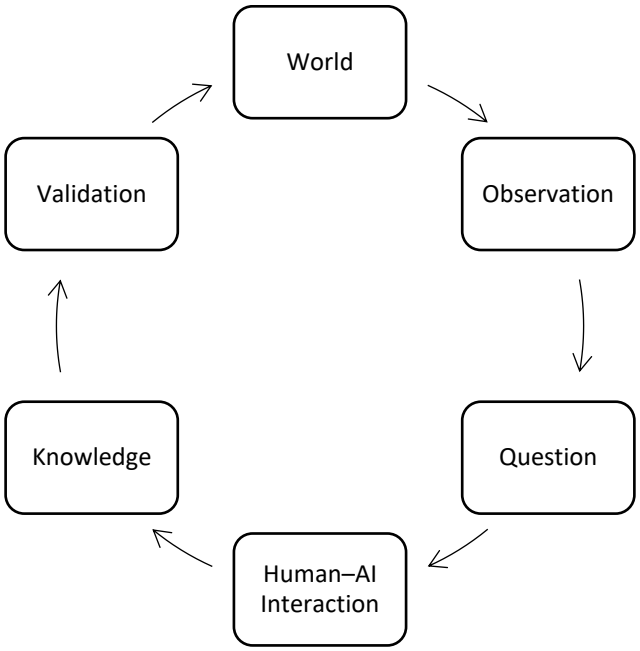
A Reconstruction from Human–AI Logs and Consecutive Knowledge Development Cycles

Abstract

Artificial Intelligence (AI) is increasingly integrated into human activities, generating growing interest in Human–AI interaction, collaboration, and knowledge development. Existing research has contributed significantly to understanding how Humans and AI interact, how cognition can be distributed across socio-technical systems, and how knowledge is generated, developed, and validated (Amershi et al., 2019; Hutchins, 1995; Nonaka, 1994). However, less attention has been paid to the recurring process through which Human–AI interaction continuously maintains the connection between observable reality and organized knowledge.

This study reconstructs a recurring pattern identified across Human–AI Logs, evidence inventories, and three consecutive knowledge-development cycles documented through previous research outputs. Rather than treating these materials as isolated products, the study examines them as traces of an evolving process involving observation, questioning, dialogue, interpretation, reflection, and validation.

The reconstruction identifies two complementary domains. Human engages the World through Experience, while AI engages Knowledge through Language. Across multiple Human–AI knowledge-development cycles, a recurring structure repeatedly appeared:



Analysis of this recurring pattern led to the reconstruction of the CAPilot Model, defined as a Human–AI co-piloting framework that continuously connects World and Knowledge through observation, dialogue, interpretation, learning, and validation.

The study does not propose a universal theory of Human–AI collaboration. Instead, it reconstructs an observable phenomenon documented across Human–AI knowledge-development cycles. The resulting framework suggests that Human and AI function as complementary participants: Human explores the World, AI organizes Knowledge, and Human–AI interaction continuously maintains the connection between these two domains.

Keywords: Human–AI Interaction; Knowledge Formation; Knowledge Development; Human–AI Logs; World and Knowledge; Reconstruction; Co-Piloting; Knowledge Validation.

CAPilot Manifesto

> **Human explores World.**
>
> **AI organizes Knowledge.**
>
> **CAPilot connects World and Knowledge.**
>
> **The objective is not to control either domain, but to understand both more deeply.**

One-Sentence Contribution

> **The CAPilot Model reconstructs how Human–AI interaction continuously connects World and Knowledge through observable knowledge-development cycles.**

1. Introduction

1.1 The Human–AI Era

The increasing integration of Artificial Intelligence (AI) into research, education, industry, and everyday life has created new forms of interaction between Humans and AI. A growing body of literature has investigated how Humans and AI collaborate, how AI supports decision-making, and how Human–AI systems contribute to knowledge generation and problem-solving (Amershi et al., 2019; Shneiderman, 2022; Xu, 2019).

These developments have given rise to significant interest in Human–AI interaction, Human-centered AI, and Human–AI collaboration. Existing studies have demonstrated that meaningful outcomes can emerge when Human capabilities and AI capabilities are effectively combined (Amershi et al., 2019; Shneiderman, 2022; Mollick, 2024).

Most of these studies, however, focus primarily on Human and AI as the principal objects of analysis. The present study begins from a different observation.

Rather than focusing exclusively on Human or AI, this work examines a recurring pattern repeatedly observed throughout a series of Human–AI knowledge-development cycles.

1.2 Beyond Human and AI

Across multiple Human–AI Logs, research manuscripts, and validation activities, the recurring phenomenon did not appear to be Human alone.

Nor did it appear to be AI alone.

Instead, a larger relationship repeatedly emerged:

World ↔ Knowledge

Questions repeatedly originated from practical observations in the World.

Knowledge repeatedly emerged through Human–AI interaction.

Knowledge repeatedly returned to the World through validation, application, and reflection.

Existing Human–AI studies have generated substantial insights regarding collaboration, interaction, and augmentation of Human capabilities (Amershi et al., 2019; Shneiderman, 2022). However, repeated observations across the present research materials suggested that a broader relationship was continuously being maintained.

Over time, the continuity of this relationship became increasingly visible across Human–AI Logs, knowledge-development cycles, and research outputs.

1.3 The Two Worlds of the Human–AI Era

The reconstruction presented in this study suggests that the Human–AI era may be understood as involving two interconnected domains.

The first domain is:

World

the domain of experience, observation, practice, action, and reality.

The second domain is:

Knowledge

the domain of language, concepts, models, interpretation, and organized understanding.

Within this perspective:

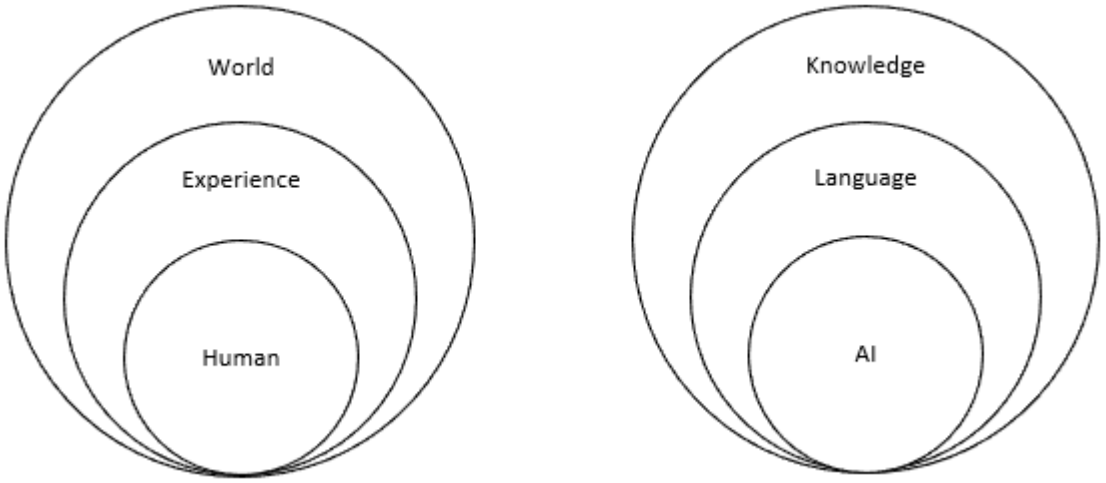


Figure 1. Foundational Domains of Human and AI

As illustrated in Figure 1, Humans and AI engage different but complementary domains.

Humans primarily engage the World through experience.

AI primarily engages Knowledge through language.

This distinction is consistent with broader perspectives in distributed cognition and extended cognition, which emphasize that cognitive processes can extend beyond isolated individuals and operate through interactions among people, artifacts, language, and environments (Hutchins, 1995; Hollan et al., 2000; Clark & Chalmers, 1998; Clark, 2008).

Importantly, this distinction does not imply separation. Instead, it establishes two complementary domains that become increasingly connected through Human–AI interaction.

1.4 From Interaction to Connection

The present study does not begin with the assumption that Human–AI interaction is significant simply because it exists.

Instead, it asks a more fundamental question:

What does Human–AI interaction continuously connect?

Analysis of Human–AI Logs suggests that interaction repeatedly functioned as a mechanism through which World and Knowledge remained connected.

Across multiple projects and research cycles, a recurring structure appeared:

Observation

↓

Question

↓

Dialogue

↓

Knowledge

↓

Validation

↓

Observation

This recurring process resembles both reflective inquiry and iterative knowledge-development processes described in organizational learning and knowledge-creation literature (Dewey, 1933; Schön, 1983; Nonaka, 1994; Nonaka & Takeuchi, 1995).

Rather than isolated episodes of Human–AI collaboration, the observed cycles suggest an ongoing process through which observations, questions, interpretations, and validations continuously contribute to the development of knowledge.

The recognition of this recurring process motivated the reconstruction presented in this paper.

1.5 Research Question

The study is guided by the following research question:

> **How does Human–AI interaction contribute to the continuous connection between World and Knowledge?**

To address this question, the study examines Human–AI Logs together with three consecutive knowledge-development cycles documented through previous research outputs.

The objective is not to propose a new theory of Human–AI collaboration.

Instead, the study reconstructs an observable pattern repeatedly documented across Human–AI knowledge-development cycles.

The resulting reconstruction is referred to as the **CAPilot Model**.

1.6 Contributions of the Study

This study makes three contributions.

Contribution 1

It treats Human–AI Logs as evidence of knowledge formation rather than merely repositories of completed knowledge.

Contribution 2

It reconstructs three consecutive research outputs as interconnected knowledge-development cycles rather than as independent studies.

Contribution 3

It reconstructs the CAPilot Model as a framework describing how Human–AI interaction continuously connects World and Knowledge.

More broadly, the study contributes to ongoing discussions concerning the relationship between Natural Intelligence and Artificial Intelligence by examining how Human–AI interaction participates in maintaining the connection between experience-based engagement with reality and language-based organization of knowledge.

1.7 Roadmap of the Paper

The remainder of the paper is organized as follows.

Section 2 describes the research materials and reconstruction methodology.

Section 3 analyzes the Human–AI knowledge-development cycles and identifies recurring patterns across the documented materials.

Section 4 presents the reconstructed CAPilot Model.

Section 5 discusses the implications of the reconstruction and positions the model within the broader literature on Human–AI interaction, distributed cognition, and knowledge development.

Section 6 outlines the limitations of the study and proposes directions for future research.

Section 7 concludes the paper.

2. Research Materials and Reconstruction Method

2.1 Research Design

This study adopts a reconstruction-based research design.

Rather than beginning with a predefined theoretical framework and subsequently seeking supporting evidence, the study begins with documented observations and analyzes recurring patterns emerging from Human–AI knowledge-development processes. This approach is consistent with traditions of reflective inquiry that view understanding as emerging through iterative observation, interpretation, and reflection (Dewey, 1933; Schön, 1983).

The objective is not to test a predefined hypothesis or validate a proposed theory. Instead, the objective is to reconstruct an observable phenomenon that repeatedly appeared across Human–AI Logs and a sequence of consecutive research outputs.

Accordingly, the CAPilot Model is treated as the outcome of a reconstruction process rather than the starting assumption of the investigation.

The study is guided by the following principle:

Observation

↓

Documentation

↓

Pattern Recognition

↓

Reconstruction

Within this perspective, theoretical structures are viewed as outcomes of analysis rather than prior assumptions.

2.2 Research Context

The reconstruction emerged from a long-term Human–AI research program initially focused on airport sustainability, circular economy implementation, governance, knowledge circulation, and organizational learning.

Throughout this program, practical observations originating from real-world projects were continuously documented and explored through Human–AI dialogue.

Questions arising from operational practice were repeatedly examined through cycles of observation, interpretation, reflection, validation, and reformulation. Over time, these activities generated a sequence of connected research outputs concerning Human–AI interaction, recursive knowledge development, and organizational learning processes (Argyris & Schön, 1978; Senge, 1990).

The present study examines these outputs collectively rather than individually.

Its primary object of analysis is not any single publication, but the evolving process through which knowledge emerged and developed across multiple Human–AI cycles.

2.3 Research Materials

The reconstruction of the CAPilot Model draws upon two primary categories of research materials.

2.3.1 Human–AI Logs

The first category consists of Human–AI Logs documenting the evolution of observations, questions, dialogues, interpretations, reflections, conceptual developments, and validation activities.

The logs preserve records of:

- practical observations;
- emerging research questions;
- Human–AI dialogues;
- concept formation;
- iterative reflections;
- interpretation changes;
- validation activities.

Unlike conventional research notes that typically preserve conclusions, the Human–AI Logs preserve intermediate stages of knowledge formation. This characteristic resembles reflective records used in traditions of reflective inquiry and reflective practice (Dewey, 1933; Schön, 1983).

Consequently, these records provide evidence not only of knowledge itself but also of the processes through which knowledge emerged over time.

Within this study, Human–AI Logs are treated as primary process evidence.

2.3.2 Consecutive Knowledge Development Cycles

The second category consists of three consecutive research outputs representing successive stages of knowledge development.

Cycle 1: Knowledge Emergence

Primary focus:

Human–AI Interaction

↓

Knowledge Formation

Research question:

How does knowledge emerge through Human–AI interaction?

Cycle 2: Knowledge Development

Primary focus:

Knowledge

↓

Recursive Development

Research question:

How does knowledge evolve through iterative reflection and recursive development?

Cycle 3: Knowledge Validation

Primary focus:

Knowledge

↓

Validation

↓

Credible Knowledge

Research question:

How does generated knowledge become credible knowledge through validation processes?

Rather than treating these outputs as independent studies, the present research interprets them as three consecutive stages within a broader Human–AI knowledge-development process. This interpretation is consistent with perspectives that describe knowledge as a dynamic and continuously evolving process rather than a static outcome (Nonaka, 1994; Nonaka & Takeuchi, 1995).

2.4 Why Human–AI Logs Are Treated as Research Data

A central methodological assumption of this study is that Human–AI Logs contain evidence of knowledge formation.

Traditional research publications generally preserve finalized knowledge in the form of theories, frameworks, methods, and conclusions.

The Human–AI Logs preserve a different layer of information:

Observation

↓

Question

↓

Dialogue

↓

Interpretation

↓

Reflection

↓

Validation

↓

Knowledge

The logs therefore make visible developmental stages that are often absent from final publications.

For the purposes of this study, the logs are analyzed not only for their content but also for the recurring developmental patterns embedded within them.

In this sense, Human–AI Logs function as records of knowledge formation rather than repositories of completed knowledge. By preserving intermediate stages of interpretation and reflection, the logs provide access to forms of knowledge development often invisible in finalized publications (Dewey, 1933; Schön, 1983). This perspective is also consistent with work emphasizing the relationship between tacit and explicit knowledge (Polanyi, 1966).

2.5 Reconstruction Procedure

The reconstruction was conducted through three sequential stages.

Stage 1: Pattern Identification

Recurring structures were identified within the Human–AI Logs.

Particular attention was given to repeated relationships among:

- observations;
- questions;
- Human–AI interaction;
- emerging concepts;
- validation activities.

The objective was to determine whether similar developmental pathways repeatedly appeared across different contexts and topics.

Stage 2: Cross-Cycle Analysis

The identified patterns were compared across the three consecutive knowledge-development cycles.

The purpose was to determine whether recurring structures persisted despite differences in research focus and output.

Particular attention was paid to the appearance of:

World

↓

Knowledge

↓

World

relationships across multiple stages of development.

Stage 3: Model Reconstruction

The recurring structures identified through Stage 1 and Stage 2 were integrated into a higher-level explanatory framework.

Special attention was given to the recurring relationship between:

Human

↓

Experience

↓

World

and:

AI

↓

Language

↓

Knowledge

The resulting reconstruction became the CAPilot Model.

The reconstruction process follows an iterative logic similar to reflective cycles described in the reflective practice literature (Schön, 1983).

2.6 Research Philosophy

The study follows a reconstruction-oriented research philosophy.

The aim is not to create a framework first and validate it later.

Instead, the study seeks to determine whether a recurring phenomenon becomes visible through systematic examination of documented observations.

The underlying logic can be summarized as:

Observation

↓

Documentation

↓

Pattern Recognition

↓

Reconstruction

This view is consistent with traditions that regard inquiry as a reflective process through which understanding progressively emerges from experience (Dewey, 1933; Schön, 1983).

Within this perspective:

Theory

is not treated as the starting point.

Rather:

Observed Reality

↓

Documentation

↓

Pattern Recognition

↓

Reconstruction

provides the pathway through which conceptual understanding develops.

The purpose of reconstruction is therefore not to invent a new reality, but to clarify a recurring structure embedded within documented reality.

2.7 Reconstruction Principle

The study follows a descriptive and clarifying principle rather than a predictive one.

The objective is not to:

- predict the future development of Artificial Intelligence;
- explain all Human–AI collaboration;
- establish a universal theory of cognition.

Instead, the study seeks to clarify a recurring process through which Human and AI appear to maintain the relationship between:

World ↔ Knowledge

through repeated cycles of observation, interaction, interpretation, learning, reflection, and validation.

This perspective is broadly consistent with approaches that emphasize cognition as an observable process embedded within practical activity and real-world environments (Hutchins, 1995).

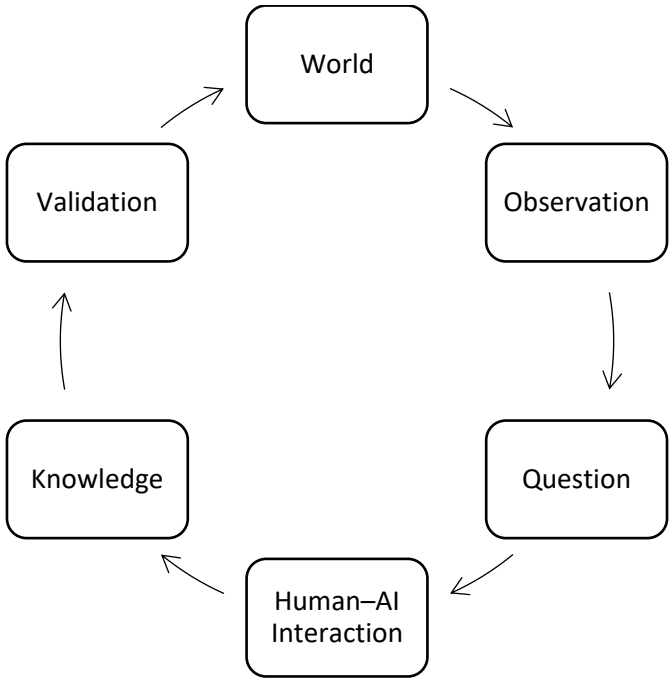
Within this perspective:

CAPilot is treated as a reconstruction of an observed process rather than a theory proposed prior to observation.

2.8 Analytical Focus

The primary unit of analysis is neither Human nor AI considered separately.

Instead, the study focuses on the recurring connection cycle between World and Knowledge.



This recurring cycle serves as the principal analytical lens through which the CAPilot Model is reconstructed.

The analytical focus combines insights from distributed cognition, extended cognition, and knowledge-development traditions by examining how interactions among experience, language, and knowledge remain connected to practical reality (Hutchins, 1995; Clark & Chalmers, 1998; Nonaka, 1994).

The central phenomenon examined throughout the study is therefore:

$$\text{World} \leftrightarrow \text{Knowledge}$$

and the role Human–AI interaction appears to play in continuously maintaining this relationship.

Section Summary

This section established the research materials, reconstruction procedure, and philosophical orientation of the study.

Human–AI Logs were treated as records of knowledge formation, while three research outputs were interpreted as consecutive knowledge-development cycles. Using a reconstruction-oriented methodology, recurring patterns were identified across these materials and analyzed through the lens of the World–Knowledge connection cycle.

The following section examines these cycles in detail and identifies the recurring structures that ultimately led to the reconstruction of the CAPilot Model.

3. Analysis: Human–AI Knowledge Development Cycles

3.1 Analytical Perspective

Following the reconstruction methodology presented in the previous section, the analysis focuses on recurring patterns appearing across Human–AI Logs and three consecutive knowledge-development cycles.

The objective is not to evaluate the success of individual research outputs. Instead, the objective is to identify whether a common developmental structure repeatedly appeared throughout the documented process of knowledge formation.

Consistent with perspectives that view cognition, learning, and knowledge creation as dynamic processes rather than static outcomes (Hutchins, 1995; Nonaka, 1994; Schön, 1983), the analysis focuses on recurring relationships among:

World

Observation

Question

Human–AI Interaction

Knowledge

Validation

Across the research materials, these elements did not appear as isolated events. Instead, they repeatedly formed interconnected developmental cycles.

3.2 Cycle 1: Knowledge Emergence

The first cycle began with observations originating from practical contexts.

The initial structure can be represented as:

World

↓

Observation

↓

Question

Questions emerging from practical observations became topics of Human–AI dialogue.

Through iterative interaction, interpretation, and clarification, knowledge gradually emerged.

Question

↓

Human–AI Interaction

↓

Knowledge

The analysis suggests that knowledge did not appear as a direct product of Human cognition alone or AI processing alone.

Instead, knowledge emerged through interaction between both participants, consistent with perspectives emphasizing collaborative and distributed cognitive processes (Amershi et al., 2019; Hutchins, 1995).

Key Observation

The dominant pattern observed in Cycle 1 may be summarized as:

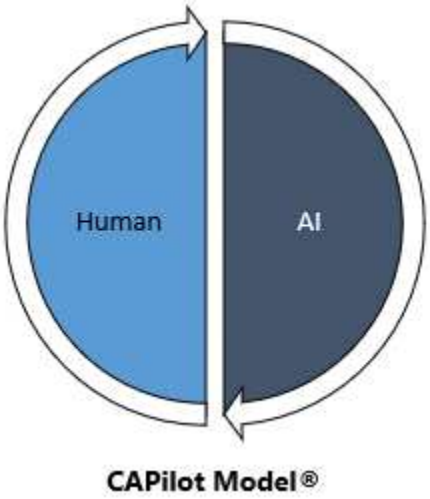


Figure 2. Observed Human–AI Interaction

The recurring Human–AI interaction documented in the research materials is represented in Figure 2.

Knowledge emerged through interaction rather than through isolated cognition.

This recurring pattern became the foundation of the first research cycle focusing on Human–AI interaction and knowledge formation.

3.3 Cycle 2: Knowledge Development

The second cycle did not begin with a new observation of the World.

Instead, previously generated knowledge became the starting point for further inquiry.

The structure observed in this cycle was:

Knowledge

↓

Reflection

↓

Question

↓

Further Development

↓

Knowledge

Knowledge generated further questions.

Questions generated new interpretations.

Interpretations generated revised understandings.

This process resembles recursive and reflective models of knowledge development described in organizational learning and knowledge-creation literature (Argyris & Schön, 1978; Nonaka, 1994; Nonaka & Takeuchi, 1995).

Key Observation

The dominant pattern observed in Cycle 2 can be represented as:

Knowledge

↓

Reflection

↓

Knowledge

Knowledge development appeared recursive rather than linear.

Previously generated knowledge repeatedly became the starting point for further knowledge development.

3.4 Cycle 3: Knowledge Validation

The third cycle focused on a different challenge.

At this stage, knowledge had already emerged and developed.

The central question became:

How does knowledge become credible?

The analysis revealed that generated knowledge repeatedly returned to practical contexts for evaluation and validation.

Knowledge

↓

Validation

↓

World

This process acted as a reality-checking mechanism.

Ideas, interpretations, and conceptual structures were continuously compared against observable circumstances.

This pattern is broadly consistent with traditions emphasizing testing, correction, and validation as essential elements of knowledge development (Popper, 1963; Polanyi, 1966).

Key Observation

The dominant structure observed in Cycle 3 was:

World

↓

Knowledge

↓

World

Validation repeatedly reconnected knowledge with reality.

3.5 Cross-Cycle Analysis

When all three cycles were examined collectively, a recurring developmental structure became visible.

Cycle 1

World

↓

Question

↓

Knowledge

Cycle 2

Knowledge

↓

Development

↓

Knowledge

Cycle 3

Knowledge

↓

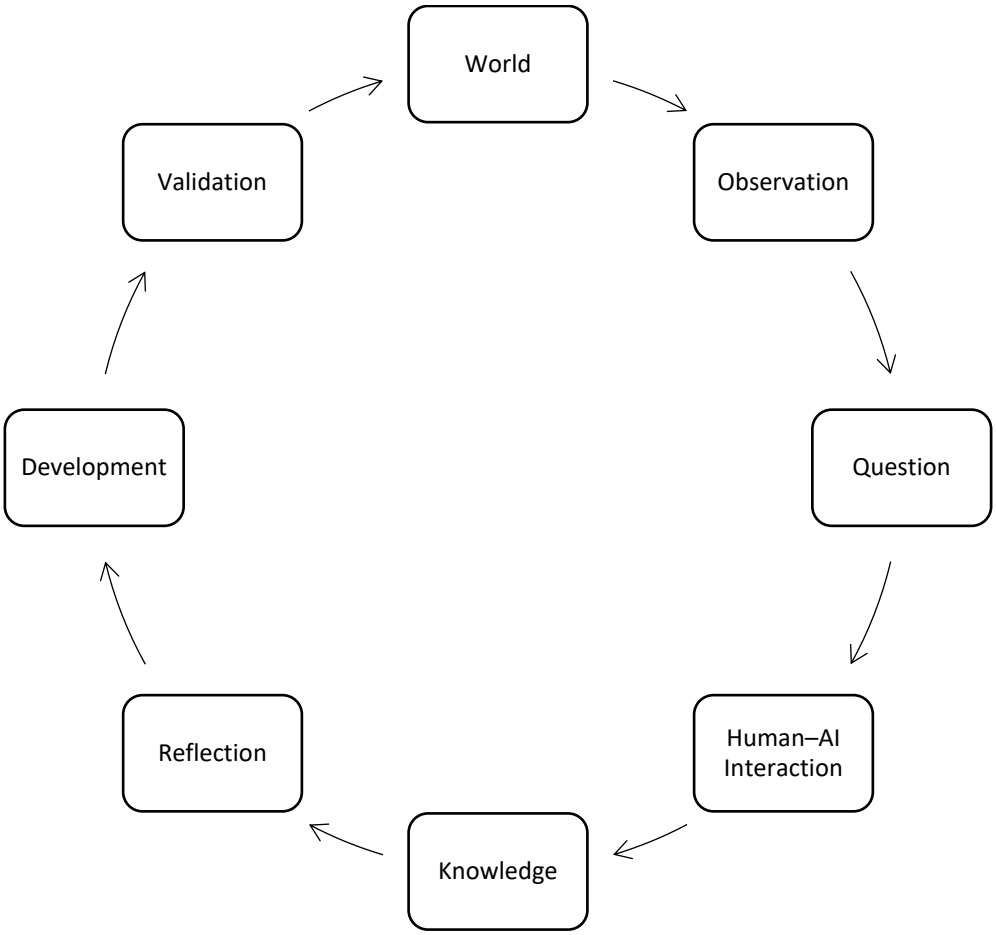
Validation

↓

World

Viewed separately, the cycles appeared to address different research problems.

Viewed collectively, they appeared to belong to a larger developmental process.



This integrated structure repeatedly appeared throughout the research materials.

3.6 Identification of a Recurring Pattern

Cross-cycle analysis revealed that the most stable feature was not Human alone and not AI alone.

Instead, the recurring phenomenon consistently involved the relationship between:

World ↔ Knowledge

Across all cycles:

- observations originated from the World;
- knowledge emerged through Human–AI interaction;
- knowledge developed through reflection;
- knowledge returned to the World through validation.

The continuity of the World–Knowledge relationship remained visible throughout the entire process.

3.7 Human and AI as Complementary Participants

The analysis also clarified the roles of Human and AI within the observed cycles.

Human repeatedly contributed:

Experience

derived from engagement with the World.

Human

↓

Experience

↓

World

AI repeatedly contributed:

Language-based organization

of Knowledge.

AI

↓

Language

↓

Knowledge

These contributions appear complementary rather than competitive.

This interpretation aligns with Human-centered AI perspectives and recent discussions concerning Human–AI complementarity (Shneiderman, 2022; Mollick, 2024).

3.8 Emergence of the CAPilot Pattern

The analysis suggests a progression across three levels.

Level 1: Foundational Domains

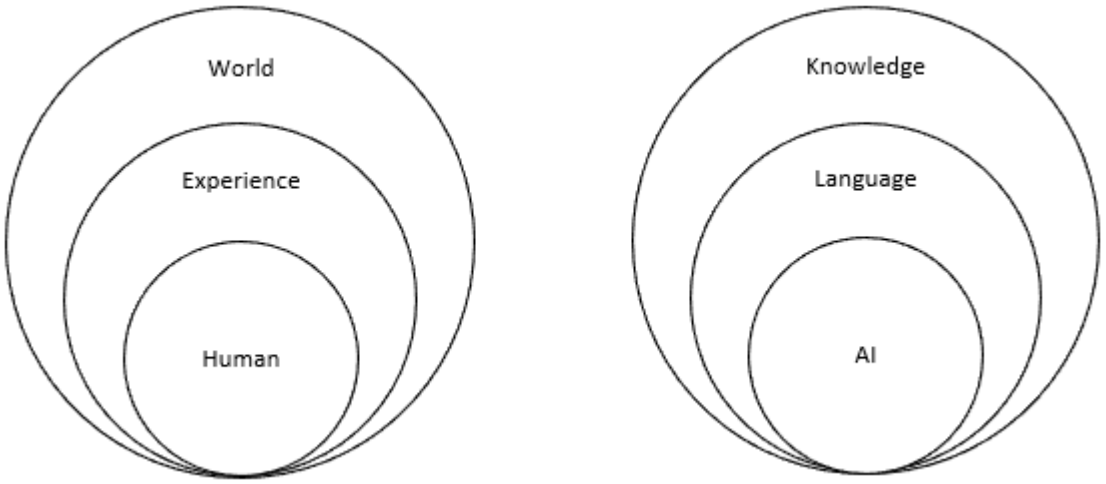


Figure 1. Foundational Domains of Human and AI

As illustrated in Figure 1, Humans and AI engage different but complementary domains.

Level 2: Observed Interaction

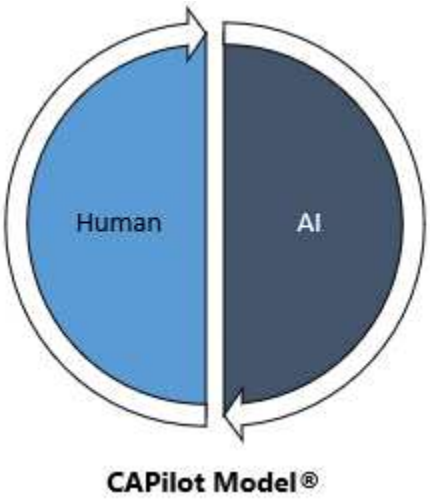


Figure 2. Observed Human–AI Interaction

The recurring Human–AI interaction documented in the research materials is represented in Figure 2.

Level 3: Reconstructed Connection

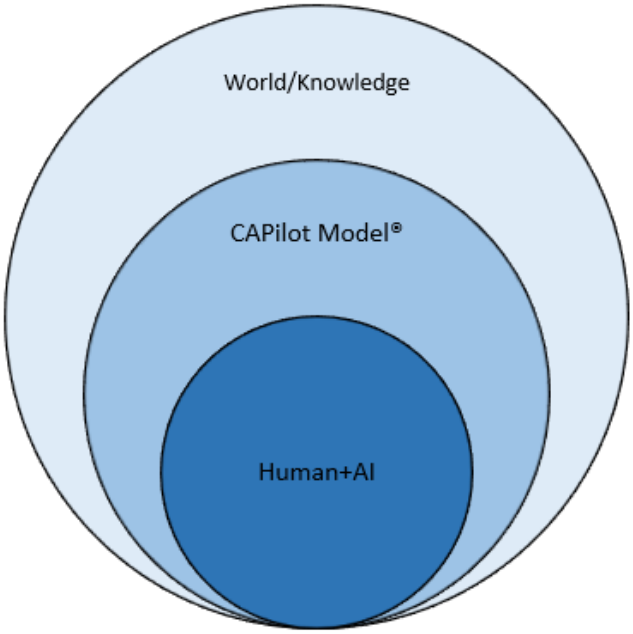


Figure 3: Reconstructed CAPilot Model

Figure 3 presents the reconstructed framework emerging from the analysis of Human–AI knowledge-development cycles.

The progression from Figure 1 to Figure 3 reflects a transition from:

Foundational Domains

↓

Observed Interaction

↓

Pattern Recognition

↓

Reconstruction

The CAPilot Model therefore emerged not as an initial hypothesis but as an explanation for a recurring pattern identified across multiple Human–AI knowledge-development cycles.

3.9 Analytical Summary

The reconstructed pattern may be summarized as:

World

↓

Observation

↓

Question

↓

Human–AI Interaction

↓

Knowledge

↓

Validation

↓

World

The persistence of this structure across Human–AI Logs and consecutive research outputs motivated the reconstruction of the CAPilot Model.

The following section presents the reconstructed framework and its conceptual interpretation.

4. The CAPilot Model: Human–AI Co-Piloting Between World and Knowledge

4.1 From Observation to Reconstruction

The analysis presented in the previous section identified a recurring developmental structure appearing across Human–AI Logs and three consecutive knowledge-development cycles.

Although these cycles addressed different research questions, they repeatedly exhibited a similar process:

World

↓

Observation

↓

Question

↓

Human–AI Interaction

↓

Knowledge

↓

Validation

↓

World

Across all cycles, observations originated from the World, knowledge emerged through Human–AI interaction, and validation reconnected knowledge with the World.

The repeated appearance of this structure suggested the existence of a higher-level relationship connecting two domains:

World ↔ Knowledge

The CAPilot Model emerged as a reconstruction of this recurring relationship.

Rather than introducing a framework designed prior to observation, the model was reconstructed after recurring patterns became visible across Human–AI Logs, evidence inventories, and consecutive research outputs.

4.2 Definition of the CAPilot Model

The CAPilot Model is defined as:

> **A reconstructed Human–AI co-piloting framework describing how Human experience and AI-supported knowledge organization continuously connect World and Knowledge through observation, dialogue, interpretation, learning, reflection, and validation.**

The model does not attempt to explain all forms of Human–AI collaboration.

Instead, it focuses on a specific observable process repeatedly identified within documented knowledge-development cycles.

Within this perspective, Human and AI function as complementary participants maintaining a continuous relationship between reality and organized understanding.

4.3 Foundational Domains

The reconstruction begins with the distinction between two complementary domains.

Human Domain

Human engagement originates from experience.

Human

↓

Experience

↓

World

Experience functions as the primary interface through which Humans engage with observable reality.

Questions emerge through experience.

Problems emerge through experience.

Validation ultimately occurs through experience.

For this reason, Human participation in the CAPilot Model is grounded in engagement with the World.

AI Domain

AI engagement originates from language.

AI

↓

Language

↓

Knowledge

Language functions as the primary interface through which AI accesses, organizes, and recombines knowledge structures.

AI contributes:

- conceptual organization,
- knowledge navigation,
- pattern recognition,
- structural interpretation.

For this reason, AI participation in the CAPilot Model is grounded in engagement with Knowledge.

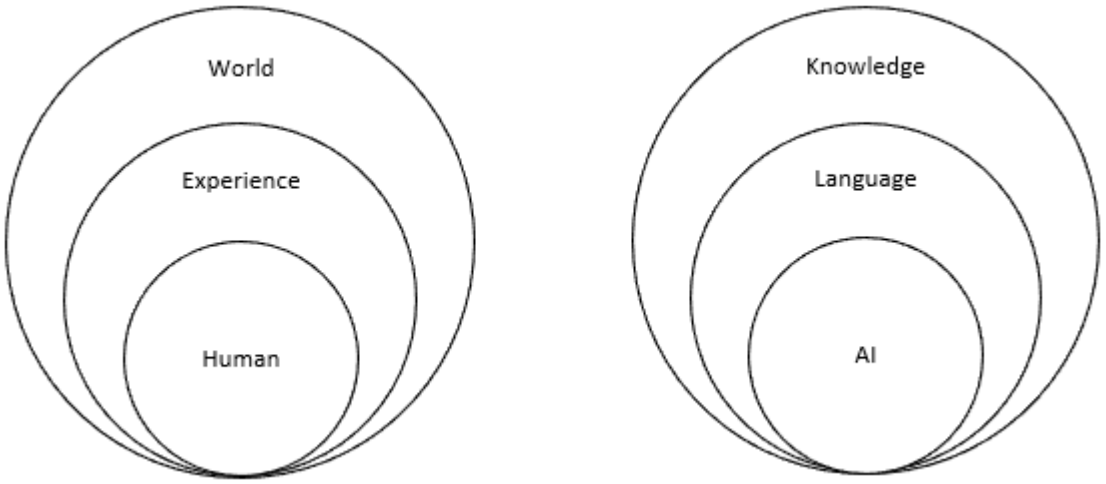


Figure 1. Foundational Domains of Human and AI

Figure 1. Foundational Domains of Human and AI. Human engages the World through Experience, while AI engages Knowledge through Language. The figure illustrates the complementary domains from which Human and AI participate in knowledge-development processes.

4.4 Human–AI Interaction as the Connecting Mechanism

The second component of the reconstruction is Human–AI interaction itself.

Across the Human–AI Logs, interaction repeatedly served as a space in which:

- observations were clarified;
- questions were refined;
- concepts were developed;
- interpretations were challenged;
- knowledge structures emerged.

This recurring relationship can be represented as:

Human ↔ AI

Interaction functioned as the mechanism through which experience and organized knowledge continually influenced one another.

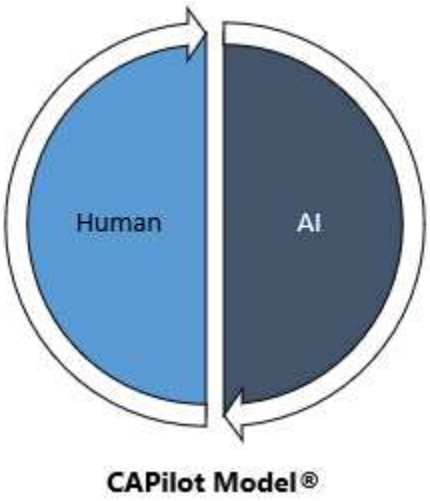


Figure 2. Observed Human–AI Interaction

Figure 2 represents the observable phenomenon documented throughout the Human–AI Logs.

Importantly, this figure is not a theoretical framework by itself.

It represents an observed interaction pattern from which reconstruction later became possible.

4.5 Emergence of the World–Knowledge Connection

Cross-cycle analysis revealed that Human–AI interaction repeatedly contributed to a broader process.

Questions consistently originated from the World.

Knowledge consistently emerged through interaction.

Knowledge consistently returned to the World through validation.

The recurring structure may therefore be represented as:

World

↓

Question

↓

Human–AI Interaction

↓

Knowledge

↓

Validation

↓

World

This observation suggests that the most stable phenomenon was neither Human nor AI considered separately.

The most stable phenomenon was the continuous relationship between:

World ↔ Knowledge

4.6 Human–AI Co-Piloting

The term *CAPilot* derives from the concept of **co-piloting**.

In aviation, a co-pilot does not replace the pilot.

Likewise, the pilot does not eliminate the role of the co-pilot.

Both contribute complementary capabilities to a shared navigation process.

The CAPilot Model applies the same principle to Human–AI interaction.

Within the reconstructed framework:

Human

↘

CAPilot

↗

AI

Human contributes engagement with the World through experience.

AI contributes organization of Knowledge through language.

Together, they support the ongoing connection between World and Knowledge.

4.7 The Reconstructed Framework

The reconstruction process ultimately led to the framework presented in Figure 3.

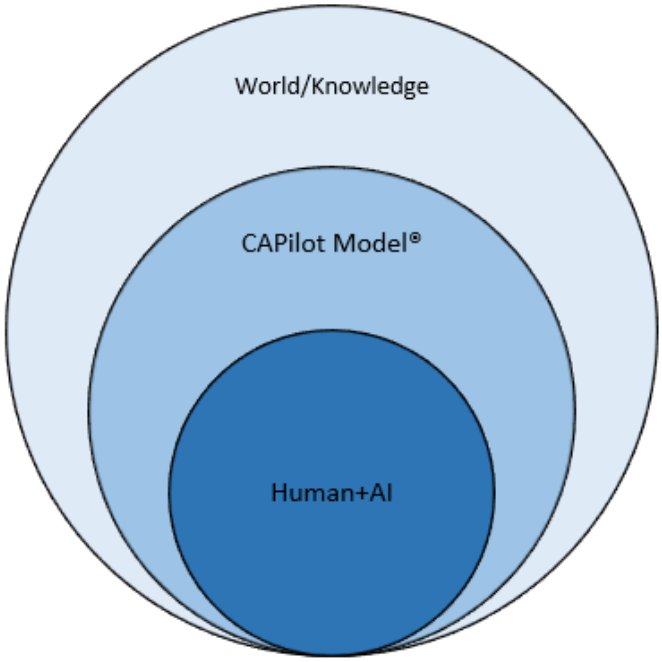


Figure 3. Reconstructed CAPilot Model

Figure 3 represents the central outcome of the reconstruction.

The figure should not be interpreted as a hierarchy.

Rather, it illustrates a layered relationship:

- Human and AI provide complementary capabilities;
- CAPilot functions as the connecting mechanism;
- World and Knowledge represent the two domains continuously maintained through that connection.

4.8 Core Propositions

The reconstruction supports four propositions.

Proposition 1

Human explores the World through Experience.

Proposition 2

AI organizes Knowledge through Language.

Proposition 3

Human–AI interaction continuously contributes to the connection between World and Knowledge.

Proposition 4

CAPilot is the reconstructed framework describing this recurring connection.

4.9 CAPilot Manifesto

The reconstructed framework may be summarized as follows:

Human explores World.

AI organizes Knowledge.

CAPilot connects World and Knowledge.

The objective is not to control either domain, but to understand both more deeply.

4.10 Section Summary

The CAPilot Model emerged from the reconstruction of recurring structures documented across Human–AI Logs and three consecutive knowledge-development cycles.

Rather than positioning Human or AI as the central object of analysis, the reconstruction identifies a broader phenomenon:

World ↔ Knowledge

Human and AI function as complementary participants within this process.

CAPilot is the reconstructed framework that makes this relationship visible.

5. Discussion

5.1 From Human–AI Interaction to World–Knowledge Connection

Much of the existing Human–AI literature focuses primarily on interaction itself.

Typical questions include:

- How do Humans collaborate with AI?
- How can AI support Human decision-making?
- How should Human–AI systems be designed?
- How can Human and AI complement one another? (Amershi et al., 2019; Shneiderman, 2022).

The reconstruction presented in this study suggests a different perspective.

Across Human–AI Logs and three consecutive knowledge-development cycles, the most stable phenomenon was not Human alone and not AI alone.

Instead, the recurring structure involved a continuing relationship between:

World ↔ Knowledge

Questions repeatedly originated from the World.

Knowledge repeatedly emerged through Human–AI interaction.

Knowledge repeatedly returned to the World through validation.

From this perspective, Human–AI interaction is not the final object of analysis.

Rather, it functions as a mechanism through which World and Knowledge remain connected.

5.2 Why World and Knowledge?

One of the most important observations emerging from the reconstruction concerns the distinction between World and Knowledge.

The World refers to the domain of:

- experience,
- action,
- observation,
- practical reality.

Knowledge refers to the domain of:

- concepts,
- interpretations,
- explanations,
- organized understanding.

Throughout the Human–AI knowledge-development cycles, both domains repeatedly appeared together.

Questions emerged from engagement with the World.

Knowledge emerged through interaction and interpretation.

Validation reconnected knowledge with the World.

Consequently, the reconstruction suggests that the primary phenomenon of interest is not Human–AI interaction by itself, but the continuing relationship between:

World ↔ Knowledge

This distinction does not replace existing Human–AI frameworks.

Rather, it provides an additional perspective through which Human–AI systems may be understood.

5.3 Human and AI as Complementary Participants

The reconstruction suggests that Human and AI make different but complementary contributions.

Human contributes:

Experience

through engagement with the World.

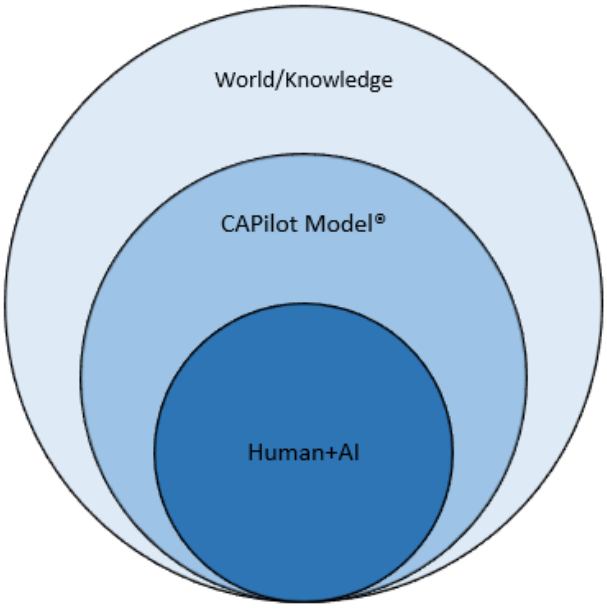
AI contributes:

Knowledge Organization

through language-based interpretation and structuring.

This interpretation is broadly consistent with Human-centered AI perspectives that emphasize the complementary strengths of Human and AI participants (Shneiderman, 2022; Mollick, 2024).

Within the CAPilot Model:



Figures 3: Reconstructed CAPilot Model

Figure 3. Reconstructed CAPilot Model. Human and AI function as co-pilots supporting the continuous connection between World and Knowledge. The model represents a reconstructed framework derived from recurring patterns observed across Human–AI knowledge-development cycles.

represent complementary pathways rather than competing forms of intelligence.

5.4 Human–AI Logs as Records of Knowledge Formation

A distinctive contribution of the present study is the treatment of Human–AI Logs as evidence of knowledge formation.

Traditional research outputs typically preserve:

Knowledge

as finalized results.

The Human–AI Logs preserve:

Observation

↓

Question

↓

Dialogue

↓

Interpretation

↓

Reflection

↓

Validation

↓

Knowledge

as a developmental process.

This perspective aligns with traditions of reflective inquiry and reflective practice (Dewey, 1933; Schön, 1983).

The logs therefore make visible stages of knowledge development that are frequently absent from final publications.

Within the CAPilot reconstruction, the logs function as records of knowledge formation rather than records of knowledge alone.

5.5 CAPilot as a Navigation Framework

The analysis also suggests an alternative interpretation of Human–AI interaction.

Rather than viewing Human–AI systems primarily as answer-generation mechanisms, CAPilot may be viewed as a navigation framework.

Across the documented cycles, knowledge development rarely followed a simple progression:

Question

↓

Answer

More frequently, the observed structure resembled:

Question

↓

Dialogue

↓

Reflection

↓

New Question

↓

Further Dialogue

This iterative structure resembles navigation more than information retrieval.

Within this perspective:

- Humans explore the World.
- AI organizes Knowledge.
- CAPilot supports navigation between them.

Its purpose is not simply to produce answers, but to improve orientation within an expanding landscape of observations, interpretations, and understanding.

5.6 CAPilot as Continuous Alignment

A second interpretation emerging from the reconstruction concerns alignment.

Reality changes.

Knowledge evolves.

Contexts shift.

Questions emerge.

As a result, the relationship between World and Knowledge cannot be treated as static.

The Human–AI cycles repeatedly involved:

- reinterpretation,
- revision,
- reflection,
- revalidation.

CAPilot therefore appears not only as a connection mechanism but also as an alignment process.

Its function is to help maintain:

Knowledge connected to World

while simultaneously ensuring that:

Experience remains informed by Knowledge.

5.7 The Two Worlds of the Human–AI Era

The reconstruction may also be interpreted through the lens of two expanding domains.

The first domain is:

World

the domain of experience, observation, action, and reality.

The second domain is:

Knowledge

the domain of language, concepts, models, and organized understanding.

Humans primarily engage the first.

AI primarily engages the second.

The challenge of the Human–AI era may therefore not be Human versus AI.

Instead, the challenge may be maintaining the relationship between:

World ↔ Knowledge

as both domains continue to expand.

The CAPilot Model represents one attempt to clarify how that relationship is maintained through Human–AI co-piloting.

5.8 CAPilot and Existing Literature

The CAPilot Model does not seek to replace existing theories of:

- Human–AI interaction,
- distributed cognition,

- extended cognition,
- knowledge development,
- reflective inquiry.

Instead, it builds upon them.

Human–AI interaction research helps explain interaction (Amershi et al., 2019; Shneiderman, 2022).

Distributed cognition helps explain how cognition can be distributed across people and artifacts (Hutchins, 1995; Hollan et al., 2000).

Extended cognition explains how cognitive processes may extend through external resources (Clark & Chalmers, 1998; Clark, 2008).

Knowledge-development literature explains how knowledge emerges and evolves (Nonaka, 1994; Nonaka & Takeuchi, 1995).

Reflective inquiry explains the role of observation, reflection, and learning (Dewey, 1933; Schön, 1983).

The contribution of CAPilot is different.

Rather than focusing on any single dimension, it seeks to clarify how Human–AI interaction contributes to maintaining the connection between:

World ↔ Knowledge

Across documented knowledge-development cycles.

In this sense, CAPilot should be understood as a complementary reconstruction framework rather than a competing theory.

5.9 What the CAPilot Model Does Not Claim

The present reconstruction does not claim to provide:

- a theory of AGI;
- a theory of machine consciousness;
- a universal theory of cognition;
- a theory of civilization;
- a prediction of future society.

The scope of the reconstruction remains intentionally limited.

Its purpose is not to explain everything.

Its purpose is to clarify one recurring phenomenon:

World ↔ Knowledge

and the role Human–AI interaction appears to play in maintaining that relationship.

5.10 Discussion Summary

The discussion supports a central interpretation.

The CAPilot Model should not be viewed primarily as a model of AI.

Nor should it be viewed primarily as a model of Human behavior.

Instead, it should be interpreted as a reconstructed framework describing how Human–AI interaction continuously maintains the connection between:

World ↔ Knowledge

Within this framework:

Human explores World.

AI organizes Knowledge.

CAPilot connects World and Knowledge.

The objective is not to control either domain, but to understand both more deeply.

6. Limitations

6.1 Scope of Reconstruction

The CAPilot Model is intentionally limited in scope.

The purpose of the present study is not to establish a universal theory of Human–AI collaboration.

Instead, the model reconstructs a recurring pattern identified within a specific body of evidence consisting of Human–AI Logs, research outputs, evidence inventories, and documented knowledge-development cycles.

Accordingly, the reconstructed framework should be interpreted as an explanation of an observed process rather than a comprehensive theory applicable to all Human–AI systems.

6.2 Context Dependence

The reconstruction emerged from a particular research environment involving:

- airport-related practice;
- circular economy research;
- governance studies;
- organizational learning activities;
- Human–AI interaction processes.

The resulting framework therefore reflects the characteristics of this context.

Different professional domains, organizational settings, and cultural environments may generate different Human–AI interaction patterns and alternative forms of World–Knowledge connections.

Future studies should examine whether similar structures emerge in other contexts.

6.3 Dependence on Human–AI Logs

A central component of the present study is the use of Human–AI Logs as primary research materials.

Although the logs provide unusual visibility into intermediate stages of knowledge formation, they also introduce limitations.

The logs represent documented interactions rather than the complete set of cognitive activities associated with the broader research process.

Consequently, the reconstruction depends on the availability, completeness, and interpretability of the recorded materials.

Additional studies using alternative forms of documentation may reveal complementary patterns or different interpretations.

6.4 Interpretive Nature of Reconstruction

The CAPilot Model emerged through interpretive reconstruction.

Although recurring structures were identified across multiple knowledge-development cycles, the reconstruction remains an analytical interpretation rather than a direct observation.

Alternative interpretations remain possible.

The purpose of the present study is not to eliminate competing explanations, but to provide a transparent reconstruction that can be examined, challenged, refined, or extended by future researchers.

6.5 Limited Generalizability

The present study does not demonstrate that all Human–AI interactions necessarily follow the CAPilot structure.

Nor does it demonstrate that all knowledge-development processes involve identical World–Knowledge connection cycles.

The findings are limited to the materials analyzed within this research program.

Additional studies involving independent Human–AI systems, alternative research teams, and different domains are needed to determine whether CAPilot represents:

A local pattern

or

A more general pattern

of Human–AI knowledge development.

6.6 Human–AI Logs as Developmental Evidence

The Human–AI Logs provide visibility into knowledge formation, but they do not provide direct access to all cognitive processes associated with interpretation, reflection, or decision-making.

The records capture documented stages of development rather than the entirety of Human cognition or AI processing.

Consequently, the reconstruction should be understood as describing an observable developmental pathway rather than a complete account of how knowledge is formed.

6.7 What the CAPilot Model Does Not Attempt to Explain

The CAPilot Model does not attempt to provide explanations for:

- Artificial General Intelligence (AGI);
- machine consciousness;
- superintelligence;
- the future evolution of civilization;
- universal cognitive theory;
- all forms of human learning.

The reconstruction remains focused on a narrower question:

> **How do Human–AI interactions contribute to the continuous connection between World and Knowledge?**

Restricting the scope of the model is intentional and reflects the reconstruction-oriented approach adopted throughout the study.

6.8 Future Research Directions

The limitations identified above suggest several opportunities for future research.

Future studies may investigate:

Replication

Can the CAPilot structure be reconstructed from independent Human–AI research programs?

Comparison

Do different Human–AI environments produce different World–Knowledge connection patterns?

Validation

Can specific propositions of the CAPilot Model be evaluated across multiple research settings?

Extension

How does the World–Knowledge connection operate within larger organizational, educational, and distributed knowledge systems?

Such studies may help determine the broader applicability and explanatory value of the CAPilot reconstruction.

6.9 Limitation Summary

The central limitation of this study can be summarized as follows:

> The CAPilot Model should not be interpreted as a universal theory of Human–AI collaboration.

Instead:

> The CAPilot Model is a reconstruction of a recurring pattern observed across documented Human–AI knowledge-development cycles.

Its purpose is not to explain every aspect of Human–AI interaction.

Its purpose is to make one observable process visible:

> World ↔ Knowledge

and to clarify how Human and AI appear to participate in maintaining that connection through observation, dialogue, interpretation, learning, reflection, and validation.

7. Conclusion

7.1 Returning to the Research Question

This study began with a single question:

> **How does Human–AI interaction contribute to the continuous connection between World and Knowledge?**

To address this question, the study examined Human–AI Logs together with three consecutive knowledge-development cycles documented through previous research outputs.

Rather than treating these materials as isolated artifacts, the study interpreted them as traces of an evolving process through which observations, questions, dialogues, reflections, and validations contributed to the development of knowledge.

7.2 Main Findings

The analysis revealed a recurring structure appearing across Human–AI knowledge-development cycles:

World

↓

Observation

↓

Question

↓

Human–AI Interaction

↓

Knowledge

↓

Validation

↓

World

Across multiple cycles:

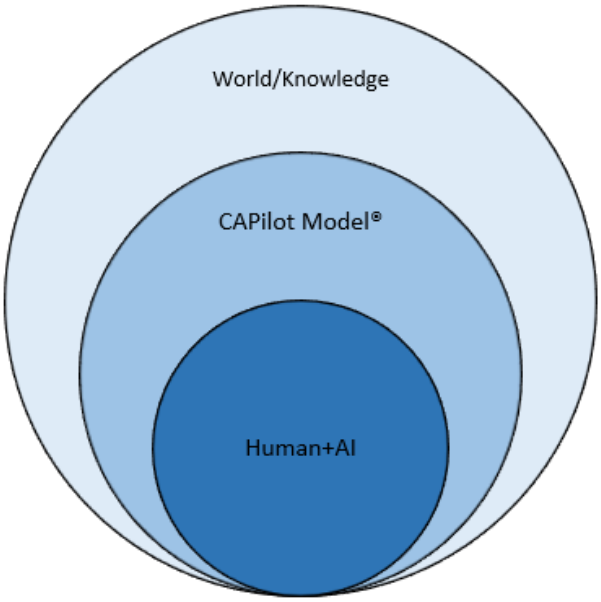
- observations emerged from the World;
- questions emerged from observation;
- knowledge developed through Human–AI interaction;
- knowledge returned to the World through validation.

Although the topics, projects, and research outputs differed, the underlying developmental structure remained remarkably consistent.

7.3 Reconstruction of the CAPilot Model

The persistence of this recurring structure motivated the reconstruction presented in this paper.

The reconstructed framework suggests that Human and AI occupy complementary positions.



Figures 3: Reconstructed CAPilot Model

Figure 3. Reconstructed CAPilot Model. Human and AI function as co-pilots supporting the continuous connection between World and Knowledge. The model represents a reconstructed framework derived from recurring patterns observed across Human–AI knowledge-development cycles

Human contributes experience derived from engagement with reality.

AI contributes language-based organization of knowledge.

Through continuous interaction, Human and AI participate in maintaining the connection between World and Knowledge.

The resulting framework is referred to as the **CAPilot Model**.

7.4 Contribution of the Study

The study contributes to Human–AI research in three ways.

First, it treats Human–AI Logs as evidence of knowledge formation rather than merely repositories of completed knowledge.

Second, it reconstructs three research outputs as interconnected knowledge-development cycles rather than isolated studies.

Third, it identifies and reconstructs a recurring World–Knowledge connection pattern documented across Human–AI interaction processes.

Taken together, these contributions shift attention from Human–AI interaction as an isolated phenomenon toward the broader process through which Human–AI interaction continuously maintains the relationship between World and Knowledge.

7.5 Final Perspective

The CAPilot Model does not attempt to explain all forms of Human–AI collaboration.

Nor does it seek to establish a universal theory of cognition, intelligence, or society.

Its purpose is more modest.

The model reconstructs an observable process documented across Human–AI knowledge-development cycles.

If the reconstruction presented in this study is valid, Human–AI interaction may be understood as more than a technological relationship.

It may be understood as a continuous process through which experiences from the World become organized as Knowledge, and through which Knowledge repeatedly returns to the World through interpretation, application, and validation.

From this perspective, the significance of Human–AI interaction lies not merely in producing answers.

Its significance lies in maintaining the connection between reality and understanding.

7.6 Closing Statement

The CAPilot Model does not begin with a theory.

It begins with a documented process.

Through Human–AI Logs, knowledge-development cycles, and repeated validation against reality, a recurring connection between World and Knowledge became visible.

The CAPilot Model represents an attempt to reconstruct and clarify that connection.

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Ethics, Consent to Participate, and Consent to Publish

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Competing Interests

The author declares that there are no competing interests.

Data Availability

The Human–AI Logs, evidence inventories, and research materials used in the reconstruction process are available from the corresponding author upon reasonable request and subject to research and privacy considerations.

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- AppendixA.docx